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ABSTRACT

Two job analyses were conducted to define knowledge domains for newly certified chemistry and physics teachers, respectively, to perform their jobs competently. The results of the job analyses will be used to develop test specifications for the Praxis II Series subject Assessments in Chemistry and Physics. Initial draft domains were prepared for both subjects and reviewed by advisory panels. After revision, the draft domain for chemistry consisted of 8 major content areas and 181 knowledge statements. The domain for physics consisted of 8 major content areas and 184 statements. Survey responses of 175 teachers and 81 teacher educators supported 116 statements as important for the chemistry knowledge domain. Responses of 330 teachers and teacher educators supported 124 of the 184 physics statements. The supported statements and major content areas from both surveys should be used to construct test specifications to measure content knowledge for physics and chemistry teachers. Eight appendixes include the surveys and supplemental information about responses and methodology. Twelve tables present study findings. (Contains nine references.) (SLD)

THE PRAXIS SERIES
Professional Assessments for Beginning Teachers™

Job Analyses of the Knowledge Important for Newly Licensed (Certified) Chemistry and Physics Teachers

Richard J. Tannenbaum

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Educational Testing Service

Job Analyses of the Knowledge Important for Newly Licensed (Certified) Chemistry and Physics Teachers

by

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Division of Applied Measurement Research

Educational Testing Service

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Job Analyses of the Knowledge Important
For Newly Licensed (Certified) Chemistry and Physics Teachers

Richard J. Tannenbaum

Executive Summery

Two job analysis studies were conducted to define knowledge domains important for newly licensed (certified) chemistry and physics teachers, respectively, to perform their jobs in a competent manner. The results of the job analyses will be used to develop test specifications for the Praxis II Subject Assessments in Chemistry and Physics.

Initial draft domains of important knowledge statements were constructed by ETS Test Development staff with expertise in chemistry and physics and ETS Research staff with expertise in job analysis. In the process of developing these drafts, the ETS subject-matter experts reviewed previous National Teacher Examination (NTE) chemistry and physics test specifications, state licensure (certification) requirements, and relevant professional literature.

The draft domain for chemistry consisted of eight major content areas partitioned into various subareas and 162 specific knowledge statements. The eight major content areas were: (1) **Chemistry as an Experimental Science**, (2) **Organization of Matter**, (3) **Chemical Bonding and Molecular Geometry**, (4) **The Kinetic Theory and States of Matter**, (5) **Thermodynamics and Chemical Reactions**, (6) **Solutions and Solubility**, (7) **Environmental/Societal Issues Related to Chemistry**, and (8) **Pedagogy Specific to Chemistry**.

The draft domain for physics consisted of nine major content areas also partitioned into various subareas and 160 specific knowledge statements. The nine major content areas were: (1) **Properties and States of Matter**, (2) **Mechanics**, (3) **Heat and Thermodynamics**, (4) **Electricity and Magnetism**, () **Wave Motion**, (6) **Atomic and Nuclear Physics**, (7) **Environmental/Societal Issues Related to Physics**, (8) **Mathematical and Measurement Skills**, and (9) **Pedagogy Specific to Physics**.

After the draft domains were constructed each was mailed to a different panel of nine external subject-matter experts (one panel with content expertise in chemistry received the chemistry domain and the other with content expertise in physics received the physics domain). These subject-matter experts were secondary school teachers and teacher educators. The purpose of each External Review Panel was to review the draft domain in terms of: (1) the appropriateness of the overall structure (i.e., do the major content areas adequately define the important components of the knowledge domain) and (2) the appropriateness of the specific knowledge statements and their completeness and clarity. Revisions suggested by the panels, including additions and deletions of content areas and knowledge statements, were obtained via telephone interviews conducted by ETS Research staff. Based upon the compiled suggestions some reorganization of the domains occurred.

The structure of the chemistry domain was modified to include eight new major content areas partitioned into various subareas and 156 specific knowledge statements. The eight new major content areas were: (1) **Scientific Methodology/Technology/History** (which incorporated content from the original area **Chemistry as an Experimental Science**); (2) **Basic Topics in Physical Science** (which included content from the original areas **Organization of Matter; Kinetic Theory and States of Matter**; and **Thermodynamics and Chemical Bonding Reactions**); (3) **Chemical Periodicity**; (4) **Nomenclature**; (5) **The Mole, Chemical Bonding, and Molecular Geometry**; (6) **Biochemistry**; (7) **Science, Technology, and Society** (which included the content from the original area **Environmental/Societal Issues Related to Chemistry**); and (8) **Pedagogy Specific to the Physical Sciences**.

The structure of the physics domain was modified to include eight new major content areas partitioned into various subareas and 160 specific knowledge statements. The eight new major content areas were: (1) **Scientific Methodology/Technology/History** (which included content that originally was part of the area **Mathematical and Measurement Skills**); (2) **Basic Topics in Physical Science** (which incorporated content from the original areas **Properties and States of Matter** and **Heat and Thermodynamics**); (3) **Mechanics**; (4) **Electricity and Magnetism**; (5) **Waves**; (6) **Modern Physics** (which incorporated the original area **Atomic and Nuclear Physics**); (7) **Science, Technology, and Society** (which included the content from the original area **Environmental/Societal Issues Related to Physics**); and (8) **Pedagogy Specific to the Physical Sciences**.

The revised draft domains were then reviewed by an Advisory/Test Development Committee. This committee consisted of secondary school teachers, teacher educators, and a district administrator with expertise in both chemistry and physics. One committee was formed because of the large degree of overlap in the knowledge domains of chemistry and physics. The purpose of this committee was to modify the draft domains so that they accurately reflected what the members of the committee believed were the knowledge important for new licensed (certified) chemistry and physics teachers. This modification process occurred during a four-day meeting held at ETS. The outcomes of the modification included only minor wording changes and the additional deletion of some knowledge statements.

The revised domains were then subject to verification/refutation through national surveys of chemistry and physics education professionals (i.e., teachers, teacher educators, and state administrators). The chemistry education professionals received the chemistry knowledge domain; and the physics education professionals received the physics knowledge domain. The participants were asked to rate the specific knowledge statements in terms o *importance* for and *level of understanding* needed by newly licensed (certified) chemistry and physics teachers.

Three types of data analysis were conducted to support the development of content valid (content relevant) test specifications for the Subject Assessments in chemistry and physics: (1) means were computed of the importance ratings for each knowledge statement by the groups of education professionals and by the appropriate subgroups of respondents; (2) correlations of the profiles of these mean importance ratings were computed across the groups of education professionals and within the appropriate subgroups of respondents; and (3) percents were

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computed across each of the five response categories associated with the level of understanding rating scale for each knowledge statement. These percents were computed at the aggregate level of the survey respondents to provide more easily interpretable, and therefore, useful information to the Advisory/Test Development Committee. To be included in the mean and correlational analyses, a respondent category was required to have at least 30 respondents (e.g., ≥ 30 state administrators, ≥ 30 females). This is a necessary condition to ensure that the computed mean values are accurate estimates of the corresponding population mean values (Walpole, 1974).

A mean importance rating cutpoint of 2.50 (midpoint between moderately important and important) was established to designate knowledge statements as eligible (≥ 2.50) or ineligible (< 2.50) for inclusion in the development of test specification.

Study 1: Chemistry

The results of the mean analysis conducted by teachers and teacher educators (there were no respondents identified as state administrators) indicated 60 knowledge statements were rated less than 2.50. This represents 33% of the content domain. Five additional knowledge statements were rated below 2.50 by two of the subgroups (geographic region and teaching experience) of respondents. **In total, 65 of the 181 statements (36%) did not meet the 2.50 criterion for inclusion. Still, however, 64% of the domain (116 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements indicated a very high level of agreement. The coefficient for the comparison between teachers and teacher educators was .92; the coefficients for the subgroup comparisons all exceeded .90.

The 116 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of chemistry teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Advisory/Test Development Committee in its decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

The results of the analysis of the level of understanding rating scale indicated that 40% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 48% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of judged importance of the eight major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the chemistry knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined knowledge domain. With respect to importance (see Table 1), both teachers and teacher educators judged the same four content areas to be important and one or the other group judged the remaining content areas to be moderately important or important. With respect to content coverage (see Table 5), the teachers judged six content areas to be well covered and two to be between adequately covered and well covered. The teacher educators judged two content areas to be well covered and six to be between adequately covered and well covered.

Study 2: Physics

The results of the mean analysis conducted by teachers and teacher educators (there were no respondents identified as state administrators) indicated 56 knowledge statements were rated less than 2.50. This represents 30% of the knowledge domain. Four additional knowledge statements were rated below 2.50 by two of the subgroups (sex and teaching experience) of respondents. **In total, 60 of the 184 statements (33%) did not meet the 2.50 criterion for inclusion. Still, however, 67% of the domain (124 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements indicated a very high level of agreement. The coefficient for the comparison between teachers and teacher educators was .91; the coefficients for the subgroup comparisons all exceeded .90.

The 124 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of physics teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Advisory/Test Development Committee in its decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

The results of the analysis of the level of understanding rating scale indicated that 58% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 48% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of the judged importance of the eight major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the physics knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined content domain. With respect to importance (see Table 7), both teachers and teacher educators judged the same five content areas to be important. Of the remaining three content areas, one was judged to be important by the teacher educators and moderately important by the teachers; and two were judged to be moderately important by both teachers and teacher educators. With respect to content coverage (see Table 11), both teachers and teacher educators judged all eight content areas to be well covered.

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for Newly Licensed (Certified) Chemistry and Physics Teachers

Introduction

The Subject Assessments in the Sciences of The Praxis Series: Professional Assessments for Beginning Teachers™ offer a multiple-choice core test and one or more candidate-constructed-response modules. The optional modules include Content Area Performance Assessments that allow candidates to demonstrate in-depth understanding of the subject and Content-Specific Pedagogy modules to demonstrate knowledge about teaching the subject. The Praxis Series can be used by state agencies as one of several criteria for initial teacher licensure (certification). Two of the Subject Assessments in the Sciences cover the physical sciences of chemistry and physics. To identify the content domains of these examinations and to support the content validity (content relevance) of these examinations, two job analysis studies were conducted of the knowledge important for newly licensed (certified) chemistry and physics teachers, respectively. This report will describe the job analysis studies. In particular, it will present the (1) methods used to identify and define the job-related knowledge, (2) types of statistical analysis conducted, (3) results of these analyses, and (4) implications of the results for developing test specifications.

Standards for Educational and Psychological Testing

The *Standards for Educational and Psychological Testing* (1985) is a comprehensive technical guide that provides criteria for the evaluation of tests, testing practices, and the effects of test use. It was developed jointly by the American Psychological Association (APA), the American Educational Research Association (AERA), and the National Council on Measurement in Education (NCME). The guidelines presented in the *Standards* have, by professional consensus, come to define the necessary components of quality testing. As a consequence, a testing program that adheres to the *Standards* is more likely to be judged to be valid (defensible) than one that does not.

There are two categories of criteria within the *Standards*, primary and secondary. Those classified as primary "should be met by all tests . . . unless a sound professional reason is available to show why it is not necessary, or technically feasible, to do so in a particular case. Test developers and users . . . are expected to be able to explain why any primary standards have not been met" (AERA/APA/NCME, 1985, p. 2). One of the primary standards is that the content domain of a licensure or certification test should be defined in terms of the importance of the content for competent performance in an occupation. "Job analyses provide the primary basis for defining the content domain." (p. 64).

The use of job analysis to define the content domain is a critical component in establishing the content validity of licensure and certification examinations. Content validity is the principle validation strategy used for these examinations. It refers to the extent to which the content covered by an examination overlaps with the important components (tasks, knowledge, skills, or abilities) of a job (Arvey & Faley, 1988). Demonstration of content validity is accomplished through the judgments of subject-matter experts. It is enhanced by the inclusion of large numbers of subject-matter experts who represent the wide range of relevant areas of expertise (Ghiselli, Campbell, & Zedeck, 1981). The lack of a well-designed job analysis is frequently cited (by the courts) as a major cause of test invalidity.

Job Analysis

Job analysis refers to procedures designed to obtain descriptive information about the tasks performed on a job and/or the knowledge, skills, and abilities thought necessary to perform those tasks (Gael, 1983). The specific type of job information collected by a job analysis is determined by the purpose for which the information will be used. For purposes of developing licensure and certification examinations, a job analysis should identify the important knowledge or abilities necessary to protect the public -- interpreted as the importance of the content for competent performance in an occupation (*Standards for Educational and Psychological Testing*, AERA/APA/NCME, 1985). In addition, a well-designed job analysis should include the participation of various subject-matter experts (Mehrens, 1987); and the data collected should be representative of the diversity within the job. Diversity refers to regional or job context factors and to subject-matter-expert factors such as race/ethnicity, experience, and sex (Kuehn, Stallings, & Holland, 1990). The job analyses conducted for chemistry and physics were designed to be consistent with the *Standards* and current professional practices.

Objectives of the Job Analysis Studies

The objectives of these studies were: (1) to construct comprehensive domains of knowledge that are important for newly licensed (certified) chemistry and physics teachers; and then (2) to obtain, using survey methodology, the independent judgments of two national samples of chemistry and physics educational professionals (i.e., teachers, teacher educators, state administrators) to verify or refute the importance of the domains. The verification/refutation component serves a critical role to ensure that the domains (in whole or in part) are judged to be relevant to the job of newly licensed (certified) chemistry and physics teachers by a wide range of education professionals. Knowledge that is verified to be important will be used in the development of test specifications for The Praxis II Subject Assessments in the Sciences.

Method

In overview, the methodology consisted of defining the knowledge important for newly licensed (certified) chemistry and physics teachers to perform their jobs in a competent manner. This was accomplished first by having subject-matter experts define knowledge domains important for newly licensed (certified) chemistry and physics teachers and then by presenting these judgments for verification or refutation through national surveys of chemistry and physics education professionals. The chemistry education professionals received the chemistry knowledge domain; and the physics education professionals received the physics knowledge domain. The verification/refutation aspect of the survey approach functions as a "check and balance" on the judgments of the subject-matter experts and reduces the likelihood that unimportant knowledge will be included in the development of the test specifications. The survey participants were chemistry and physics teachers, teacher educators, and state administrators whose names were obtained from the memberships of the (1) American Chemical Society, (2) American Association of Physics Teachers, and (3) National Science Teachers Association. The participants were asked to rate specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) chemistry and physics teachers to perform their jobs in a competent manner. The specific steps in the job analyses are described below.

Build Draft Domains of Knowledge

The first step in the process of conducting the job analyses was to construct preliminary knowledge domains. These drafts would function as the initial definition of the knowledge domains of newly licensed (certified) chemistry and physics teachers. The domains were constructed by Educational Testing Service (ETS) Test Development staff with subject-matter expertise in chemistry and physics and ETS Research staff with expertise in job analysis. In the process of developing these drafts, the ETS subject-matter experts reviewed previous National Teacher Examination (NTE) chemistry and physics test specifications, state licensure (certification) requirements, and relevant professional literature.

The draft domain for chemistry consisted of eight major content areas partitioned into various subareas and 162 specific knowledge statements. The eight major content areas were: (1) **Chemistry as an Experimental Science**, (2) **Organization of Matter**, (3) **Chemical Bonding and Molecular Geometry**, (4) **The Kinetic Theory and States of Matter**, (5) **Thermodynamics and Chemical Reactions**, (6) **Solutions and Solubility**, (7) **Environmental/Societal Issues Related to Chemistry**, and (8) **Pedagogy Specific to Chemistry**.

The draft domain for physics consisted of nine major content areas also partitioned into various subareas and 160 specific knowledge statements. The nine major content areas were: (1) **Properties and States of Matter**, (2) **Mechanics**, (3) **Heat and Thermodynamics**, (4) **Electricity and Magnetism**, (5) **Wave Motion**, (6) **Atomic and Nuclear Physics**, (7) **Environmental/Societal Issues Related to Physics**, (8) **Mathematical and Measurement Skills**, and (9) **Pedagogy Specific to Physics**.

Review of Draft Domains by External Review Panels

After the draft domains were constructed each was mailed to a different panel of nine external subject-matter experts (one panel with content expertise in chemistry received the chemistry domain and the other with content expertise in physics received the physics domain). These subject-matter experts were secondary school teachers and teacher educators and had representation by sex and geographic region (see Appendix A for list of members). The purpose of each External Review Panel was to review the draft domain in terms of: (1) the appropriateness of the overall structure (i.e., do the major content areas adequately define the important components of the knowledge domain) and (2) the appropriateness of the specific knowledge statements and their completeness and clarity. In addition, the members of the panels were asked to identify other knowledge that they believed should be added to the domain. The recommendations of the panels were obtained via telephone interviews conducted by ETS Research staff. ETS Test Development staff then reviewed the compiled recommendations of the panels. Based upon the suggested revisions of the panels and Test Development staff's re-evaluation of the domains, some reorganization occurred.

The structure of the chemistry domain was modified to include eight new major content areas partitioned into various subareas and 156 specific knowledge statements. The eight new major content areas were: (1) **Scientific Methodology/Technology/History** (which incorporated content from the original area **Chemistry as an Experimental Science**); (2) **Basic Topics in Physical Science** (which included content from the original areas **Organization of Matter; Kinetic Theory and States of Matter**; and **Thermodynamics and Chemical Bonding Reactions**); (3) **Chemical Periodicity**; (4) **Nomenclature**; (5) **The Mole, Chemical Bonding, and Molecular Geometry**; (6) **Biochemistry**; (7) **Science, Technology, and Society** (which included the content from the original area **Environmental/Societal Issues Related to Chemistry**); and (8) **Pedagogy Specific to the Physical Sciences.**

The structure of the physics domain was modified to include eight new major content areas partitioned into various subareas and 160 specific knowledge statements. The eight new major content areas were: (1) **Scientific Methodology/Technology/History** (which included content that originally was part of the area **Mathematical and Measurement Skills**); (2) **Basic Topics in Physical Science** (which incorporated content from the original areas **Properties and States of Matter** and **Heat and Thermodynamics**); (3) **Mechanics**; (4) **Electricity and Magnetism**; (5) **Waves**; (6) **Modern Physics** (which incorporated the original area **Atomic and Nuclear Physics**); (7) **Science, Technology, and Society** (which included the content from the original area **Environmental/Societal Issues Related to Physics**); and (8) **Pedagogy Specific to the Physical Sciences.**

Advisory/Test Development Committee Meeting

Consistent with a content validity framework, the job analysis studies were designed to obtain input from many subject-matter experts at several critical points in the domain definition process. To this end, an Advisory/Test Development Committee of secondary school teachers (n=5), teacher educators (n=2), and a district administrator was formed (see Appendix B for list of members). This committee also had representation by race/ethnicity, sex, and geographic region. One committee was formed because of the large degree of overlap in the knowledge domains of chemistry and physics. The committee members, appropriately, had relevant expertise in both chemistry and physics. The purpose of this committee was to review the draft domains (both chemistry and physics) in terms of their overall structures, completeness, appropriateness of the knowledge statements and clarity of wording. In addition, the members were asked to identify other content areas and knowledge statements that they believed should be added to the domains and to delete content areas and knowledge statements that they believed should not be included in the domains. In essence, the members were asked to modify the domains so that they accurately reflected what the committee believed were the knowledge important for newly licensed (certified) chemistry and physics teachers. The committee also reviewed and approved the rating scales for the national surveys and the biographical data that would be asked of the survey participants. The biographical data were collected to describe the composition of those who returned completed surveys and to permit analysis of the survey responses by various subgroups of respondents (e.g., males and females).

The revision process occurred during a four-day meeting held at ETS. The meeting was led jointly by ETS Test Development and Research staff. (Prior to the meeting, the members of the committee were mailed copies of both draft domains to review. They were informed about the purpose of the meeting and asked to come prepared to discuss their reviews of the draft domains.) During the course of the meeting, the domains were revised to reflect the consensus of the committee. This resulted in minor wording changes and the addition and deletion of some knowledge statements. However, no significant changes occurred in the structure of either domain.

Pilot Test of the Job Analysis Surveys

Prior to the national administrations, the job analysis surveys were mailed to a small group of chemistry and physics secondary school teachers and teacher educators. These pilot participants were asked to review either the chemistry or physics survey for clarity of wording and instruction, ease of use, and comprehensiveness of content coverage. They were asked to make their comments on a questionnaire that accompanied the survey and to mail the questionnaire and survey back to ETS in a postage-paid envelope. No significant revisions were suggested by the pilot participants.

Final Format of the Job Analysis Surveys

The finalized job analysis surveys (see Appendix C for copies of the surveys) consisted of three parts. Part I of each survey included the content areas and specific knowledge statements. Space was also provided for respondents to add knowledge statements that they believed should be included in the domain. In addition, the respondents were asked to rate, using a 5-point scale, how well the knowledge statements within a major content area covered the important aspects of that major content area. This provides an indication of content coverage. The eight major content areas that defined the chemistry domain included 181 specific knowledge statements and eight overall content area importance statements. The eight major content areas that defined the physics domain included 184 specific knowledge statements and eight overall content area importance statements. The knowledge statements were judged using two rating scales. (The same rating scales were used in each survey, except for the substitution of the terms chemistry and physics. For illustrative purposes, the scales for chemistry are presented below.) One was an importance scale:

How important is an understanding of this knowledge area for newly licensed (certified) chemistry teachers if they are to perform their jobs in a competent manner?

(0) *Of no importance*
(1) *Of little importance*
(2) *Moderately important*
(3) *Important*
(4) *Very important*

This scale is consistent with the *Standards* emphasis on identifying a content domain that is important for competent job performance. The other scale addressed the level of understanding needed for competent job performance:

What level of understanding is typically needed by newly licensed (certified) chemistry teachers in each knowledge area?

(0) *An understanding of the content area is not needed*
(1) *Requires the ability to define the terms used in the knowledge area*
(2) *Requires the ability to comprehend the essential properties of the knowledge area*
(3) *Requires the ability to apply/utilize the knowledge area to address problems or questions*
(4) *Requires the ability to analyze the knowledge area into component parts and explain the interrelationships among the parts*

This rating scale was designed to provide Test Development staff, responsible for developing test specifications, with information that may assist in their decisions about the level of cognitive complexity that should be represented on the specifications. Both of these rating scales were reviewed and approved by the Advisory/Test Development Committee.

Part II of each survey asked the participants to indicate the relative weight that each of the major content areas should receive on the examination. This was accomplished by their distributing 100 total points across the major content areas. These point distributions were easily converted into percentages, representing the percent of items that the survey respondents believed should be devoted to each area.

Part III of each survey was the background information section. The survey participants were asked to respond to several questions that described their demographic makeup (e.g., teaching experience, age, sex, race/ethnicity). This information was used to describe the survey respondents and to perform relevant subgroup analyses.

Administration of the Job Analysis Surveys

Each of the job analysis surveys, accompanied by a letter of invitation to participate (see Appendix D for copies of the letters), was mailed to 800 education professionals. The chemistry survey was mailed to 500 chemistry teachers (10 per state), 250 teacher educators (5 per state), and 50 administrators (1 per state). These individuals were randomly selected from the memberships of the American Chemical Society and the National Science Teachers Association. The physics survey also was mailed to 800 education professionals in the same proportions as the chemistry survey. These individuals were randomly selected from the memberships of the American Association of Physics Teachers and the National Science Teachers Association. Approximately one week after the surveys were mailed, a follow-up postcard was mailed to the participants reminding them to complete and return the surveys.

The purpose of the survey administrations was to identify a core of knowledge statements that relatively large numbers of education professionals judged to be relevant (verified to be important) to newly licensed (certified) chemistry and physics teachers. The latter objective is accomplished by analyzing the mean importance ratings provided by the three groups of education professionals and by the appropriate subgroups of respondents. Knowledge statements that are judged to be important by **all** respondent groups and subgroups (within chemistry and physics) define the respective cores. Each core becomes the primary database for the development of test specifications. The derivation of test specifications from those knowledge statements verified to be important by the surveyed education professionals provides a substantial evidential basis for the content validity (content relevance) of the Subject Assessments in Chemistry and Physics.

Results

Data Analyses of Survey Responses

Three types of data analysis were conducted to support the development of content valid (content relevant) test specifications for the Subject Assessments in Chemistry and Physics: (1) means were computed of the importance ratings for each knowledge statement by the groups of education professionals and by the appropriate subgroups of respondents; (2) correlations of the profiles of these mean importance ratings were computed across the groups of education professionals and within the appropriate subgroups of respondents; and (3) percents were computed across each of the five response categories associated with the level of understanding rating scale for each knowledge statement. These percents were computed at the aggregate level of the survey respondents to provide more easily interpretable, and therefore, useful information to the Advisory/Test Development Committee. To be included in the mean and correlational analyses, a respondent category was required to have at least 30 respondents (e.g., $\geq$ 30 state administrators, $\geq$ 30 females). This is a necessary condition to ensure that the computed mean values are accurate estimates of the corresponding population mean values (Walpole, 1974).

Means. The mean analysis is used to determine the level (absolute value) of importance attributed to the knowledge statements by teachers, teacher educators and state administrators, and by appropriate subgroups of respondents (sex, race/ethnicity, geographic region, teaching experience). Knowledge statements that meet or exceed a mean importance value of 2.50 (to be discussed in a later section) by **all groups of education professionals** (teachers, teacher educators, and state administrators) and by **all subgroups of respondents** may be included in the development of the test specifications. In addition, mean ratings were computed for the responses to the content coverage section and the recommendation for test content section of each job analysis survey.

Correlations. The correlational analysis is used to determine the extent of agreement among the groups of education professionals and within the subgroups of respondents about the relative importance of the knowledge statements. Relative importance refers to the similarity of the pattern of mean ratings generated by the different respondent groups. For example, the profile of 181 mean ratings for chemistry teachers is correlated with the profile of 181 mean ratings for teacher educators. If these two profiles are similar (the shapes of the profiles are complementary), the value of the correlation coefficient will be close to 1.00.

Percents. The percent analysis may be used by test development committees to guide their decisions about the level of cognitive complexity that should be represented on the examinations. By inspecting where among the five response categories the largest percentages are located, test developers may, more accurately, be able to construct examination items at an appropriate cognitive level for beginning (newly licensed or certified) chemistry and physics teachers.

Criterion for Interpretation of Mean Importance Ratings

Since the purpose of job analysis is to ensure that only the more important knowledge statements are included in the development of test specifications, a criterion (cutpoint) for inclusion needs to be established. A reasonable criterion that has been used in a similar job analysis study (Rosenfeld & Tannenbaum, 1991) is a mean importance rating that represents the midpoint between moderately important and the next higher scale value. For the importance rating scales used in the present job analysis studies, the value of this criterion is 2.50 (midpoint between moderately important and important). It is believed that this criterion is consistent with the intent of content validity, which is to include important knowledge and to exclude unimportant knowledge from the assessment measures. Therefore, knowledge statements that receive a mean importance rating of 2.50 or more may be considered eligible for inclusion in the development of test specifications; knowledge statements that receive a mean rating of less than 2.50 may not be considered for inclusion. (However, because survey participants were not involved in the development of the content domains, they may lack certain insights that the Advisory/Test Development Committee members have due to their high level of involvement in the definition of the domains. As a consequence, if the committee believes that a knowledge statement rated below 2.50 should be included in the specifications and the committee can provide *compelling written rationales*, that knowledge statement may be reinstated for inclusion in the test specifications.)

Study 1: Chemistry

Survey Respondents

Response rate. Of the 800 total surveys that were mailed, eight were returned due to an invalid mailing address. Thus, 792 surveys were actually administered. Of these 792, 329 were returned. This represents an overall response rate of 42% (329/792).

Demographic characteristics. Sixty percent of the respondents were between the ages of 35 years and 54 years. Sixty-eight percent were males and 32% were females. The majority of respondents (92%) were White. Most (59%) had 11 or more years of teaching experience in chemistry. Fifty-five percent identified themselves as either regular teachers (not substitutes) or permanent substitutes; 26% identified themselves as college faculty; none of the respondents identified themselves as a state administrator. Twenty-one percent of the respondents were from the Northeast region of the country; 29% were from the Central region; 23% were from the Southern region; and 27% were from the Far West region. A complete breakdown of the demographic characteristics of the respondents is provided in Appendix E.

Results of Data Analyses: Teachers and Teacher Educators

Mean importance. The mean importance rating for each of the 181 knowledge statements is provided in Appendix F. The means are presented for (1) teachers (regular and permanent substitutes, n=175) and (2) teacher educators (n=81). Because none of the respondents identified himself/herself as a state administrator, this demographic group was not included in the analysis. Inspection of these distributions of mean ratings indicated that teachers rated 51% of the knowledge statements (n=92) 3.00 (important) or higher; teacher educators rated 29% of the knowledge statements (n=52) 3.00 or higher. A comparison of the means across the two groups indicated that teachers rated 158 knowledge statements (87%) higher than did teacher educators.

The overall mean importance ratings for the eight major content areas were also computed for teachers and teacher educators. The means are presented in Table 1. Four content areas, **Scientific Methodology/Techniques/History; Basic Topics in Physical Science; Chemical Periodicity;** and **The Mole, Chemical Bonding, and Molecular Geometry**, were judged to be important (scale vale of 3.00) by both groups of respondents. The other four content areas, **Nomenclature; Biochemistry; Science, Technology, and Society**; and **Pedagogy Specific to the Physical Sciences**, were judged to be moderately important (scale value of 2.00) or important by either teachers or teacher educators.

Table 1
Overall Mean Importance Ratings for Each of the Eight Major Knowledge Areas by Teachers and Teacher Educators

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	3.33	3.22
Basic Topics in Physical Science	3.30	3.19
Chemical Periodicity	3.52	3.22
Nomenclature	3.09	2.82
The Mole, Chemical Bonding, and Molecular Geometry	3.56	3.41
Biochemistry	2.19	2.40
Science, Technology, and Society	2.75	2.49
Pedagogy Specific to the Physical Sciences	3.11	2.79

As previously discussed, knowledge statements that receive a mean importance rating of less than 2.50 (midpoint between moderately important and important) may not be considered for inclusion in the development of test specifications, unless a *compelling written rationale* is provided by the Advisory/Test Development Committee for their reinstatement. Those knowledge statements rated less than 2.50 by the teachers and/or teacher educators are presented in Table 2. Of the 181 individual knowledge statements, 60 (33%) were rated below 2.50; and of these 60 statements, almost half (48%) were rated below 2.50 only by the teacher educators.

<u>Correlation of the profiles of mean importance ratings</u>. The profiles of mean importance ratings for the teachers and teacher educators were correlated. The value of the correlation coefficient was .92. This indicates that there is a very high level of agreement between the two respondent groups in terms of the relative importance of the knowledge statements.

Table 2
Knowledge Statements Rated Below 2.50 by Teachers and/or Teacher Educators

	TEACHERS N = 175	TEACHER EDUCATORS N = 81
	Mean	Mean
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY		
History and Philosophy of Science		
5. Historical roots of science	2.26	2.23
6. Contributions of individuals	2.18	2.10
7. Contributions of ethnic groups and cultures	1.73	1.27
Mathematics, Measurement, and Date Manipulation		
15. Statistics of distributions	2.01	1.99
16. Simple digital (binary) logic	1.56	1.57
18. Differentiation and simple integration	1.53	1.81
B. BASIC TOPICS IN PHYSICAL SCIENCE		
Heat and Thermodynamics		
33. Historical development of heat and energy	1.92	1.82
35. Brownian motion	2.28	2.01
38. Conduction, convection, and radiation	2.42	2.26
42. Expansion and contraction		2.14
46. Third law of thermodynamics (i.e., the concept of absolute zero temperature)		2.46
Atomic and Nuclear Structure		
48. Historical discovery of particles (e.g., electron, neutron)		2.12
49. Atomic models and their experimental bases (Thomson, Rutherford, and Bohr)		2.43
52. deBroglie's hypothesis	2.46	2.31
53. Heisenberg uncertainty principle		2.30
54. Schrödinger's wave equation	2.14	1.78
63. Nuclear forces and binding energy		2.19
64. Mass/energy transformation		2.20
65. Types of radioactive decay (e.g., alpha, beta, gamma emission)		2.46
66. Artificial and natural radioactivity	2.49	2.21
67. Half-life of radioactive isotopes		2.31
68. Nuclear reactions (transmutations, fission, fusion)		2.30

Table 2 (cont.)

	TEACHERS N = 175	TEACHER EDUCATORS N = 81
	Mean	Mean
C. CHEMICAL PERIODICITY		
71. The development of the periodic table		2.41
73. Trends in melting and boiling temperatures		2.29
D. NOMENCLATURE		
82. Nomenclature of the classes or organic compounds (e.g., aldehydes, ketones)	2.49	2.49
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY		
98. Hybrid orbitals	2.46	2.46
99. Resonance and delocalization	2.27	2.43
The Kinetic Theory and States of Matter		
101. Maxwell-Blotzmann velocity distributions	2.00	2.01
102. Diffusion of gases		2.47
105. Real *versus* ideal gases		2.46
110. Rel. among phases of matter, forces between particles and particle energy		2.33
111. Characteristics of crystals	2.22	1.94
Chemical Reactions		
116. Spontaneity in chemical reactions (e.g., entropy, Gibbs-Helmholtz equation)		2.48
117. Collision theory and reaction rates		2.29
120. Rate expressions and orders of reactions	2.48	2.25
121. Reaction mechanisms	2.40	2.03
124. Properties and production of ammonia (e.g., the Haber equilibrium)	2.11	1.71
127. Metallurgical properties of the transition metals	1.97	1.63
128. Redox properties of the halogens and the halide ions	2.28	2.14
129. Faraday's laws of electrolysis	2.27	2.33
Solutions and Solubility		
131. Types of solutions (e.g., solid-solid, solid-liquid, liquid-gas)		2.48
135. Solubility product (K_{sp})		2.48
144. Production, properties, and use of the common acids (e.g., sulfuric,)	2.29	2.26

Table 2 (cont.)

	TEACHERS N = 175	TEACHER EDUCATORS N = 81
	Mean	Mean
F. BIOCHEMISTRY		
150. Monomers and polymers	2.37	
151. Biologically important compounds (e.g., sugar, carbohydrates, proteins)	2.49	
152. Biologically important chemical processes (e.g., bioluminescence)	2.28	2.32
153. Structure and replication of nucleic acids	2.04	2.19
154. Energy storage and release in biological systems	2.09	2.09
G. SCIENCE, TECHNOLOGY, AND SOCIETY		
160. Risk mgmt issues associated with energy production, transmission, and use		2.28
161. Risk mgmt issues assoc. with production/storage/use/disposal of products		2.45
162. Waste management issues and recycling		2.46
163. Management of resources (e.g., soil, water, metals, and fossil fuels)		2.46
164. Use of science and technology to predict and prepare for natural disasters	2.31	1.77
166. Technology transfer (e.g., spin-offs from space technology,)	2.41	1.89
167. Issues assoc. with use of chem. in agriculture/food preparation/preservation		2.41
168. Social, political, and economic issues arising from science and technology		2.31
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES		
171. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences		2.43
Curriculum: Organization and Materials		
177. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence		2.49
178. Lesson plans in the physical sciences curricula for all students, justification for the plans		2.30
180. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences		2.21

Percents. The percent of responses for each of the five categories associated with the level of understanding rating scale was computed for the aggregate of the chemistry survey respondents. This analysis provides some overall guidance with respect to the level of cognitive complexity that should be represented on the Subject Assessment in Chemistry. The percents are displayed in Appendix G. Inspection of these percent distributions indicates that for 88 knowledge statements the two highest percentages were between levels 2 (*comprehension*) and 3 (*application/utilization*); and for 86 knowledge statements the two highest percentages were between levels 3 and 4 (*analysis*).

Results of Data Analyses: Subgroups of Respondents

Mean importance. A significant contribution towards the accumulation of evidence in support of the job-relevance of the Subject Assessment in Chemistry is the verification of the importance of the knowledge statements by a wide range of chemistry education professionals. Therefore, mean importance ratings for each knowledge statement were computed for the following subgroups of respondents: (1) geographic region (Northeast, n=70; Central, n=94; Southern, n=76; Far West, n=87); (2) sex (female, n=105; male, n=222); and (3) teaching experience[1] (≤ 5 years, n=33; > 5 years, n=141). The means are presented in Appendix H. An analysis of importance ratings by geographic region is consistent with recent legal emphasis on addressing regional job variability when conducting job analysis for content domain specification purposes (Kuehn et al., 1990). The four geographic regions included for analysis are consistent with the categorization established by the National Association of State Directors of Teacher Education and Certification (NASDTEC). Sex was included because it represents a protected "class" under Title VII of the Civil Rights ACT of 1964. (Race/ethnicity was not included in the subgroup analyses because of the insufficient number of minority respondents, i.e., < 30.) The dichotomous breakdown of teaching experience at the five-year point was chosen so that the judgments of less experienced teachers will be represented and so that the judgments of more experienced teachers will be represented.

The results of the subgroup analysis indicated that five additional knowledge statements (i.e., beyond the 60 statements previously identified by the mean analysis conducted on the teachers and teacher educators) were judged to be below the 2.50 cutpoint. The five statements are presented in Table 3. Three knowledge statements were rated below the cutpoint only by teachers with five or less years of teaching experience; and two knowledge statements were rated below the cutpoint only by respondents from the Central region of the country.

Correlations of the profiles of mean importance ratings. Correlation coefficients were computed for the profiles of mean importance ratings for the same subgroups used in the mean analysis. The coefficients are presented in Table 4. All the values exceeded .90. This indicates that there is a very high level of agreement within the subgroups of respondents in terms of the relative importance of the knowledge statements.

[1] Teaching experience includes only those respondents who had identified themselves as regular teachers or permanent substitutes.

Table 3
Knowledge Statements Rated Below 2.50 by Geographic Region, Sex, and Teaching Experience

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
B. BASIC TOPICS IN PHYSICAL SCIENCE								
51 Planck's hypothesis		2.33						
58 Spectroscopy		2.48						
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY								
96 Simple structures of isomers							2.42	
139 Colligative properties of solutions							2.45	
F. BIOCHEMISTRY								
149 Organic functional groups and their reactions							2.45	

Table 4
Correlations of the Profiles of Mean Importance Ratings by Geographic Region, Sex, and Teaching Experience

	1	2	3	4
GEOGRAPHIC REGION				
1. Northeast		.97	.97	.97
2. Central			.98	.97
3. Southern				.97
4. Far West				
SEX				
1. Female		.95		
2. Male				
TEACHING EXPERIENCE (years)				
1. ≤ 5		.94		
2. > 5				

Mean Ratings of Content Coverage

The survey participants were asked to rate, using a 5-point scale, how well the knowledge statements within a major content area covered the important aspects of that major content area. Responses to this provide an indication of the adequacy (comprehensiveness) of the domain of knowledge. The scale values ranged from a low of 1 (very poorly) to a high of 5 (very well); the midpoint of the scale was value 3 (adequately). The means of these ratings for teachers and teacher educators are presented in Table 5. For the teachers, all the means were close to or exceeded 4.00 (well covered). For the teacher educators, only two content areas, **Nomenclature** and **Biochemistry**, were judged to be a half unit or more below a mean value of 4.00 (both were judged to be more than adequately well covered). These results indicate that the content areas were judged, by both respondent groups, to be well covered.

Table 5
Mean Ratings of Content Coverage

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	4.16	3.88
Basic Topics in Physical Science	4.28	3.99
Chemical Periodicity	4.32	4.05
Nomenclature	3.83	3.50
The Mole, Chemical Bonding, and Molecular Geometry	4.38	4.14
Biochemistry	3.82	3.47
Science, Technology, and Society	4.16	3.65
Pedagogy Specific to the Physical Sciences	4.18	3.86

Mean Percentage Weights for Test Content Emphasis

The survey participants were asked to indicate the weight that each of the major content areas should receive on the Subject Assessment in Chemistry. This information may be used by the Advisory/Test Development Committee to assist in its decision about how much emphasis the content areas should receive on the test specifications. To obtain the weights, the participants were asked to distribute a total of 100 points across the major areas. The mean values were then converted into percentages. The mean percentage weights for teachers and teacher educators are presented in Table 6. For both groups, **The Mole, Chemical Bonding, and Molecular Geometry** and **Basic Topics in Physical Science** received the most emphasis; **Biochemistry**; **Science, Technology, and Society**; and **Pedagogy Specific to the Physical Sciences,** were among the least emphasized content areas.

Table 6
Mean Percentage Weights

Major Content Areas	Means: Teachers	Means: Teacher Educators
Scientific Methodology/Techniques/History	11.75	10.94
Basic Topics in Physical Science	18.25	20.21
Chemical Periodicity	14.08	13.49
Nomenclature	11.08	8.83
The Mole, Chemical Bonding, and Molecular Geometry	22.03	23.05
Biochemistry	5.81	8.15
Science, Technology, and Society	8.72	7.31
Pedagogy Specific to the Physical Sciences	8.32	8.21

Summary and Conclusion

A job analysis was conducted to define a knowledge domain important for newly licensed (certified) chemistry teachers to perform their jobs in a competent manner. The results of the job analysis will be used to develop test specifications for the Praxis II Subject Assessment in Chemistry.

An initial draft domain of important knowledge statements was constructed by ETS Test Development staff with expertise in chemistry and ETS Research staff with expertise in job analysis. This draft domain was reviewed by an External Review Panel of subject-matter experts and then revised accordingly. The revised draft was then reviewed, modified, and approved by an external Advisory/Test Development Committee. The revised knowledge domain was then subjected to verification/refutation through the use of a national survey of chemistry teachers, teacher educators, and state administrators. The survey participants were asked to rate specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) chemistry teachers. A mean importance cutpoint of 2.50 (midpoint between moderately important and important) was established to designate knowledge statements as eligible (≥ 2.50) or ineligible (< 2.50) for inclusion in the development of test specifications.

The results of the mean analysis conducted by teachers and teacher educators indicated 60 knowledge statements were rated less than 2.50 (see Table 2). This represents 33% of the content domain. Five additional knowledge statements were rated below 2.50 by two of the subgroups (geographic region and teaching experience) of respondents (see Table 3). **In total, 65 of the 181 statements (36%) did not meet the 2.50 criterion for inclusion. Still, however, 64% of the domain (116 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements indicated a very high level of agreement. The coefficient for the comparison between teachers and teacher educators was .92; the coefficients for the subgroup comparisons all exceeded .90.

The 116 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of chemistry teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Advisory/Test Development Committee in its decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

The results of the analysis of the level of understanding rating scale indicated that 49% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 48% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of judged importance of the eight major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the chemistry knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined knowledge domain. With respect to importance (see Table 1), both teachers and teacher educators judged the same four content areas to be important and one or the other group judged the remaining content areas to be moderately important or important. With respect to content coverage (see Table 5), the teachers judged six content areas to be well covered and two to be between adequately covered and well covered. The teacher educators judged two content areas to be well covered and six to be between adequately covered and well covered.

Study 2: Physics

Survey Respondents

Response rate. Of the 800 total surveys that were mailed, six were returned due to an invalid mailing address. Thus, 794 surveys were actually administered. Of these 794, 330 were returned. This represents an overall response rate of 42% (330/794).

Demographic characteristics. Seventy percent of the respondents were between the ages of 35 years and 54 years. Eighty-one percent were males and 18% were females. The majority of respondents (91%) were White. Most (67%) had 11 or more years of teaching experience in physics. Sixty percent identified themselves as either regular teachers (not substitutes) or permanent substitutes; 30% identified themselves as college faculty; none of the respondents identified themselves as a state administrator. Twenty-four percent of the respondents were from the Northeast region of the country; 29% were from the Central region; 25% were from the Southern region; and 22% were from the Far West region. A complete breakdown of the demographic characteristics of the respondents is provided in Appendix E.

Results of Data Analyses: Teachers and Teacher Educators

Mean importance. The mean importance rating for each of the 184 knowledge statements is provided in Appendix F. The means are presented for (1) teachers (regular and permanent substitutes, n=191) and (2) teacher educators (n=95). Because none of the respondents identified himself/herself as a state administrator, this demographic group was not included in the analysis. Inspection of these distributions of mean ratings indicated that teachers rated 44% of the knowledge statements (n=81) 3.00 (important) or higher; teacher educators rated 33% of the knowledge statements (n=60) 3.00 or higher. A comparison of the means across the two groups indicated that teachers rated 147 knowledge statements (80%) higher than did teacher educators.

The overall mean importance ratings for the eight major content areas were also computed for teachers and teacher educators. The means are presented in Table 7. Five content areas, **Scientific Methodology/Techniques/History; Basic Topics in Physical Science; Mechanics; Electricity and Magnetism**; and **Waves**, were judged to be important (scale value of 3.00) by both groups of respondents. The teacher educators also judged **Modern Physics** to be important. The other three content areas, **Modern Physics; Science Technology, and Society**, and **Pedagogy Specific to the Physical Sciences**, were judged to be within a half unit of a mean value of 3.00.

As previously discussed, knowledge statements that receive a mean importance rating of less than 2.50 (midpoint between moderately important and important) may not be considered for inclusion in the development of test specifications, unless a *compelling written rationale* is provided by the Advisory/Test Development Committee for their reinstatement. Those knowledge statements rated less than 2.50 by the teachers and/or teacher educators are presented in Table 8. Of the 184 individual knowledge statements, 56 (30%) were rated below 2.50; and of these 56 statements, almost half (43%) were rated below 2.50 only by the teacher educators.

Table 7
Overall Mean Importance Ratings for Each of the Eight Major Knowledge Areas by Teachers and Teacher Educators

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	3.16	3.10
Basic Topics in Physical Science	3.15	3.07
Mechanics	3.69	3.70
Electricity and Magnetism	3.25	3.40
Waves	3.39	3.24
Modern Physics	2.80	3.05
Science, Technology, and Society	2.77	2.51
Pedagogy Specific to the Physical Sciences	2.90	2.76

Table 8
Knowledge Statements Rated Below 2.50 by Teachers and/or Teacher Educators

	TEACHERS N = 191	TEACHER EDUCATORS N = 95
	Mean	Mean
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY		
History and Philosophy of Science		
5. Historical roots of science	2.32	2.45
6. Contributions of individuals	2.27	2.18
7. Contributions of ethnic groups and cultures	1.72	1.63
Mathematics, Measurement, and Date Manipulation		
15. Statistics of distributions	2.12	2.06
16. Simple digital (binary) logic	1.73	1.58
18. Differentiation and simple integration	2.13	
B. BASIC TOPICS IN PHYSICAL SCIENCE		
Heat and Thermodynamics		
34. Historical development of heat and energy	2.14	1.93
36. Equipartition of energy	2.32	2.06

Table 8 (cont.)

	TEACHERS N = 191	TEACHER EDUCATORS N = 95
	Mean	Mean
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)		
37. Brownian motion	2.24	1.99
47. Third law of thermodynamics (i.e., the concept of absolute zero temperature)		2.47
48. Reversibility and irreversibility	2.47	2.36
Atomic and Nuclear Structure		
49. Historical discovery of particles (e.g., electron, neutron)	2.33	2.19
C. MECHANICS		
80. Orbital motion (e.g., Copernicus, Galileo, Kepler)		2.42
82. Fluid mechanics (e.g., Archimedes' principle, Bernoulli's principle)	2.48	
83. Relativistic effects on length, mass, and time	2.35	2.16
D. ELECTRICITY AND MAGNETISM		
88. Gauss's law		2.32
94. Internal resistance of batteries		2.28
98. Alternating current circuits (e.g., average power, peak, effective current)		2.36
101. Transformers		2.36
103. Motors		2.29
104. Large scale generation and transmission of energy and power	2.34	2.05
105. *n*- and *p*-type semiconductors	2.22	1.97
106. Semiconductor devices (e.g., diodes, transistors)	2.35	2.03
107. Integrated circuits	2.16	1.82
108. Superconductivity	2.49	1.98
111. Gauss's law of magnetism (nonexistence of monopoles)	2.40	2.05
113. Principle and calibration of electrical meters (e.g., galvanometers)	2.52	2.17
114. Types of magnetism (e.g., diamagnetism)	2.13	1.82
115. Biot-Savart law and Ampere's law (relating current to magnetic field)	2.49	
116. Maxwell's equations	2.13	2.20
117. Lorentz force law and applications	2.33	

Table 8 (cont.)

	TEACHERS N = 191	TEACHER EDUCATORS N = 95
	Mean	Mean
E. WAVES		
123. Absorption and transmission		2.47
125. Scattering		2.32
130. Dispersion		2.39
134. Sound: air columns and strings (e.g., timbre, beats, harmonics)		2.41
136. Color (addition and subtraction; relationship to frequency)		2.21
137. Coherent radiation (sources and special properties)	2.41	2.25
140. Thin films	2.41	2.01
F. MODERN PHYSICS		
143. Blackbody radiation	2.36	
150. Schrödinger's wave equation	2.02	2.06
151. Orbital theory - quantum numbers		2.46
152. Pauli exclusion principle	2.36	
155. Lorentz transformations and inertial reference frames	2.14	2.12
157. Elementary particles (e.g., hadrons, leptons)	2.08	2.17
158. Strong and weak forces	2.31	2.09
G. SCIENCE, TECHNOLOGY, AND SOCIETY		
164. Risk mgmt issues associated with energy production/transmission/use		2.29
165. Risk mgmt associated with production/storage/use/disposal of products		2.16
166. Waste management issues and recycling		2.32
167. Management of resources (e.g., soil, water, metals, and fossil fuels)		2.28
168. Use of science and technology to predict/prepare for natural disasters	2.36	1.89
170. Technology transfer (e.g., spin-offs from space technology)		1.98
171. Social/political/economic issues arising from science and technology		2.34

Table 8 (cont.)

	TEACHERS N = 191	TEACHER EDUCATORS N = 95
	Mean	Mean
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES		
174. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences		2.37
Curriculum: Organization and Materials		
180. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence		2.37
181. Lesson plans in the physical sciences curricula for all students, justification for the plans		2.07
183. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences		2.49

Correlation of the profiles of mean importance ratings. The profiles of mean importance ratings for the teachers and teacher educators were correlated. The value of the correlation coefficient was .91. This indicates that there is a very high level of agreement between the two respondent groups in terms of the relative importance of the knowledge statements.

Percents. The percent of responses for each of the five categories associated with the level of understanding rating scale was computed for the aggregate of the physics survey respondents. This analysis provides some overall guidance with respect to the level of cognitive complexity that should be represented on the Subject Assessment in Physics. The percents are displayed in Appendix G. Inspection of these percent distributions indicates that for 107 knowledge statements the two highest percentages were between levels 2 (comprehension) and 3 (application/utilization); and for 75 knowledge statements the two highest percentages were between levels 3 and 4 (analysis).

Results of Data Analyses: Subgroups of Respondents

Mean importance. A significant contribution towards the accumulation of evidence in support of the job-relevance of the Subject Assessment in Physics is the verification of the importance of the knowledge statements by a wide range of physics education professionals. Therefore, mean importance ratings for each knowledge statement were computed for the following subgroups of respondents: (1) geographic region (Northeast, n=78; Central, n=96; Southern, n=80; Far West, n=72); (2) sex (female, n=60; male, n=266); and (3) teaching experience[1] (≤ 5 years, n=37; > 5 years, n=153). The means are presented in Appendix H.

An analysis of importance ratings by geographic region is consistent with recent legal emphasis on addressing regional job variability when conducting job analysis for content domain specification purposes (Kuehn et al., 1990). The four geographic regions included for analysis are consistent with the categorization established by the National Association of State Directors of Teacher Education and Certification (NASDTEC). Sex was included because it represents a protected "class" under Title VII of the Civil Rights ACT of 1964. (Race/ethnicity was not included in the subgroup analyses because of the insufficient number of minority respondents, i.e., < 30.) The dichotomous breakdown of teaching experience at the five-year point was chosen so that the judgments of less experienced teachers will be represented and so that the judgments of more experienced teachers will be represented.

The results of the subgroup analysis indicated that four additional knowledge statements (i.e., beyond the 56 statements previously identified by the mean analysis conducted on the teachers and teacher educators) were judged to be below the 2.50 cutpoint. The four statements are presented in Table 9. Three knowledge statements were "flagged" by the teaching experience subgroup; and one was flagged by the sex subgroup.

Table 9
Knowledge Statements Rated Below 2.50 by Geographic Region, Sex, and Teaching Experience

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=78	C N=96	S N=80	FW N=72	F N=60	M N=266	≤5 N=37	>5 N=153
B. BASIC TOPICS IN PHYSICAL SCIENCE								
56 Artificial and natural radioactivity							2.41	
F. MODERN PHYSICS								
147 deBroglie's hypothesis								2.48
154 Special relativity							2.45	
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES								
197 Resources available in the community						2.47		

[1] Teaching experience includes only those respondents who had identified themselves as regular teachers or permanent substitutes.

Correlations of the profiles of mean importance ratings. Correlation coefficients were computed for the profiles of mean importance ratings for the same subgroups used in the mean analysis. The coefficients are presented in Table 10. All the values exceeded .90. This indicates that there is a very high level of agreement within the subgroups of respondents in terms of the relative importance of the knowledge statements.

Table 10
Correlations of the Profiles of Mean Importance Ratings by Geographic Region, Sex, and Teaching Experience

	1	2	3	4
GEOGRAPHIC REGION				
1. Northeast		.97	.96	.97
2. Central			.97	.97
3. Southern				.96
4. Far West				
SEX				
1. Female		.94		
2. Male				
TEACHING EXPERIENCE (years)				
1. ≤ 5		.91		
2. > 5				

Mean Ratings of Content Coverage

The survey participants were asked to rate, using a 5-point scale, how well the knowledge statements within a major content area covered the important aspects of that major content area. Responses to this provide an indication of the adequacy (comprehensiveness) of the domain of knowledge. The scale values ranged from a low of 1 (very poorly) to a high of 5 (very well); the midpoint of the scale was value 3 (adequately). The means of these ratings for teachers and teacher educators are presented in Table 11. All the means were close to or exceeded 4.00. This indicates that both groups of respondents judged the major content areas to be well covered.

Mean Percentage Weights for Test Content Emphasis

The survey participants were asked to indicate the weight that each of the major content areas should receive on the Subject Assessment in Physics. This information may be used by the Advisory/Test Development Committee to assist in its decision about how much emphasis the content areas should receive on the test specifications. To obtain the weights, the participants were asked to distribute a total of 100 points across the major areas. The mean values were then converted into percentages. The mean percentage weights for teachers and teacher educators are presented in Table 12. For both groups, **Mechanics; Electricity and Magnetism; Basic Topics in Physical Science**; and **Waves** received the most emphasis; **Science, Technology, and Society** and **Pedagogy Specific to the Physical Sciences** received the least emphasis.

Table 11
Mean Ratings of Content Coverage

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	4.04	3.89
Basic Topics in Physical Science	4.11	3.82
Mechanics	4.40	4.07
Electricity and Magnetism	4.27	4.04
Waves	4.32	4.08
Modern Physics	4.16	3.97
Science, Technology, and Society	4.07	3.79
Pedagogy Specific to the Physical Sciences	4.09	3.81

Table 12
Mean Percentage Weights

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	9.43	8.78
Basic Topics in Physical Science	14.29	14.11
Mechanics	20.95	19.77
Electricity and Magnetism	15.93	17.05
Waves	13.90	13.11
Modern Physics	9.91	13.00
Science, Technology, and Society	7.66	7.22
Pedagogy Specific to the Physical Sciences	7.52	6.99

Summary and Conclusion

A job analysis was conducted to define a knowledge domain important for newly licensed (certified) physics teachers to perform their jobs in a competent manner. The results of the job analysis will be used to develop test specifications for the Praxis II Subject Assessment in Physics.

An initial draft domain of important knowledge statements was constructed by ETS Test Development staff with expertise in physics and ETS Research staff with expertise in job analysis. This draft domain was reviewed by an External Review Panel of subject-matter experts and then revised accordingly. The revised draft was then reviewed, modified, and approved by an external Advisory/Test Development Committee. The revised knowledge domain was then subjected to verification/refutation through the use of a national survey of physics teachers, teacher educators, and state administrators. The survey participants were asked to rate specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) physics teachers. A mean importance cutpoint of 2.50 (midpoint between moderately important and important) was established to designate knowledge statements as eligible (≥ 2.50) or ineligible (< 2.50) for inclusion in the development of test specifications.

The results of the mean analysis conducted by teachers and teacher educators indicated 56 knowledge statements were rated less than 2.50 (see Table 8). This represents 30% of the knowledge domain. Four additional knowledge statements were rated below 2.50 by two of the subgroups (sex and teaching experience) of respondents (see Table 9). **In total, 60 of the 184 statements (33%) did not meet the 2.50 criterion for inclusion. Still, however, 67% of the domain (124 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements indicated a very high level of agreement. The coefficient for the comparison between teachers and teacher educators was .91; the coefficients for the subgroup comparisons all exceeded .90.

The 124 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of physics teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Advisory/Test Development Committee in its decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

The results of the analysis of the level of understanding rating scale indicated that 58% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 41% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of the judged importance of the eight major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the physics knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined content domain. With respect to importance (see Table 7), both teachers and teacher educators judged the same five content areas to be important. Of the remaining three content areas, one was judged to be important by the teacher educators and moderately important by the teachers; and two were judged to be moderately important by both teachers and teacher educators. With respect to content coverage (see Table 11), both teachers and teacher educators judged all eight content areas to be well covered.

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Appendix C

Ca1 <u>Job Analysis Survey for Teachers of Chemistry</u>

Cb1 <u>Job Analysis Survey for Teachers of Physics</u>

Ca1 Job Analysis Survey for Teachers of Chemistry

Ca1

JOB ANALYSIS INVENTORY

FOR TEACHERS

OF CHEMISTRY

By

Educational Testing Service
Princeton, New Jersey

Ca2

INTRODUCTION

Educational Testing Service (ETS) is developing a new generation of assessments for the purpose of licensing (certifying) teachers. The inventory that follows is part of our development effort and is designed to gather information concerning the job of a **newly licensed chemistry teacher**. It was developed by high school teachers, college faculty, and state department of education officials, along with ETS staff.

Those who constructed this inventory recognize that chemistry teachers are required to teach students with varying backgrounds and levels of ability. For this reason, the collaborators believe that teachers should have a broad and deep understanding of chemistry in order to teach it. The inventory asks you to respond to a list of statements and to judge (a) the importance of the knowledge statements for newly licensed (certified) chemistry teachers and (b) the level of understanding needed by newly licensed (certified) chemistry teachers. **Please do not relate each statement to your own job but rather to what you believe newly licensed chemistry teachers should know.**

The information you provide will guide the development of the NTE Chemistry examination. It is expected that the new examination will differ from the current examination in both content and design. In addition to the development of a new examination, this study will contribute to our understanding of chemistry teaching as a profession. We expect the results of the study to be widely disseminated and to be very useful to the profession.

The inventory has been mailed to a group of approximately 800 professionals. Its value is directly related to the number of individuals who return their inventories. Because you represent a large number of professionals, your responses are extremely important. The inventory requires approximately 60 minutes to complete. Please return your completed inventory within 10 days.

PART I - KNOWLEDGE AREAS FOR CHEMISTRY TEACHERS

The purpose of this inventory is to determine what you believe newly licensed (certified) chemistry teachers should know in order to perform their job in a competent manner. On the following pages you will find eight major content areas and, beneath each, a list of knowledge and ability statements that define the particular content area. The order of presentation of the eight content areas in the inventory is not meaningful.

The eight content areas are:

A. **SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY**
B. **BASIC TOPICS IN PHYSICAL SCIENCE**
C. **CHEMICAL PERIODICITY**
D. **NOMENCLATURE**
E. **THE MOLE, CHEMICAL BONDING AND MOLECULAR GEOMETRY**
F. **BIOCHEMISTRY**
G. **SCIENCE, TECHNOLOGY, AND SOCIETY**
H. **PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES**

For each statement within each of these content areas, you will be asked to make the following judgments:

How important is an understanding of this knowledge area for newly licensed (certified) chemistry teachers if they are to perform their jobs in a competent manner?

(0) Of no importance
(1) Of little importance
(2) Moderately important
(3) Important
(4) Very important

What level of understanding is typically needed by newly licensed (certified) chemistry teachers in each knowledge area?

(Note: These levels are hierarchically arranged: level #2 subsumes level #1; level #3 subsumes levels #2 and #1; level #4 subsumes levels #3, #2, and #1. The zero (0) point is not subsumed by any other scale point.)

(0) An understanding of the knowledge area is not needed.
(1) Requires the ability to define the terms used in the knowledge area.
(2) Requires the ability to comprehend the essential properties of the knowledge area.
(3) Requires the ability to apply/utilize the knowledge area to address problems or questions.
(4) Requires the ability to analyze the knowledge area into component parts and explain the interrelationships among the parts.

Circle your responses using the scales adjacent to each statement. To familiarize yourself with the content areas and statements, you may wish to glance through Part I before making your judgments.

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY

	IMPORTANCE	LEVEL OF UNDERSTANDING
Methodology		
1. Scientific methods (e.g., formulation of problem, hypotheses, experiments, interpretations, predictions, conclusions)	0 1 2 3 4	0 1 2 3 4
2. Science process skills (e.g., qualitative and quantitative observations, interpretations, communication, inferences, applications)	0 1 2 3 4	0 1 2 3 4
3. Assumptions, models, laws, and theories	0 1 2 3 4	0 1 2 3 4
4. Design of experiments (e.g., controls, independent and dependent variables)	0 1 2 3 4	0 1 2 3 4
History and Philosophy of Science		
5. Historical roots of science	0 1 2 3 4	0 1 2 3 4
6. Contributions of individuals	0 1 2 3 4	0 1 2 3 4
7. Contributions of ethnic groups and cultures	0 1 2 3 4	0 1 2 3 4
Mathematics, Measurement, and Data Manipulation		
8. The metric and SI systems	0 1 2 3 4	0 1 2 3 4
9. Scientific notation	0 1 2 3 4	0 1 2 3 4
10. Estimation and approximation	0 1 2 3 4	0 1 2 3 4
11. Significant figures in measurement and calculations	0 1 2 3 4	0 1 2 3 4
12. Unit/dimensional analysis	0 1 2 3 4	0 1 2 3 4
13. Experimental errors (e.g., sources, quantifications, precision, accuracy)	0 1 2 3 4	0 1 2 3 4
14. Mathematical relationships and patterns in numerical data (e.g., direct, exponential)	0 1 2 3 4	0 1 2 3 4
15. Statistics of distributions	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
16. Simple digital (binary) logic	0 1 2 3 4	0 1 2 3 4
17. Organization and interpretation of data and equations (e.g., tables, graphs, spreadsheets)	0 1 2 3 4	0 1 2 3 4
18. Differentiation and simple integration	0 1 2 3 4	0 1 2 3 4
Laboratory and Safety		
19. Use and calibration of laboratory equipment (e.g., balances, laboratory burners, glassware, thermometers, barometers, pH meters, spectroscopes)	0 1 2 3 4	0 1 2 3 4
20. Maintenance of laboratory equipment (e.g., balances, laboratory burners, glassware, thermometers, barometers, pH meters, spectroscopes)	0 1 2 3 4	0 1 2 3 4
21. Preparation and set-up of reagents, materials, and apparatus	0 1 2 3 4	0 1 2 3 4
22. Laboratory safety (e.g., laboratory hazards, storage and disposal of materials)	0 1 2 3 4	0 1 2 3 4
23. Emergency procedures for laboratory accidents	0 1 2 3 4	0 1 2 3 4
24. Overall evaluation of the importance of Scientific Methodology/Techniques/History	0 1 2 3 4	

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)

25. How well do the knowledge areas in section A cover the important aspects of Scientific Methodology/Techniques/History?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

___

___

B. BASIC TOPICS IN PHYSICAL SCIENCE

	IMPORTANCE	LEVEL OF UNDERSTANDING
Matter and Energy		
26. Physical and chemical properties (e.g., states of matter, homogeneous, heterogeneous)	0 1 2 3 4	0 1 2 3 4
27. Particulate nature of matter (e.g., atoms, ions, molecules)	0 1 2 3 4	0 1 2 3 4
28. Elements, compounds, and mixtures	0 1 2 3 4	0 1 2 3 4
29. Physical and chemical changes	0 1 2 3 4	0 1 2 3 4
30. Conservation of mass/energy	0 1 2 3 4	0 1 2 3 4
31. Forms of energy (e.g., kinetic, potential, mechanical, sound, magnetic, electrical, light, heat, nuclear, chemical)	0 1 2 3 4	0 1 2 3 4
32. Energy transformations	0 1 2 3 4	0 1 2 3 4
Heat and Thermodynamics		
33. Historical development of heat and energy concepts	0 1 2 3 4	0 1 2 3 4
34. Kinetic molecular theory	0 1 2 3 4	0 1 2 3 4
35. Brownian motion	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	**LEVEL OF UNDERSTANDING**
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
36. Heat *versus* temperature	0 1 2 3 4	0 1 2 3 4
37. Temperature scales and measurement	0 1 2 3 4	0 1 2 3 4
38. Conduction, convection, and radiation	0 1 2 3 4	0 1 2 3 4
39. Heat capacity, thermal exchange, heat of fusion, and heat of vaporization	0 1 2 3 4	0 1 2 3 4
40. Concepts of enthalpy and entropy	0 1 2 3 4	0 1 2 3 4
41. Phase changes	0 1 2 3 4	0 1 2 3 4
42. Expansion and contraction	0 1 2 3 4	0 1 2 3 4
43. Zeroth law of thermodynamics (i.e., direction of heat flow)	0 1 2 3 4	0 1 2 3 4
44. First law of thermodynamics (i.e., energy is conserved)	0 1 2 3 4	0 1 2 3 4
45. Second law of thermodynamics - entropy	0 1 2 3 4	0 1 2 3 4
46. Third law of thermodynamics (i.e., the concept of absolute zero temperature)	0 1 2 3 4	0 1 2 3 4
47. Reversibility and irreversibility	0 1 2 3 4	0 1 2 3 4
Atomic and Nuclear Structure		
48. Historical discovery of particles (e.g., electron, neutron)	0 1 2 3 4	0 1 2 3 4
49. Atomic models and their experimental bases (Thomson, Rutherford, and Bohr)	0 1 2 3 4	0 1 2 3 4
50. Structure of the atom	0 1 2 3 4	0 1 2 3 4
51. Planck's hypothesis	0 1 2 3 4	0 1 2 3 4
52. deBroglie's hypothesis	0 1 2 3 4	0 1 2 3 4
53. Heisenberg uncertainty principle	0 1 2 3 4	0 1 2 3 4
54. Schrödinger's wave equation	0 1 2 3 4	0 1 2 3 4
55. Orbital theory - quantum numbers	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
56. Characteristics of an electron in an atom (e.g., shells, orbitals)	0 1 2 3 4	0 1 2 3 4
57. Properties of electromagnetic radiation	0 1 2 3 4	0 1 2 3 4
58. Spectroscopy	0 1 2 3 4	0 1 2 3 4
59. Pauli exclusion principle	0 1 2 3 4	0 1 2 3 4
60. Hund's rule	0 1 2 3 4	0 1 2 3 4
61. Chemical properties related to electron configuration (e.g., atomic valences and reactivity)	0 1 2 3 4	0 1 2 3 4
62. Atomic mass, atomic number, mass number and isotopes	0 1 2 3 4	0 1 2 3 4
63. Nuclear forces and binding energy	0 1 2 3 4	0 1 2 3 4
64. Mass/energy transformation	0 1 2 3 4	0 1 2 3 4
65. Types of radioactive decay (e.g., alpha, beta, gamma emission)	0 1 2 3 4	0 1 2 3 4
66. Artificial and natural radioactivity	0 1 2 3 4	0 1 2 3 4
67. Half-life of radioactive isotopes	0 1 2 3 4	0 1 2 3 4
68. Nuclear reactions (transmutation, fission, fusion)	0 1 2 3 4	0 1 2 3 4
69. **Overall evaluation of the importance of Basic Topics in Physical Science**	0 1 2 3 4	

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)

70. How well do the knowledge areas in section B cover the important aspects of Basic Topics in Physical Science?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

____

____

C. CHEMICAL PERIODICITY	IMPORTANCE	LEVEL OF UNDERSTANDING
71. The development of the periodic table	0 1 2 3 4	0 1 2 3 4
72. The position of metals, nonmetals, and metalloids	0 1 2 3 4	0 1 2 3 4
73. Trends in melting and boiling temperatures ...	0 1 2 3 4	0 1 2 3 4
74. Trends in atomic radii, ionization energy, electron affinity, and electronegativity	0 1 2 3 4	0 1 2 3 4
75. Relationship of periodic table to electron configurations of the atoms	0 1 2 3 4	0 1 2 3 4
76. Oxidation numbers for elements in a compound	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of <u>IMPORTANCE</u> for and <u>LEVEL OF UNDERSTANDING</u> needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	**LEVEL OF UNDERSTANDING**
(0) Of no importance	**(0) An understanding of the knowledge area is not needed**
(1) Of little importance	**(1) DEFINE the terms used in the knowledge area**
(2) Moderately important	**(2) COMPREHEND the essential properties of the knowledge area**
(3) Important	**(3) APPLY/UTILIZE the knowledge area to address problems or questions**
(4) Very important	**(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts**

C. CHEMICAL PERIODICITY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
77. Periodicity of the oxidation states of the elements	0 1 2 3 4	0 1 2 3 4
78. Chemical properties and reactions of the elements as reflected by their positions in the periodic table	0 1 2 3 4	0 1 2 3 4
79. **Overall evaluation of the importance of Chemical Periodicity**	0 1 2 3 4	

80. How well do the knowledge areas in section C cover the important aspects of Chemical Periodicity?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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D. NOMENCLATURE		
81. Inorganic nomenclature of ionic compounds and acids	0 1 2 3 4	0 1 2 3 4
82. Nomenclature of the classes of organic compounds (e.g., saturated and unsaturated hydrocarbons, alcohols, ethers, aldehydes, ketones)	0 1 2 3 4	0 1 2 3 4
83. **Overall evaluation of the importance of Nomenclature**	0 1 2 3 4	

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D. NOMENCLATURE (cont.)

84. How well do the knowledge areas in section D cover the important aspects of Nomenclature?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY

		IMPORTANCE	LEVEL OF UNDERSTANDING
85.	Mole concept and mass-mole-number relationships	0 1 2 3 4	0 1 2 3 4
86.	Information conveyed by a chemical formula	0 1 2 3 4	0 1 2 3 4
87.	Law of constant composition and law of multiple proportions	0 1 2 3 4	0 1 2 3 4
88.	Percent composition of elements in a compound	0 1 2 3 4	0 1 2 3 4
89.	Information conveyed by empirical and molecular formulas	0 1 2 3 4	0 1 2 3 4
90.	Ionic, covalent, and metallic bonds	0 1 2 3 4	0 1 2 3 4
91.	Rules for calculating oxidation numbers of atoms in a compound	0 1 2 3 4	0 1 2 3 4
92.	Electron dot formulas and structural formulas	0 1 2 3 4	0 1 2 3 4
93.	Multiple bonds	0 1 2 3 4	0 1 2 3 4
94.	Types of bonding related to electronegativity differences	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. THE MOLE, CHEMICAL BONDING AND MOLECULAR GEOMETRY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
95. Valence shell electron pair repulsion model for molecular shapes (VSEPR)	0 1 2 3 4	0 1 2 3 4
96. Simple structures of isomers	0 1 2 3 4	0 1 2 3 4
97. Chemical and physical properties of compounds related to type of bonding and geometry	0 1 2 3 4	0 1 2 3 4
98. Hybrid orbitals	0 1 2 3 4	0 1 2 3 4
99. Resonance and delocalization	0 1 2 3 4	0 1 2 3 4
The Kinetic Theory and States of Matter		
100. Assumptions of the kinetic molecular theory of gases	0 1 2 3 4	0 1 2 3 4
101. Maxwell-Boltzmann velocity distributions	0 1 2 3 4	0 1 2 3 4
102. Diffusion of gases	0 1 2 3 4	0 1 2 3 4
103. Relationships among volume, pressure, temperature, and quantity for ideal gases	0 1 2 3 4	0 1 2 3 4
104. Dalton's law of partial pressures	0 1 2 3 4	0 1 2 3 4
105. Real *versus* ideal gases	0 1 2 3 4	0 1 2 3 4
106. Forces of attraction among molecules (e.g., hydrogen bonds, dipole-dipole interactions)	0 1 2 3 4	0 1 2 3 4
107. Phase changes for a pure substance (e.g., pressure and temperature effects)	0 1 2 3 4	0 1 2 3 4
108. Relationships among evaporation rate, boiling temperature, and vapor pressure	0 1 2 3 4	0 1 2 3 4
109. Special properties of water (e.g., density of solid *versus* liquid, high heat capacity, unusually high boiling temperature)	0 1 2 3 4	0 1 2 3 4
110. Relationships among phases of matter, forces between particles and particle energy (e.g., shape, volume, diffusion, density, and compressibility)	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)

	IMPORTANCE	LEVEL OF UNDERSTANDING
111. Characteristics of crystals	0 1 2 3 4	0 1 2 3 4
Chemical Reactions		
112. Equation balancing from written descriptions of chemical reactions	0 1 2 3 4	0 1 2 3 4
113. General types of chemical reactions (i.e., composition, decomposition, ionic replacement)	0 1 2 3 4	0 1 2 3 4
114. Stoichiometry	0 1 2 3 4	0 1 2 3 4
115. Endothermic and exothermic reactions	0 1 2 3 4	0 1 2 3 4
116. Spontaneity in chemical reactions (e.g., free energy, entropy, Gibbs-Helmholtz equation)	0 1 2 3 4	0 1 2 3 4
117. Collision theory and reaction rates	0 1 2 3 4	0 1 2 3 4
118. Activation energy and the effects of a catalyst	0 1 2 3 4	0 1 2 3 4
119. Rate-influencing factors in chemical reactions (e.g., temperature, pressure, concentration, catalyst)	0 1 2 3 4	0 1 2 3 4
120. Rate expressions and orders of reactions	0 1 2 3 4	0 1 2 3 4
121. Reaction mechanisms	0 1 2 3 4	0 1 2 3 4
122. Chemical equilibria	0 1 2 3 4	0 1 2 3 4
123. Le Châtelier's principle and factors that disturb the equilibrium of systems (e.g., temperature, concentration)	0 1 2 3 4	0 1 2 3 4
124. Properties and production of ammonia (e.g., the Haber equilibrium)	0 1 2 3 4	0 1 2 3 4
125. Oxidation and reduction reactions	0 1 2 3 4	0 1 2 3 4
126. Electrochemical cells and electrode reactions	0 1 2 3 4	0 1 2 3 4
127. Metallurgical properties of the transition metals	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)

		IMPORTANCE	LEVEL OF UNDERSTANDING
128.	Redox properties of the halogens and the halide ions	0 1 2 3 4	0 1 2 3 4
129.	Faraday's laws of electrolysis	0 1 2 3 4	0 1 2 3 4
130.	Practical applications of electrochemistry (e.g., electroplating, lead storage battery, pH meter)	0 1 2 3 4	0 1 2 3 4
	Solutions and Solubility		
131.	Types of solutions (e.g., solid-solid, solid-liquid, liquid-gas)	0 1 2 3 4	0 1 2 3 4
132.	Solutes, solvents and solubility	0 1 2 3 4	0 1 2 3 4
133.	Effects of temperature and pressure on solubility	0 1 2 3 4	0 1 2 3 4
134.	Dissolving process	0 1 2 3 4	0 1 2 3 4
135.	Solubility product (K_{sp})	0 1 2 3 4	0 1 2 3 4
136.	Concentration of solutes (e.g., dilute, concentrated, saturated; molarity)	0 1 2 3 4	0 1 2 3 4
137.	Conductivity of solutions and the ionization process	0 1 2 3 4	0 1 2 3 4
138.	Strong and weak electrolytes; non-electrolytes	0 1 2 3 4	0 1 2 3 4
139.	Colligative properties of solutions	0 1 2 3 4	0 1 2 3 4
140.	Characteristic properties of acids, bases, and salts	0 1 2 3 4	0 1 2 3 4
141.	Arrhenius, Brønsted-Lowry, and Lewis acid-base theories	0 1 2 3 4	0 1 2 3 4
142.	pH of solutions of strong and weak acids and bases	0 1 2 3 4	0 1 2 3 4
143.	Relative strengths of acids and bases	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)

	IMPORTANCE	LEVEL OF UNDERSTANDING
144. Production, properties, and use of the common acids (e.g., sulfuric, phosphoric, nitric, hydrochloric)	0 1 2 3 4	0 1 2 3 4
145. Acid-base titration and indicators	0 1 2 3 4	0 1 2 3 4
146. Buffer solutions	0 1 2 3 4	0 1 2 3 4
147. **Overall evaluation of the importance of the Mole, Chemical Bonding, and Molecular Geometry**	0 1 2 3 4	

148. How well do the knowledge areas in section E cover the important aspects of The Mole, Chemical Bonding, and Molecular Geometry?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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F. BIOCHEMISTRY

	IMPORTANCE	LEVEL OF UNDERSTANDING
149. Organic functional groups and their reactions	0 1 2 3 4	0 1 2 3 4
150. Monomers and polymers	0 1 2 3 4	0 1 2 3 4
151. Biologically important compounds (e.g., sugars, carbohydrates, amino acids, proteins, nucleic acids, carboxylic acids, enzymes)	0 1 2 3 4	0 1 2 3 4
152. Biologically important chemical processes (e.g., photosynthesis, bioluminescence, respiration, hydrolysis, phosphorylation)	0 1 2 3 4	0 1 2 3 4
153. Structure and replication of nucleic acids	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

F. BIOCHEMISTRY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
154. Energy storage and release in biological systems	0 1 2 3 4	0 1 2 3 4
155. **Overall evaluation of the importance of Biochemistry?**	0 1 2 3 4	

156. How well do the knowledge areas in section F cover the important aspects of Biochemistry?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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G. SCIENCE, TECHNOLOGY, AND SOCIETY	IMPORTANCE	LEVEL OF UNDERSTANDING
157. Awareness of ethical and moral responsibilities of scientists	0 1 2 3 4	0 1 2 3 4
158. Awareness of ethical issues, risks, and benefits associated with the application of science	0 1 2 3 4	0 1 2 3 4
159. Detection of environmental hazards	0 1 2 3 4	0 1 2 3 4
160. Risk management issues associated with energy production, transmission, and use	0 1 2 3 4	0 1 2 3 4
161. Risk management issues associated with production, storage, use, and disposal of consumer products	0 1 2 3 4	0 1 2 3 4
162. Waste management issues and recycling	0 1 2 3 4	0 1 2 3 4
163. Management of resources (e.g., soil, water, metals, and fossil fuels)	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

G. SCIENCE, TECHNOLOGY, AND SOCIETY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
164. Use of science and technology to predict and prepare for natural disasters	0 1 2 3 4	0 1 2 3 4
165. Use of technology in everyday life (e.g., lamp, smoke detector, TV, computer, internal combustion engine)	0 1 2 3 4	0 1 2 3 4
166. Technology transfer (e.g., spin-offs from space technology, superconductors)	0 1 2 3 4	0 1 2 3 4
167. Issues associated with the use of chemicals in agriculture, food preparation and preservation	0 1 2 3 4	0 1 2 3 4
168. Social, political and economic issues arising from science and technology	0 1 2 3 4	0 1 2 3 4
169. **Overall evaluation of the importance of Science, Technology, and Society**	0 1 2 3 4	

170. How well do the knowledge areas in section G cover the important aspects of Science, Technology, and Society?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

____

____

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competant manner.

IMPORTANCE	**LEVEL OF UNDERSTANDING**
(0) Of no importance	**(0) An understanding of the knowledge area is not needed**
(1) Of little importance	**(1) DEFINE the terms used in the knowledge area**
(2) Moderately important	**(2) COMPREHEND the essential properties of the knowledga area**
(3) Important	**(3) APPLY/UTILIZE the knowledge area to address problems or questions**
(4) Very important	**(4) ANALYZE the knowledge araa into component parts and explain the interrelationships among the parts**

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES

		IMPORTANCE	LEVEL OF UNDERSTANDING
171.	Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences.	0 1 2 3 4	0 1 2 3 4
172.	Recognition of and compensation for complex factors associated with societal and school-related issues that may affect student's learning of the physical sciences	0 1 2 3 4	0 1 2 3 4
	Curriculum: Organization and Materials		
173.	Reasons for learning the physical sciences	0 1 2 3 4	0 1 2 3 4
174.	Reasons for teaching a particular topic in the physical sciences	0 1 2 3 4	0 1 2 3 4
175.	Integration within topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
176.	Integration among the physical sciences and other disciplines	0 1 2 3 4	0 1 2 3 4
177.	Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	0 1 2 3 4	0 1 2 3 4
178.	Lesson plans in the physical sciences curricula for all students and justification for the plans	0 1 2 3 4	0 1 2 3 4
179.	Selection and use of curricular materials and resources (e.g., textbooks and other printed materials, computer software, laboratory materials) for the physical sciences	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)

	IMPORTANCE	LEVEL OF UNDERSTANDING
180. Selection and use of mass media (e.g., film, television, video) appropriate for topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
181. Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	0 1 2 3 4	0 1 2 3 4
Instruction		
182. Prerequisite knowledge, experience, and skills that students need for various topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
183. Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
184. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	0 1 2 3 4	0 1 2 3 4
185. Design of appropriate lab experiences for various instructional goals and student learning needs	0 1 2 3 4	0 1 2 3 4
186. Strategies for motivating and encouraging students to succeed in the physical sciences	0 1 2 3 4	0 1 2 3 4
187. Strategies for addressing controversial and/or sensitive issues in the physical sciences	0 1 2 3 4	0 1 2 3 4
Assessment and Evaluation		
188. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) chemistry teachers if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)

	IMPORTANCE	LEVEL OF UNDERSTANDING
189. Errors in student work and performance that arise from prior conceptions about topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
Professional Concerns		
190. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	0 1 2 3 4	0 1 2 3 4
191. Professional and scholarly organizations for science educators	0 1 2 3 4	0 1 2 3 4
192. Legal responsibilities and liabilities for teachers in the physical sciences	0 1 2 3 4	0 1 2 3 4
193. Responsibilities for continuing education in the physical sciences and in science education	0 1 2 3 4	0 1 2 3 4
194. Resources available in the community	0 1 2 3 4	0 1 2 3 4
195. Science-related career information	0 1 2 3 4	0 1 2 3 4
196. **Overall evaluation of the importance of Pedagogy Specific to the Physical Sciences**	0 1 2 3 4	

197. How well do the knowledge areas in section H cover the important aspects of Pedagogy Specific to the Physical Sciences?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

PART II - RECOMMENDATIONS FOR TEST CONTENT

Listed below are eight broad topics that may be covered on the new licensing examination for chemistry. If the examination contained 100 questions, how many questions should be included from each topic? If you feel a category should not be included in the exam, put 0 in the space provided. Make sure your responses sum to 100.

TOPICS	NUMBER OF TEST QUESTIONS (out of 100)
198. SCIENTIFIC METHODOLOGY/TECHNIQUES/ HISTORY	________
199. BASIC TOPICS IN PHYSICAL SCIENCE	________
200. CHEMICAL PERIODICITY	________
201. NOMENCLATURE	________
202. THE MOLE, CHEMICAL BONDING AND MOLECULAR GEOMETRY	________
203. BIOCHEMISTRY	________
204. SCIENCE, TECHNOLOGY, AND SOCIETY	________
205. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES	________
TOTAL	100

PART III - BACKGROUND INFORMATION

The information that you provide in this section is completely confidential and will be used for research purposes only. Please answer the questions by circling the number that most closely describes you or your professional activities. Unless otherwise indicated, please circle only one response for each question.

206. Where do you work?

1. Alabama
2. Alaska
3. Arizona
4. Arkansas
5. California
6. Colorado
7. Connecticut
8. Delaware
9. District of Columbia
10. Florida
11. Georgia
12. Hawaii
13. Idaho
14. Illinois
15. Indiana
16. Iowa
17. Kansas
18. Kentucky
19. Louisiana
20. Maine
21. Maryland
22. Massachusetts
23. Michigan
24. Minnesota
25. Mississippi
26. Missouri
27. Montana
28. Nebraska
29. Nevada
30. New Hampshire
31. New Jersey
32. New Mexico
33. New York
34. North Carolina
35. North Dakota
36. Ohio
37. Oklahoma
38. Oregon
39. Pennsylvania
40. Puerto Rico
41. Rhode Island
42. South Carolina
43. South Dakota
44. Tennessee
45. Texas
46. Utah
47. Vermont
48. Virginia
49. Washington
50. West Virginia
51. Wisconsin
52. Wyoming

207. What is your age?

1. Under 25
2. 25-34
3. 35-44
4. 45-54
5. 55-64
6. Over 64

208. What is your sex?

1. Female
2. Male

209. Which of the following best describes the area in which you work?

1. Urban
2. Suburban
3. Rural

210. How do you describe yourself?

1. Native American, American Indian, or Alaskan Native
2. Asian American, Asian, Native Hawaiian, or Pacific Islander
3. African American or Black
4. Mexican American or Chicano
5. Puerto Rican
6. Latin American, South American, Central American, or other Hispanic
7. White
8. Other

211. Which of the following <u>best</u> describes your highest educational attainment?

1. Less than a bachelor's
2. Bachelor's
3. Bachelor's + additional credits
4. Master's
5. Master's + additional credits
6. Doctorate

212. Which of the following <u>best</u> describes your current employment status?

1. Temporary substitute (assigned on a daily basis)
2. Permanent substitute (assigned on a longer term basis)
3. Regular teacher (not a substitute)
4. Principal or assistant principal
5. School administrator
6. Curriculum supervisor
7. State administrator
8. College faculty
9. Other (please specify)______________________________

213. How many years have you taught chemistry?

1. Never taught chemistry
2. Less than a year
3. 1 - 2 years
4. 3 - 5 years
5. 6 - 10 years
6. 11 - 15 years
7. 16 - 20 years
8. 21 or more years

214. What grade level(s) are you currently teaching? (Circle <u>all</u> that apply)

1. Preschool/Kindergarten
2. Grades 1-4
3. Grades 5-8
4. Grades 9-12
5. College
6. Do not teach
7. Other (please specify)______________________________

215. Which of the following describes your current teaching assignment? (Circle all that apply)?

1. Biology
2. Earth and Space Science
3. Ecology
4. General Science
5. Marine Science
6. Physical Science
7. Physics
8. Chemistry
9. College
10. Do not teach
11. Other (please specify)________________________________

216. Circle the following organizations to which you belong.

1. American Association of Physics Teachers
2. American Association for the Advancement of Science
3. American Chemical Society
4. American Federation of Teachers
5. National Association of Biology Teachers
6. National Association for Research in Science Teaching
7. National Science Supervisors Association
8. National Science Teachers Association
9. National Association for Science, Technology, and Society
10. National Education Association
11. Other (please specify)________________________________

THANK YOU FOR COMPLETING THIS INVENTORY.
PLEASE RETURN IT WITHIN 10 DAYS USING THE ENCLOSED ENVELOPE.

Cb1 Job Analysis Survey for Teachers of Physics

Cb1

JOB ANALYSIS INVENTORY

FOR TEACHERS

OF PHYSICS

By

Educational Testing Service
Princeton, New Jersey

Cb2

INTRODUCTION

Educational Testing Service (ETS) is developing a new generation of assessments for the purpose of licensing (certifying) teachers. The inventory that follows is part of our development effort and is designed to gather information concerning the job of a **newly licensed physics teacher**. It was developed by high school teachers, college faculty, and state department of education officials, along with ETS staff.

Those who constructed this inventory recognize that physics teachers are required to teach students with varying backgrounds and levels of ability. For this reason, the collaborators believe that teachers should have a broad and deep understanding of physics in order to teach it. The inventory asks you to respond to a list of statements and to judge (a) the importance of the knowledge statements for newly licen (certified) physics teachers and (b) the level of understanding needed by newly licensed (certified) physics teachers. **Please do not relate each statement to your own job but rather to what you believe newly licensed (certified) physics teachers should know.**

The information you provide will guide the development of a new NTE Physics examination. It is expected that the new examination will differ from the current examination in both content and design. In addition to the development of a new examination, this study will contribute to our understanding of physics teaching as a profession. We expect the results of the study to be widely disseminated and to be very useful to the profession.

The inventory has been mailed to a group of approximately 800 professionals. Its value is directly related to the number of individuals who return their completed inventories. Because you represent a large number of professionals, your responses are extremely important. The inventory requires approximately 60 minutes to complete. Please return your completed inventory within 10 days.

PART I - KNOWLEDGE AREAS FOR PHYSICS TEACHERS

The purpose of this inventory is to determine what you believe newly licensed (certified) physics teachers should know in order to perform their job in a competent manner. On the following pages you will find eight major content areas and, beneath each, a list of knowledge statements that define the particular content area. The order of presentation of the eight content areas in the inventory is not meaningful.

The eight content areas are:

A. **SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY**
B. **BASIC TOPICS IN PHYSICAL SCIENCE**
C. **MECHANICS**
D. **ELECTRICITY AND MAGNETISM**
E. **WAVES**
F. **MODERN PHYSICS**
G. **SCIENCE, TECHNOLOGY, AND SOCIETY**
H. **PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES**

For each statement within each of these content areas, you will be asked to make the following judgments:

How important is an understanding of this knowledge area for newly licensed (certified) physics teachers if they are to perform their jobs in a competent manner?

(0) Of no importance
(1) Of little importance
(2) Moderately important
(3) Important
(4) Very important

What level of understanding is typically needed by newly licensed (certified) physics teachers in each knowledge area?

(Note: These levels are hierarchically arranged: level #2 subsumes level #1; level #3 subsumes levels #2 and #1; level #4 subsumes levels #3, #2, and #1. The zero (0) point is not subsumed by any other scale point.)

(0) An understanding of the knowledge area is not needed.
(1) Requires the ability to define the terms used in the knowledge area.
(2) Requires the ability to comprehend the essential properties of the knowledge area.
(3) Requires the ability to apply/utilize the knowledge area to address problems or questions.
(4) Requires the ability to analyze the knowledge area into component parts and explain the interrelationships among the parts.

Circle your responses using the scales adjacent to each statement. To familiarize yourself with the content areas and statements, you may wish to glance through Part I before making your judgments.

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY	IMPORTANCE	LEVEL OF UNDERSTANDING
Methodology		
1. Scientific methods (e.g., formulation of problem, hypotheses, experiments, interpretations, predictions, conclusions)	0 1 2 3 4	0 1 2 3 4
2. Science process skills (e.g., qualitative and quantitative observations, interpretations, communication, inferences, applications)	0 1 2 3 4	0 1 2 3 4
3. Assumptions, models, laws, and theories	0 1 2 3 4	0 1 2 3 4
4. Design of experiments (e.g., controls, independent and dependent variables)	0 1 2 3 4	0 1 2 3 4
History and Philosophy of Science		
5. Historical roots of science	0 1 2 3 4	0 1 2 3 4
6. Contributions of individuals	0 1 2 3 4	0 1 2 3 4
7. Contributions of ethnic groups and cultures	0 1 2 3 4	0 1 2 3 4
Mathematics, Measurement, and Data Manipulation		
8. The metric and SI systems	0 1 2 3 4	0 1 2 3 4
9. Scientific notation	0 1 2 3 4	0 1 2 3 4
10. Estimation and approximation	0 1 2 3 4	0 1 2 3 4
11. Significant figures in measurement and calculations	0 1 2 3 4	0 1 2 3 4
12. Unit/dimensional analysis	0 1 2 3 4	0 1 2 3 4
13. Experimental errors (e.g., sources, quantifications, precision, accuracy)	0 1 2 3 4	0 1 2 3 4
14. Mathematical relationships and patterns in numerical data (e.g., direct, exponential)	0 1 2 3 4	0 1 2 3 4
15. Statistics of distributions	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
16. Simple digital (binary) logic	0 1 2 3 4	0 1 2 3 4
17. Organization and interpretation of data and equations (e.g., tables, graphs, spreadsheets)	0 1 2 3 4	0 1 2 3 4
18. Differentiation and simple integration	0 1 2 3 4	0 1 2 3 4
19. Vector algebra	0 1 2 3 4	0 1 2 3 4
Laboratory and Safety		
20. Use and calibration of laboratory equipment (e.g., balances, electrical meters, barometers, optical equipment)	0 1 2 3 4	0 1 2 3 4
21. Maintenance of laboratory equipment (e.g., balances, electrical meters, barometers, optical equipment)	0 1 2 3 4	0 1 2 3 4
22. Preparation and set up of materials and apparatus	0 1 2 3 4	0 1 2 3 4
23. Laboratory safety (e.g., laboratory hazards, storage and disposal of materials)	0 1 2 3 4	0 1 2 3 4
24. Emergency procedures for laboratory accidents	0 1 2 3 4	0 1 2 3 4
25. Overall evaluation of the importance of Scientific Methodology/Techniques/History	0 1 2 3 4	

Evaluate each knowledge area in terms of <u>IMPORTANCE</u> for and <u>LEVEL OF UNDERSTANDING</u> needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

<u>IMPORTANCE</u>	**<u>LEVEL OF UNDERSTANDING</u>**
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) <u>DEFINE</u> the terms used in the knowledge area
(2) Moderately important	(2) <u>COMPREHEND</u> the essential properties of the knowledge area
(3) Important	(3) <u>APPLY/UTILIZE</u> the knowledge area to address problems or questions
(4) Very important	(4) <u>ANALYZE</u> the knowledge area into component parts and explain the interrelationships among the parts

A. <u>SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)</u>

26. How well do the knowledge areas in section A cover the important aspects of Scientific Methodology/Techniques/History?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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B. <u>BASIC TOPICS IN PHYSICAL SCIENCE</u>	<u>IMPORTANCE</u>	LEVEL OF <u>UNDERSTANDING</u>
<u>Matter and Energy</u>		
27. Physical and chemical properties (e.g., states of matter, homogeneous, heterogeneous)	0 1 2 3 4	0 1 2 3 4
28. Particulate nature of matter (e.g., atoms, ions, molecules)	0 1 2 3 4	0 1 2 3 4
29. Elements, compounds, and mixtures	0 1 2 3 4	0 1 2 3 4
30. Physical and chemical changes	0 1 2 3 4	0 1 2 3 4
31. Conservation of mass/energy	0 1 2 3 4	0 1 2 3 4
32. Forms of energy (e.g., kinetic, potential, mechanical, sound, magnetic, electrical, light, heat, nuclear, chemical)	0 1 2 3 4	0 1 2 3 4
33. Energy transformations	0 1 2 3 4	0 1 2 3 4
<u>Heat and Thermodynamics</u>		
34. Historical development of heat and energy concepts	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
35. Kinetic molecular theory	0 1 2 3 4	0 1 2 3 4
36. Equipartition of energy	0 1 2 3 4	0 1 2 3 4
37. Brownian motion	0 1 2 3 4	0 1 2 3 4
38. Heat *versus* temperature	0 1 2 3 4	0 1 2 3 4
39. Temperature scales and measurement	0 1 2 3 4	0 1 2 3 4
40. Conduction, convection, and radiation	0 1 2 3 4	0 1 2 3 4
41. Heat capacity, thermal exchange, heat of fusion, and heat of vaporization	0 1 2 3 4	0 1 2 3 4
42. Phase changes	0 1 2 3 4	0 1 2 3 4
43. Expansion and contraction	0 1 2 3 4	0 1 2 3 4
44. Zeroth law of thermodynamics (i.e., direction of heat flow)	0 1 2 3 4	0 1 2 3 4
45. First law of thermodynamics (i.e., energy is conserved)	0 1 2 3 4	0 1 2 3 4
46. Second law of thermodynamics - entropy	0 1 2 3 4	0 1 2 3 4
47. Third law of thermodynamics (i.e., the concept of absolute zero temperature)	0 1 2 3 4	0 1 2 3 4
48. Reversibility and irreversibility	0 1 2 3 4	0 1 2 3 4
Atomic and Nuclear Structure		
49. Historical discovery of particles (e.g., electron, neutron)	0 1 2 3 4	0 1 2 3 4
50. Atomic models and their experimental bases (Thomson, Rutherford, and Bohr)	0 1 2 3 4	0 1 2 3 4
51. Structure of the atom	0 1 2 3 4	0 1 2 3 4
52. Characteristics of an electron in an atom (e.g., shells, orbitals)	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
53. Atomic mass, atomic number, mass number, and isotopes	0 1 2 3 4	0 1 2 3 4
54. Nuclear forces and binding energy	0 1 2 3 4	0 1 2 3 4
55. Types of radioactive decay (e.g., alpha, beta, gamma emission)	0 1 2 3 4	0 1 2 3 4
56. Artificial and natural radioactivity	0 1 2 3 4	0 1 2 3 4
57. Half-life of radioactive isotopes	0 1 2 3 4	0 1 2 3 4
58. Nuclear reaction (transmutation, fission, fusion)	0 1 2 3 4	0 1 2 3 4
59. Overall evaluation of the importance of Basic Topics in Physical Science	0 1 2 3 4	

60. How well do the knowledge areas in section B cover the important aspects of Basic Topics in Physical Science?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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C. MECHANICS	IMPORTANCE	LEVEL OF UNDERSTANDING
61. Vector quantities	0 1 2 3 4	0 1 2 3 4
62. Relationships among position, velocity, acceleration, and time for straight line motion	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

C. MECHANICS (cont.)

		IMPORTANCE	LEVEL OF UNDERSTANDING
63.	Reference frames and relative velocity (e.g., Galilean relativity)	0 1 2 3 4	0 1 2 3 4
64.	Relationships among position, velocity, constant acceleration, and time for projectile motion	0 1 2 3 4	0 1 2 3 4
65.	Relationships among position, velocity, and centripetal acceleration for uniform circular motion	0 1 2 3 4	0 1 2 3 4
66.	Periodic motion (e.g., frequency, period, amplitude)	0 1 2 3 4	0 1 2 3 4
67.	Simple harmonic motion (oscillations)	0 1 2 3 4	0 1 2 3 4
68.	Newton's laws of motion	0 1 2 3 4	0 1 2 3 4
69.	Weight *versus* mass	0 1 2 3 4	0 1 2 3 4
70.	Friction (e.g., static and dynamic coefficients)	0 1 2 3 4	0 1 2 3 4
71.	Statics (e.g., equilibrium of forces and/or torques)	0 1 2 3 4	0 1 2 3 4
72.	Relationships between work and kinetic energy changes	0 1 2 3 4	0 1 2 3 4
73.	Conservative forces and potential energy	0 1 2 3 4	0 1 2 3 4
74.	Springs (e.g., Hooke's law, energy considerations)	0 1 2 3 4	0 1 2 3 4
75.	Concepts of rigid body motion (e.g., moment of inertia, center of mass, torque, angular momentum)	0 1 2 3 4	0 1 2 3 4
76.	Impulse-momentum principle	0 1 2 3 4	0 1 2 3 4
77.	Conservation of momentum (in both elastic and inelastic collisions)	0 1 2 3 4	0 1 2 3 4
78.	Conservation of angular momentum	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

C. MECHANICS (cont.)

		IMPORTANCE	LEVEL OF UNDERSTANDING
79.	Conservation of energy	0 1 2 3 4	0 1 2 3 4
80.	Orbital motion (e.g., Copernicus, Galileo, Kepler)	0 1 2 3 4	0 1 2 3 4
81.	Newton's law of universal gravitation	0 1 2 3 4	0 1 2 3 4
82.	Fluid mechanics (e.g., Pascal's principle, Archimedes' principle, Bernoulli's principle)	0 1 2 3 4	0 1 2 3 4
83.	Relativistic effects on length, mass, and time (e.g., Lorentz transformations)	0 1 2 3 4	0 1 2 3 4
84.	**Overall evaluation of the importance of Mechanics**	0 1 2 3 4	

85. How well do the knowledge areas in section C cover the important aspects of Mechanics?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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D. ELECTRICITY AND MAGNETISM

		IMPORTANCE	LEVEL OF UNDERSTANDING
86.	Electric forces and Coulomb's law (e.g., electroscope, pith ball experiments)	0 1 2 3 4	0 1 2 3 4
87.	Electric fields	0 1 2 3 4	0 1 2 3 4
88.	Gauss's law	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D. ELECTRICITY AND MAGNETISM (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
89. Electric potential energy, electric potential, and potential difference	0 1 2 3 4	0 1 2 3 4
90. Conductors, insulators, semiconductors	0 1 2 3 4	0 1 2 3 4
91. Current	0 1 2 3 4	0 1 2 3 4
92. Resistance	0 1 2 3 4	0 1 2 3 4
93. Series and parallel circuits (e.g., Ohm's law, Kirchhoff's laws)	0 1 2 3 4	0 1 2 3 4
94. Internal resistance of batteries	0 1 2 3 4	0 1 2 3 4
95. Capacitance	0 1 2 3 4	0 1 2 3 4
96. Inductance	0 1 2 3 4	0 1 2 3 4
97. Measurement of potential difference, current, resistance, and capacitance	0 1 2 3 4	0 1 2 3 4
98. Alternating current circuits (e.g., average power, peak, effective current)	0 1 2 3 4	0 1 2 3 4
99. Magnetic flux	0 1 2 3 4	0 1 2 3 4
100. Faraday's and Lenz's laws of electromagnetic induction	0 1 2 3 4	0 1 2 3 4
101. Transformers	0 1 2 3 4	0 1 2 3 4
102. Sources of EMF (e.g., batteries, photo cells, generators)	0 1 2 3 4	0 1 2 3 4
103. Motors	0 1 2 3 4	0 1 2 3 4
104. Large scale generation and transmission of energy and power	0 1 2 3 4	0 1 2 3 4
105. *n*- and *p*-type semiconductors	0 1 2 3 4	0 1 2 3 4
106. Semiconductor devices (e.g., diodes, transistors)	0 1 2 3 4	0 1 2 3 4
107. Integrated circuits	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D. ELECTRICITY AND MAGNETISM (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
108. Superconductivity	0 1 2 3 4	0 1 2 3 4
109. Magnets	0 1 2 3 4	0 1 2 3 4
110. Magnetic fields	0 1 2 3 4	0 1 2 3 4
111. Gauss's law of magnetism (nonexistence of monopoles)	0 1 2 3 4	0 1 2 3 4
112. Magnetic forces	0 1 2 3 4	0 1 2 3 4
113. Principle and calibration of electrical meters (e.g., galvanometers, voltmeters, ammeters)	0 1 2 3 4	0 1 2 3 4
114. Types of magnetism (e.g., diamagnetism)	0 1 2 3 4	0 1 2 3 4
115. Biot-Savart law and Ampere's law (relating current to magnetic field)	0 1 2 3 4	0 1 2 3 4
116. Maxwell's equations	0 1 2 3 4	0 1 2 3 4
117. Lorentz force law and applications (force on a charged particle moving in an electric and/or a magnetic field; cyclotron; mass spectrometry)	0 1 2 3 4	0 1 2 3 4
118. **Overall evaluation of the importance of Electricity and Magnetism**	0 1 2 3 4	

119. How well do the knowledge areas in section D cover the important aspects of Electricity and Magnetism?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE

(0) Of no importance
(1) Of little importance
(2) Moderately important
(3) Important
(4) Very important

LEVEL OF UNDERSTANDING

(0) An understanding of the knowledge area is not needed
(1) DEFINE the terms used in the knowledge area
(2) COMPREHEND the essential properties of the knowledge area
(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. WAVES	IMPORTANCE	LEVEL OF UNDERSTANDING
120. Wave characteristics (speed, amplitude, wavelength, frequency)	0 1 2 3 4	0 1 2 3 4
121. Inverse square law for intensity	0 1 2 3 4	0 1 2 3 4
122. Transverse and longitudinal waves	0 1 2 3 4	0 1 2 3 4
123. Absorption and transmission	0 1 2 3 4	0 1 2 3 4
124. Reflection	0 1 2 3 4	0 1 2 3 4
125. Scattering	0 1 2 3 4	0 1 2 3 4
126. Refraction and Snell's law	0 1 2 3 4	0 1 2 3 4
127. Interference and superposition of waves	0 1 2 3 4	0 1 2 3 4
128. Standing waves	0 1 2 3 4	0 1 2 3 4
129. Diffraction (Fraunhofer and Fresnel)	0 1 2 3 4	0 1 2 3 4
130. Dispersion	0 1 2 3 4	0 1 2 3 4
131. Resonance and natural frequencies	0 1 2 3 4	0 1 2 3 4
132. Doppler effect	0 1 2 3 4	0 1 2 3 4
133. Characteristics of sound waves (pitch, loudness [dB], speed)	0 1 2 3 4	0 1 2 3 4
134. Sound: air columns and strings (e.g., timbre, beats, harmonics)	0 1 2 3 4	0 1 2 3 4
135. The electromagnetic spectrum (gamma rays to radio waves)	0 1 2 3 4	0 1 2 3 4
136. Color (addition and subtraction; relationship to frequency)	0 1 2 3 4	0 1 2 3 4
137. Coherent radiation (sources and special properties)	0 1 2 3 4	0 1 2 3 4
138. Geometric optics (e.g., mirrors, lenses, prisms, fiber optics)	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. WAVES (cont.)

		IMPORTANCE	LEVEL OF UNDERSTANDING
139.	Polarization	0 1 2 3 4	0 1 2 3 4
140.	Thin films	0 1 2 3 4	0 1 2 3 4

141. **Overall evaluation of the importance of Waves** 0 1 2 3 4

142. How well do the knowledge areas in section E cover the important aspects of Waves?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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F. MODERN PHYSICS

		IMPORTANCE	LEVEL OF UNDERSTANDING
143.	Blackbody radiation	0 1 2 3 4	0 1 2 3 4
144.	Photoelectric effect	0 1 2 3 4	0 1 2 3 4
145.	Spectroscopy	0 1 2 3 4	0 1 2 3 4
146.	Planck's hypothesis	0 1 2 3 4	0 1 2 3 4
147.	deBroglie's hypothesis	0 1 2 3 4	0 1 2 3 4
148.	Wave-particle duality	0 1 2 3 4	0 1 2 3 4
149.	Heisenberg uncertainty principle	0 1 2 3 4	0 1 2 3 4
150.	Schrödinger's wave equation	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

F. MODERN PHYSICS (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
151. Orbital theory - quantum numbers	0 1 2 3 4	0 1 2 3 4
152. Pauli exclusion principle	0 1 2 3 4	0 1 2 3 4
153. Michelson-Morley experiment (ether and the speed of light)	0 1 2 3 4	0 1 2 3 4
154. Special relativity	0 1 2 3 4	0 1 2 3 4
155. Lorentz transformations and inertial reference frames	0 1 2 3 4	0 1 2 3 4
156. Mass/energy transformations	0 1 2 3 4	0 1 2 3 4
157. Elementary particles (e.g., hadrons, leptons)	0 1 2 3 4	0 1 2 3 4
158. Strong and weak forces	0 1 2 3 4	0 1 2 3 4
159. **Overall evaluation of the importance of Modern Physics**	0 1 2 3 4	

160. How well do the knowledge areas in section F cover the important aspects of Modern Physics?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

G. SCIENCE, TECHNOLOGY, AND SOCIETY	IMPORTANCE	LEVEL OF UNDERSTANDING
161. Awareness of ethical and moral responsibilities of scientists	0 1 2 3 4	0 1 2 3 4
162. Awareness of ethical issues, risks, and benefits associated with the applications of science	0 1 2 3 4	0 1 2 3 4
163. Detection of environmental hazards	0 1 2 3 4	0 1 2 3 4
164. Risk management issues associated with energy production, transmission, and use	0 1 2 3 4	0 1 2 3 4
165. Risk management issues associated with production, storage, use, and disposal of consumer products	0 1 2 3 4	0 1 2 3 4
166. Waste management issues and recycling	0 1 2 3 4	0 1 2 3 4
167. Management of resources (e.g., soil, water, metals, fossil fuels)	0 1 2 3 4	0 1 2 3 4
168. Use of science and technology to predict and prepare for natural disasters	0 1 2 3 4	0 1 2 3 4
169. Use of technology in everyday life (e.g., lamp, smoke detector, TV, computer, internal combustion engine)	0 1 2 3 4	0 1 2 3 4
170. Technology transfer (e.g., spin-offs from space technology, superconductors)	0 1 2 3 4	0 1 2 3 4
171. Social, political and economic issues arising from science and technology	0 1 2 3 4	0 1 2 3 4
172. Overall evaluation of the importance of Science, Technology, and Society	0 1 2 3 4	

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

G. SCIENCE, TECHNOLOGY, AND SOCIETY (cont.)

173. How well do the knowledge areas in section G cover the important aspects of Science, Technology, and Society?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES

	IMPORTANCE	LEVEL OF UNDERSTANDING
174. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences	0 1 2 3 4	0 1 2 3 4
175. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect students' learning of the physical sciences	0 1 2 3 4	0 1 2 3 4
Curriculum: Organization and Materials		
176. Reasons for learning the physical sciences	0 1 2 3 4	0 1 2 3 4
177. Reasons for teaching a particular topic in physical sciences	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)

		IMPORTANCE	LEVEL OF UNDERSTANDING
178.	Integration within topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
179.	Integration among the physical sciences and other disciplines	0 1 2 3 4	0 1 2 3 4
180.	Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	0 1 2 3 4	0 1 2 3 4
181.	Lesson plans in the physical sciences curricula for all students and justification for the plans	0 1 2 3 4	0 1 2 3 4
182.	Selection and use of curricular materials and resources (e.g., textbooks and other printed materials, computer software, laboratory materials) for the physical sciences	0 1 2 3 4	0 1 2 3 4
183.	Selection and use of mass media (e.g., film, television, video) appropriate for topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
184.	Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	0 1 2 3 4	0 1 2 3 4

Instruction

		IMPORTANCE	LEVEL OF UNDERSTANDING
185.	Prerequisite knowledge, experience, and skills that students need for various topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
186.	Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)

	IMPORTANCE	LEVEL OF UNDERSTANDING
187. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	0 1 2 3 4	0 1 2 3 4
188. Design of appropriate lab experiences for various instructional goals and student learning needs	0 1 2 3 4	0 1 2 3 4
189. Strategies for motivating and encouraging students to succeed in the physical sciences	0 1 2 3 4	0 1 2 3 4
190. Strategies for addressing controversial and/or sensitive issues in the physical sciences	0 1 2 3 4	0 1 2 3 4
Assessment and Evaluation		
191. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	0 1 2 3 4	0 1 2 3 4
192. Errors in student work and performance that arise from prior conceptions about topics in the physical sciences	0 1 2 3 4	0 1 2 3 4
Professional Concerns		
193. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	0 1 2 3 4	0 1 2 3 4
194. Professional and scholarly organizations for science educators	0 1 2 3 4	0 1 2 3 4
195. Legal responsibilities and liabilities for teachers in the physical sciences	0 1 2 3 4	0 1 2 3 4
196. Responsibilities for continuing education in the physical sciences and in science education	0 1 2 3 4	0 1 2 3 4
197. Resources available in the community	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of physics courses if they are to perform their job in a competent manner.

IMPORTANCE	**LEVEL OF UNDERSTANDING**
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
198. Science-related career information	0 1 2 3 4	0 1 2 3 4
199. **Overall evaluation of the importance of Pedagogy Specific to the Physical Sciences ....**	0 1 2 3 4	

200. How well do the knowledge areas in section H cover the important aspects of Pedagogy Specific to the Physical Sciences?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

____

____

PART II - RECOMMENDATIONS FOR TEST CONTENT

Listed below are eight broad topics that may be covered on the new licensing examination for physics. If the examination contained 100 questions, how many questions should be included from each topic? If you feel a category should not be included in the exam, put 0 in the space provided. Make sure your responses sum to 100.

<u>TOPICS</u>	<u>NUMBER OF TEST QUESTIONS (out of 100)</u>
201. SCIENTIFIC METHODOLOGY/TECHNIQUES/ HISTORY	______
202. BASIC TOPICS IN PHYSICAL SCIENCE	______
203. MECHANICS	______
204. ELECTRICITY AND MAGNETISM	______
205. WAVES	______
206. MODERN PHYSICS	______
207. SCIENCE, TECHNOLOGY, AND SOCIETY	______
208. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES	______
TOTAL	100

PART III - BACKGROUND INFORMATION

The information that you provide in this section is completely confidential and will be used for research purposes only. Please answer the questions by circling the number that most closely describes you or your professional activities. Unless otherwise indicated, please circle only one response for each question.

209. Where do you work?

1. Alabama
2. Alaska
3. Arizona
4. Arkansas
5. California
6. Colorado
7. Connecticut
8. Delaware
9. District of Columbia
10. Florida
11. Georgia
12. Hawaii
13. Idaho
14. Illinois
15. Indiana
16. Iowa
17. Kansas
18. Kentucky
19. Louisiana
20. Maine
21. Maryland
22. Massachusetts
23. Michigan
24. Minnesota
25. Mississippi
26. Missouri
27. Montana
28. Nebraska
29. Nevada
30. New Hampshire
31. New Jersey
32. New Mexico
33. New York
34. North Carolina
35. North Dakota
36. Ohio
37. Oklahoma
38. Oregon
39. Pennsylvania
40. Puerto Rico
41. Rhode Island
42. South Carolina
43. South Dakota
44. Tennessee
45. Texas
46. Utah
47. Vermont
48. Virginia
49. Washington
50. West Virginia
51. Wisconsin
52. Wyoming

210. What is your age?

1. Under 25
2. 25-34
3. 35-44
4. 45-54
5. 55-64
6. Over 64

211. What is your sex?

1. Female
2. Male

212. Which of the following best describes the area in which you work?

1. Urban
2. Suburban
3. Rural

213. How do you describe yourself?

1. Native American, American Indian, or Alaskan Native
2. Asian American, Asian, Native Hawaiian, or Pacific Islander
3. African American or Black
4. Mexican American or Chicano
5. Puerto Rican
6. Latin American, South American, Central American, or other Hispanic
7. White
8. Other

214. Which of the following best describes your highest educational attainment?

1. Less than a bachelor's
2. Bachelor's
3. Bachelor's + additional credits
4. Master's
5. Master's + additional credits
6. Doctorate

215. Which of the following best describes your current employment status?

1. Temporary substitute (assigned on a daily basis)
2. Permanent substitute (assigned on a longer term basis)
3. Regular teacher (not a substitute)
4. Principal or assistant principal
5. School administrator
6. Curriculum supervisor
7. State administrator
8. College faculty
9. Other (please specify)________________________________

216. How many years have you taught physics?

1. Never taught physics
2. Less than a year
3. 1 - 2 years
4. 3 - 5 years
5. 6 - 10 years
6. 11 - 15 years
7. 16 - 20 years
8. 21 or more years

217. What grade level(s) are you currently teaching? (Circle all that apply)

1. Preschool/Kindergarten
2. Grades 1-4
3. Grades 5-8
4. Grades 9-12
5. College
6. Do not teach
7. Other (please specify)________________________________

218. Which of the following describes your current teaching assignment? (Circle all that apply)?

1. Biology
2. Earth and Space Science
3. Ecology
4. General Science
5. Marine Science
6. Physical Science
7. Physics
8. Chemistry
9. College
10. Do not teach
11. Other (please specify)______________________________

219. Circle the following organizations to which you belong.

1. American Association of Physics Teachers
2. American Association for the Advancement of Science
3. American Chemical Society
4. American Federation of Teachers
5. National Association of Biology Teachers
6. National Association for Research in Science Teaching
7. National Science Supervisors Association
8. National Science Teachers Association
9. National Association for Science, Technology, and Society
10. National Education Association
11. Other (please specify)______________________________

THANK YOU FOR COMPLETING THIS INVENTORY.
PLEASE RETURN IT WITHIN 10 DAYS USING THE ENCLOSED ENVELOPE.

Appendix D

Da1 Survey Cover Letter - Chemistry

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

609-921-9000
609-734-1090 (Fax)
CABLE-EDUCTESTSVC

DIVISION OF APPLIED
MEASUREMENT RESEARCH

October 1990

Dear Colleague:

I am writing to ask your cooperation in a project that should be of importance to teachers, college faculty, administrators, and other professionals in your field. Educational Testing Service (ETS) is in the process of developing a new generation of assessments for the purpose of licensing teachers. One type of assessment will be created to measure the prospective teacher's subject-matter or specialty-area knowledge and will likely take place upon completion of the undergraduate teacher education program. One such assessment is a new version of the NTE Chemistry examination. I am asking for your help as we develop this examination.

As part of the developmental process, ETS has worked closely with an advisory committee of classroom teachers, college faculty, and school administrators to identify potentially important knowledge and skill areas in chemistry instruction. The enclosed inventory has been constructed as a way to obtain your judgments of the importance of these areas for newly licensed (certified) chemistry teachers. Your responses and those of other professionals to this inventory will guide the development of the new examination.

You will notice that the inventory asks for some background information about you; this is solely for purposes of describing respondents. **Your answers will be treated in strict confidence.**

A postage-paid envelope is enclosed for the return of your completed inventory. Thank you for your participation in this very important project.

Sincerely,

Richard Tannenbaum, Ph.D.
Associate Research Scientist

Enclosures (2)

Db1 <u>Survey Cover Letter - Physics</u>

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

609-921-9000
609-734-1090 (Fax)
CABLE-EDUCTESTSVC

DIVISION OF APPLIED
MEASUREMENT RESEARCH

October 1990

Dear Colleague:

I am writing to ask your cooperation in a project that should be of importance to teachers, college faculty, administrators, and other professionals in the field. Educational Testing Service (ETS) is in the process of developing a new generation of assessments for the purpose of licensing teachers. One type of assessment will be created to measure the prospective teacher's subject-matter or specialty-area knowledge and will likely be administered upon completion of the undergraduate teacher education program. One such assessment is a new version of the NTE Physics examination. I am asking for your help as we develop this examination.

As part of the developmental process, ETS has worked closely with an advisory committee of classroom teachers, college faculty, and school administrators to identify potentially important knowledge and skill areas in physics instruction. The enclosed inventory has been constructed as a way to obtain your judgments of the importance of these areas for newly licensed (certified) physics teachers. Your responses and those of other professionals to this inventory will guide the development of the new examination.

You will notice that the inventory asks for some background information about you; this is solely for purposes of describing respondents. **Your answers will be treated in strict confidence.**

A postage-paid envelope is enclosed for the return of your completed inventory. Thank you for your participation in this important project.

Sincerely,

Richard Tannenbaum, Ph.D.
Associate Research Scientist

Enclosures (2)

Appendix E

Ea1 Respondent Demographic - Chemistry

	Number	Percent
GEOGRAPHIC REGION		
Northeast	70	21.4
Central	94	28.7
Southern	76	23.2
Far West	87	26.6
Total	327	
Missing Responses	2	
AGE (years)		
Under 25	4	1.2
25 - 34	66	20.2
35 - 44	79	24.2
45 - 54	118	36.1
55 - 64	47	14.4
Over 64	13	4.0
Total	327	
Missing Responses	2	
SEX		
Female	105	32.1
Male	222	67.9
Total	327	
Missing Responses	2	
SCHOOL SETTING		
Urban	100	30.8
Suburban	142	43.7
Rural	83	25.5
Total	325	
Missing Responses	4	

	Number	Percent
RACE/ETHNICITY		
Native American	5	1.6
Asian American	9	2.8
Black	5	1.6
Mexican American	1	0.3
Puerto Rican	1	0.3
Hispanic	1	0.3
White	297	92.2
Other	3	0.9
Total	322	
Missing Responses	7	
HIGHEST EDUCATIONAL ATTAINMENT		
Less than Bachelor's	0	0.0
Bachelor's	3	0.9
Bachelor's + Credits	49	15.0
Master's	22	6.7
Master's + Credits	136	41.7
Doctorate	116	35.6
Total	326	
Missing Responses	3	
CURRENT EMPLOYMENT STATUS		
Temporary Substitute	2	0.6
Permanent Substitute	1	0.3
Regular Teacher (not a substitute)	174	55.1
Principal/Assistant Principal	0	0.0
School Administrator	1	0.3
Curriculum Supervisor	4	1.3
State Administrator	0	0.0
College Faculty	81	25.6

	Number	Percent
CURRENT EMPLOYMENT STATUS (cont.)		
Other	53	16.8
Total	316	
Missing Responses	13	
TEACHING EXPERIENCE (years)		
Never taught	11	3.4
Less than 1	3	0.9
1 - 2	29	8.9
3 - 5	39	12.0
6 - 10	51	15.6
11 - 15	47	14.4
16 - 20	43	13.2
21 or more	103	31.6
Total	326	
Missing Responses	3	
GRADES CURRENTLY TEACHING[1]		
Preschool/Kindergarten	1	0.2
Grades 1 - 4	2	0.5
Grades 5 - 8	19	5.0
Grades 9 - 12	183	48.2
College	114	30.0
Do Not Teach	29	7.6
Other	32	8.4
Total	380	
CURRENT TEACHING ASSIGNMENT[1]		
Biology	35	5.8
Earth and Space Science	17	2.8
Ecology	5	0.8

	Number	Percent
CURRENT TEACHING ASSIGNMENT (cont.)		
General Science	19	3.2
Marine Science	6	1.0
Physical Science	50	8.3
Physics	60	10.0
Chemistry	265	44.0
College	61	10.1
Do Not Teach	30	5.0
Other	55	9.1
Total	603	
MEMBERSHIP IN ORGANIZATIONS[1]		
American Association of Physics Teachers	28	4.0
American Association for the Advancement of Science	56	8.0
American Chemical Society	257	36.3
American Federation of Teachers	7	1.0
National Association of Biology Teachers	6	0.8
National Association for Research in Science Teaching	6	0.8
National Science Supervisors Association	4	0.6
National Science Teachers Association	126	17.8
National Association for Science, Technology, and Society	1	0.1
National Educational Association	107	15.1
Other	110	15.5
Total	708	

[1] NOTE: Multiple responses were permitted. Hence, the total will exceed 329 and 100%.

Eb1 Respondent Demographic - Physics

	Number	Percent
GEOGRAPHIC REGION		
Northern	78	23.9
Central	96	29.4
Southern	80	24.5
Far West	72	22.1
Total	326	
Missing Responses	4	
AGE (years)		
Under 25	2	0.6
25 - 34	32	9.8
35 - 44	98	30.1
45 - 54	131	40.2
55 - 64	53	16.3
Over 64	10	3.1
Total	326	
Missing Responses	4	
SEX		
Female	60	18.4
Male	266	80.6
Total	326	
Missing Responses	4	
SCHOOL SETTING		
Urban	80	25.1
Suburban	126	39.5
Rural	113	35.4
Total	319	
Missing Responses	11	

	Number	Percent
RACE/ETHNICITY		
Native American	9	2.8
Asian American	9	2.8
Black	2	0.6
Mexican American	0	0.0
Puerto Rican	0	0.0
Hispanic	3	0.9
White	292	91.3
Other	5	1.6
Total	320	
Missing Responses	10	
HIGHEST EDUCATIONAL ATTAINMENT		
Less than Bachelor's	0	0.0
Bachelor's	3	0.9
Bachelor's + Credits	46	14.2
Master's	13	4.0
Master's + Credits	168	51.7
Doctorate	95	29.2
Total	325	
Missing Responses	5	
CURRENT EMPLOYMENT STATUS		
Temporary Substitute	0	0.0
Permanent Substitute	2	0.6
Regular Teacher (not a substitute)	189	59.1
Principal/Assistant Principal	3	0.9
School Administrator	3	0.9
Curriculum Supervisor	8	2.5
State Administrator	0	0.0
College Faculty	95	29.7

	Number	Percent
CURRENT EMPLOYMENT STATUS (cont.)		
Other	20	6.3
Total	320	
Missing Responses	10	
TEACHING EXPERIENCE (years)		
Never taught	5	1.5
Less than 1	2	0.6
1 - 2	9	2.8
3 - 5	36	11.1
6 - 10	56	17.3
11 - 15	43	13.3
16 - 20	59	18.2
21 or more	114	35.2
Total	324	
Missing Responses	6	
GRADES CURRENTLY TEACHING[1]		
Preschool/Kindergarten	1	0.3
Grades 1 - 4	2	0.6
Grades 5 - 8	11	3.1
Grades 9 - 12	194	54.0
College	121	33.7
Do Not Teach	12	3.3
Other	18	5.0
Total	359	
CURRENT TEACHING ASSIGNMENT[1]		
Biology	11	1.7
Earth and Space Science	22	3.4
Ecology	7	1.1

	Number	Percent
CURRENT TEACHING ASSIGNMENT (cont.)		
General Science	18	2.8
Marine Science	4	0.6
Physical Science	70	10.8
Physics	280	43.3
Chemistry	80	12.4
College	53	8.2
Do Not Teach	12	1.9
Other	89	13.8
Total	646	
MEMBERSHIP IN ORGANIZATIONS[1]		
American Association of Physics Teachers	258	36.8
American Association for the Advancement of Science	21	3.0
American Chemical Society	28	4.0
American Federation of Teachers	19	2.7
National Association of Biology Teachers	6	0.9
National Association for Research in Science Teaching	2	0.3
National Science Supervisors Association	13	1.9
National Science Teachers Association	123	17.5
National Association for Science, Technology, and Society	5	0.7
National Educational Association	114	16.2
Other	113	16.1
Total	702	

[1] NOTE: Multiple responses were permitted. Hence, the total will exceed 330 and 100%.

Appendix F

Fa1 Mean Importance Ratings by Teachers and Teacher Educators - Chemistry

	Teachers N = 175		Teacher Educators N = 81	
	Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY				
Methodology				
1. Scientific methods (e.g., formulation of problem, hypotheses, experiments)	3.53	0.68	3.44	0.72
2. Science process skills (e.g., qualitative and quantitative observations)	3.62	0.60	3.40	0.66
3. Assumptions, models, laws, and theories	3.36	0.67	3.21	0.75
4. Design of experiments (e.g., independent and dependent variables)	3.29	0.81	2.96	0.89
History and Philosophy of Science				
5. Historical roots of science	2.26	0.79	2.23	0.83
6. Contributions of individuals	2.18	0.79	2.10	0.85
7. Contributions of ethnic groups and cultures	1.73	0.87	1.27	0.94
Mathematics, Measurement, and Date Manipulation				
8. The metric and SI systems	3.73	0.55	3.57	0.63
9. Scientific notation	3.64	0.63	3.49	0.69
10. Estimation and approximation	3.11	0.81	3.07	0.83
11. Significant figures in measurement and calculations	3.30	0.81	3.22	0.87
12. Unit/dimensional analysis	3.56	0.74	3.25	0.92
13. Experimental errors (e.g., sources, quantifications, precision, accuracy)	3.10	0.74	2.79	0.79
14. Mathematical relationships and patterns in numerical data	3.17	0.74	2.83	0.86
15. Statistics of distributions	2.01	0.90	1.99	0.83
16. Simple digital (binary) logic	1.56	1.09	1.57	0.86
17. Organization and interpretation of data and equations	3.40	0.67	3.08	0.82
18. Differentiation and simple integration	1.53	1.01	1.81	0.95
Laboratory and Safety				
19. Use and calibration of laboratory equipment (e.g., laboratory burners)	3.60	0.65	3.24	0.81
20. Maintenance of laboratory equipment (e.g., laboratory burners, glassware)	3.16	0.86	2.73	0.91
21. Preparation and set-up of reagents, materials, and apparatus	3.73	0.64	3.22	0.78
22. Laboratory safety (e.g., storage and disposal of materials)	3.90	0.32	3.71	0.58
23. Emergency procedures for laboratory accidents	3.86	0.38	3.63	0.58
B. BASIC TOPICS IN PHYSICAL SCIENCE				
Matter and Energy				
26. Physical and chemical properties (e.g., homogeneous, heterogeneous)	3.32	0.71	3.36	0.74
27. Particulate nature of matter (e.g., atoms, ions, molecules)	3.72	0.52	3.64	0.56

Fa2

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)				
28. Elements, compounds, and mixtures	3.65	0.58	3.58	0.61
29. Physical and chemical changes	3.54	0.65	3.47	0.70
30. Conservation of mass/energy	3.49	0.63	3.34	0.79
31. Forms of energy (e.g., kinetic, sound, magnetic, electrical, light)	3.05	0.79	2.97	0.89
32. Energy transformations	3.00	0.82	2.78	0.82
Heat and Thermodynamics				
33. Historical development of heat and energy	1.92	0.82	1.82	0.85
34. Kinetic molecular theory	3.37	0.76	2.64	0.87
35. Brownian motion	2.28	0.95	2.01	0.77
36. Heat versus temperature	3.20	0.80	3.02	0.76
37. Temperature scales and measurement	3.26	0.74	2.90	0.80
38. Conduction, convection, and radiation	2.42	0.98	2.26	0.95
39. Heat capacity, thermal exchange, heat of fusion, and heat of vaporization	3.00	0.76	2.77	0.69
40. Concepts of enthalpy and entropy	3.05	0.85	2.70	0.83
41. Phase changes	3.34	0.67	2.84	0.75
42. Expansion and contraction	2.51	0.95	2.14	0.87
43. Zeroth law of thermodynamics (i.e., direction of heat flow)	2.59	1.00	2.59	0.91
44. First law of thermodynamics (i.e., energy is conserved)	3.10	0.89	3.15	0.85
45. Second law of thermodynamics - entropy	2.86	0.93	2.88	0.91
46. Third law of thermodynamics (i.e., concept of absolute zero temperature)	2.89	0.91	2.46	0.90
47. Reversibility and irreversibility	2.73	0.92	2.55	0.99
Atomic and Nuclear Structure				
48. Historical discovery of particles (e.g., electron, neutron)	2.55	0.91	2.12	0.87
49. Atomic models and their experimental bases	3.02	0.83	2.43	0.95
50. Structure of the atom	3.69	0.58	3.49	0.63
51. Planck's hypothesis	2.60	0.83	2.52	1.13
52. deBroglie's hypothesis	2.46	0.84	2.31	1.09
53. Heisenberg uncertainty principle	2.57	0.93	2.30	1.10
54. Schrödinger's wave equation	2.14	1.05	1.78	1.15
55. Orbital theory - quantum numbers	3.10	0.85	2.61	1.07
56. Characteristics of an electron in an atom (e.g., shells, orbitals)	3.52	0.61	3.22	0.76
57. Properties of electromagnetic radiation	2.87	0.92	2.73	0.87

Fa3

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)				
58. Spectroscopy	2.64	0.84	2.53	0.94
59. Pauli exclusion principle	2.85	0.95	2.68	1.00
60. Hund's rule	2.76	0.96	2.51	0.99
61. Chemical properties related to electron configuration	3.72	0.55	3.51	0.69
62. Atomic mass, atomic number, mass number and isotopes	3.74	0.52	3.49	0.73
63. Nuclear forces and binding energy	2.61	0.95	2.19	1.02
64. Mass/energy transformation	2.63	0.91	2.20	0.93
65. Types of radioactive decay (e.g., alpha, beta, gamma emission)	2.74	0.93	2.46	0.91
66. Artificial and natural radioactivity	2.49	0.96	2.21	0.98
67. Half-life of radioactive isotopes	2.59	0.98	2.31	0.93
68. Nuclear reactions (transmutations, fission, fusion)	2.61	1.01	2.30	0.93
C. CHEMICAL PERIODICITY				
71. The development of the periodic table	2.94	0.90	2.41	1.00
72. The position of metals, nonmetals, and metalloids	3.59	0.62	3.20	0.78
73. Trends in melting and boiling temperatures	2.75	0.85	2.29	1.00
74. Trends in atomic radii/ionization energy/electron affinity/ electronegativity	3.18	0.79	2.77	0.93
75. Relationship of period table to electron configurations of the atoms	3.65	0.61	3.41	0.75
76. Oxidation numbers for elements in a compound	3.58	0.62	3.02	0.77
77. Periodicity of the oxidation states of the elements	3.26	0.81	2.83	0.86
78. Chemical properties/reactions of elements as reflected by positions in periodic table	3.60	0.62	3.41	0.65
D. NOMENCLATURE				
81. Inorganic nomenclature of ionic compounds and acids	3.40	0.70	2.91	0.90
82. Nomenclature of the classes or organic compounds	2.49	0.86	2.49	0.89
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY				
85. Mole concept and mass-mole-number relationships	3.82	0.45	3.71	0.53
86. Information conveyed by a chemical formula	3.78	0.45	3.71	0.53
87. Law of constant composition and law of multiple proportions	3.19	0.76	2.89	1.00
88. Percent composition of elements in a compound	3.32	0.74	2.90	0.89
89. Information conveyed by empirical and molecular formulas	3.46	0.65	3.24	0.79
90. Ionic, covalent, and metallic bonds	3.52	0.61	3.31	0.79
91. Rules for calculating oxidation numbers of atoms in a compound	3.31	0.78	2.82	0.86

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)				
92. Electron dot formulas and structural formulas	3.34	0.69	2.99	0.90
93. Multiple bonds	2.99	0.84	2.96	0.82
94. Types of bonding related to electronegativity differences	3.13	0.82	2.87	0.77
95. Valence shell electron pair repulsion model for molecular shapes (VSEPR)	2.62	1.02	2.65	0.95
96. Simple structures of isomers	2.66	0.90	2.72	0.75
97. Chemical/physical properties of compounds	2.78	0.87	2.89	0.80
98. Hybrid orbitals	2.46	1.00	2.46	0.96
99. Resonance and delocalization	2.27	0.96	2.43	0.93
The Kinetic Theory and States of Matter				
100. Assumptions of the kinetic molecular theory of gases	3.35	0.75	2.85	0.92
101. Maxwell-Blotzmann velocity distributions	2.00	0.96	2.01	0.93
102. Diffusion of gases	2.78	0.80	2.47	0.85
103. Rel. among volume, pressure, temperature, and quantity for ideal gases	3.67	0.59	3.34	0.70
104. Dalton's law of partial pressures	3.25	0.76	3.00	0.72
105. Real versus ideal gases	2.91	0.87	2.46	0.84
106. Forces of attraction among molecules	2.95	0.83	3.04	0.85
107. Phase changes for a pure substance	2.86	0.88	2.56	0.87
108. Rel. among evaporation rate, boiling temperature, and vapor pressure	2.86	0.81	2.61	0.87
109. Special properties of water (e.g., density of solid versus liquid)	3.00	0.80	2.99	0.74
110. Rel. among phases of matter, forces between particles and particle energy	2.75	0.86	2.33	0.81
111. Characteristics of crystals	2.22	0.89	1.94	0.81
Chemical Reactions				
112. Equation balancing from written descriptions of chemical reactions	3.73	0.49	3.41	0.71
113. General types of chemical reactions	3.49	0.68	2.86	0.98
114. Stoichiometry	3.70	0.56	3.62	0.61
115. Endothermic and exothermic reactions	3.32	0.71	2.95	0.78
116. Spontaneity in chemical reactions	2.58	0.85	2.48	1.00
117. Collision theory and reaction rates	2.87	0.86	2.29	0.99
118. Activation energy and the effects of a catalyst	2.96	0.79	2.63	0.90
119. Rate-influencing factors in chemical reactions	3.19	0.76	2.96	0.80
120. Rate expressions and orders of reactions	2.48	0.84	2.25	0.95
121. Reaction mechanisms	2.40	0.91	2.03	1.03

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)				
122. Chemical equilibria	3.25	0.78	3.25	0.84
123. Le Châtelier's principle and factors that disturb the equilibrium of systems	3.35	0.75	3.18	0.83
124. Properties and production of ammonia (e.g., the Haber equilibrium)	2.11	1.01	1.71	0.82
125. Oxidation and reduction reactions	3.34	0.69	3.18	0.80
126. Electrochemical cells and electrode reactions	2.89	0.84	2.71	0.80
127. Metallurgical properties of the transition metals	1.97	0.93	1.63	0.85
128. Redox properties of the halogens and the halide ions	2.28	0.99	2.14	0.84
129. Faraday's laws of electrolysis	2.27	0.95	2.33	0.96
130. Practical applications of electrochemistry (e.g., electroplating, pH meter)	2.57	0.90	2.50	0.76
Solutions and Solubility				
131. Types of solutions (e.g., solid-solid, solid-liquid, liquid-gas)	3.00	0.89	2.48	0.78
132. Solutes, solvents and solubility	3.38	0.68	2.99	0.67
133. Effects of temperature and pressure on solubility	3.16	0.80	2.63	0.80
134. Dissolving process	3.08	0.77	2.51	0.87
135. Solubility product (K_{sp})	2.88	0.87	2.48	0.80
136. Concentration of solutes (e.g., dilute, concentrated, saturated; molarity)	3.50	0.65	3.26	0.82
137. Conductivity of solutions and the ionization process	2.99	0.81	2.70	0.82
138. Strong and weak electrolytes; non-electrolytes	3.10	0.81	2.83	0.81
139. Colligative properties of solutions	2.76	0.93	2.59	0.91
140. Characteristics of properties of acids, bases, and salts	3.63	0.56	3.58	0.59
141. Arrhenius, Brønsted-Lowery, and Lewis acid-base theories	3.13	0.88	3.06	0.88
142. pH of solutions of strong and weak acids and bases	3.39	0.75	3.31	0.76
143. Relative strengths of acids and bases	3.20	0.74	3.10	0.82
144. Production, properties, and use of the common acids	2.29	0.94	2.26	0.96
145. Acid-base titration and indicators	3.24	0.75	2.99	0.90
146. Buffer solutions	2.70	0.84	3.01	0.77
F. BIOCHEMISTRY				
149. Organic functional groups and their reactions	2.53	0.97	2.63	0.91
150. Monomers and polymers	2.37	0.95	2.56	0.92
151. Biologically important compounds (e.g., carbohydrates, amino acids)	2.49	0.95	2.65	0.91
152. Biologically important chemical processes (e.g., bioluminescence)	2.28	1.02	2.32	0.92

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
F. BIOCHEMISTRY (cont.)				
153. Structure and replication of nucleic acids	2.04	1.11	2.19	0.99
154. Energy storage and release in biological systems	2.09	1.10	2.09	0.98
G. SCIENCE, TECHNOLOGY, AND SOCIETY				
157. Awareness of ethical and moral responsibilities of scientists	3.05	0.93	2.86	0.97
158. Awareness of ethical issues/risks/benefits assoc. w/application of science	3.06	0.95	2.85	0.90
159. Detection of environmental hazards	3.10	0.81	2.51	1.06
160. Risk mgmt issues assoc. with energy production, transmission, and use	2.69	1.02	2.28	0.95
161. Risk mgmt issues assoc. w/production/storage/use/disposal of products	2.97	0.91	2.45	0.99
162. Waste management issues and recycling	2.99	0.94	2.46	0.92
163. Management of resources (e.g., soil, water, metals, and fossil fuels)	2.92	0.97	2.46	1.10
164. Use of science and technology to predict and prepare for natural disasters	2.31	1.03	1.77	0.97
165. Use of technology in everyday life (e.g., smoke detector, TV, computer)	2.74	0.98	2.52	1.00
166. Technology transfer (e.g., spin-offs from space technology,)	2.41	0.95	1.89	0.99
167. Issues assoc. with use of chemicals in agriculture/food prep./preservation	2.67	0.93	2.41	0.86
168. Social, political, and economic issues arising from science and technology	2.67	0.94	2.31	1.03
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES				
171. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences	2.65	0.94	2.43	1.07
172. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect student's learning of the physical sciences	2.91	0.95	2.70	1.05
Curriculum: Organization and Materials				
173. Reasons for learning the physical sciences	3.22	0.79	2.94	0.89
174. Reasons for teaching a particular topic in the physical sciences	3.19	0.76	2.78	0.92
175. Integration within topics in the physical sciences	3.24	0.77	2.94	0.71
176. Integration among the physical sciences and other disciplines	3.09	0.83	2.75	0.78
177. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	2.96	0.85	2.49	0.80
178. Lesson plans in the physical sciences curricula for all students, justification for the plans	2.86	0.97	2.30	1.02
179. Selection and use of curricular materials and resources (e.g., textbooks, and other printed materials, computer software, laboratory materials) for the physical sciences	3.14	0.90	3.00	0.78

	TEACHERS N = 175		TEACHER EDUCATORS N = 81	
	Mean	SD	Mean	SD
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)				
180. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences	2.70	0.90	2.21	0.95
181. Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	2.89	0.92	2.50	0.89
Instruction				
182. Prerequisite knowledge/experience/skills that students need for the physical sciences	3.14	0.76	3.04	0.79
183. Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	3.05	0.78	2.82	0.78
184. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	3.52	0.63	3.14	0.74
185. Design of appropriate lab experiences for various instructional goals and student learning needs	3.40	0.78	3.01	0.81
186. Strategies for motivating and encouraging students to succeed in the physical sciences	3.46	0.64	3.36	0.70
187. Strategies for addressing controversial and/or sensitive issues in the physical sciences	2.95	0.87	2.78	0.87
Assessment and Evaluation				
188. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	3.44	0.63	3.06	0.76
189. Errors in student work/performance from prior conceptions about the physical sciences	2.80	0.91	2.65	0.89
Professional Concerns				
190. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	2.83	0.86	2.81	0.77
191. Professional and scholarly organizations for science educators	2.80	0.86	2.65	0.88
192. Legal responsibilities/liabilities for teachers in the physical sciences	3.49	0.66	2.71	0.99
193. Responsibilities for continuing education in the physical sciences/in science education	3.18	0.76	2.81	0.99
194. Resources available in the community	2.95	0.81	2.74	0.80
195. Science-related career information	2.84	0.86	2.83	0.83

Fb1 Mean Importance Ratings by Teachers and Teacher Educators - Physics

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY				
Methodology				
1. Scientific methods (e.g., hypotheses, experiments)	3.40	0.77	3.29	0.84
2. Science process skills	3.45	0.71	3.40	0.69
3. Assumptions, models, laws, and theories	3.19	0.78	3.12	0.80
4. Design of experiments (e.g., independent and dependent variables)	3.20	0.88	3.01	0.82
History and Philosophy of Science				
5. Historical roots of science	2.32	0.81	2.45	0.92
6. Contributions of individuals	2.27	0.75	2.18	0.84
7. Contributions of ethnic groups and cultures	1.72	0.90	1.63	1.02
Mathematics, Measurement, and Date Manipulation				
8. The metric and SI systems	3.78	0.47	3.63	0.58
9. Scientific notation	3.65	0.59	3.57	0.61
10. Estimation and approximation	3.17	0.80	3.20	0.85
11. Significant figures in measurement and calculations	3.05	0.80	2.96	0.80
12. Unit/dimensional analysis	3.46	0.68	3.36	0.71
13. Experimental errors (e.g., quantifications, precision, accuracy)	2.93	0.80	2.78	0.79
14. Mathematical relationships and patterns in numerical data	3.32	0.77	3.15	0.82
15. Statistics of distributions	2.12	0.80	2.06	0.90
16. Simple digital (binary) logic	1.73	0.96	1.58	0.89
17. Organization and interpretation of data and equations	3.43	0.68	3.31	0.80
18. Differentiation and simple integration	2.13	1.04	2.64	1.02
19. Vector algebra	3.24	0.88	3.05	0.86
Laboratory and Safety				
20. Use and calibration of laboratory equipment (e.g., balances,)	3.22	0.80	3.14	0.85
21. Maintenance of laboratory equipment (e.g., balances, glassware)	2.71	0.99	2.66	0.89
22. Preparation and set-up of reagents, materials, and apparatus	3.33	0.80	3.16	0.83
23. Laboratory safety (e.g., storage and disposal of materials)	3.50	0.77	3.27	0.80
24. Emergency procedures for laboratory accidents	3.62	0.70	3.21	0.89

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
B. BASIC TOPICS IN PHYSICAL SCIENCE				
Matter and Energy				
27. Physical and chemical properties	2.84	0.90	2.76	0.91
28. Particulate nature of matter (e.g., atoms, ions, molecules)	3.20	0.78	3.16	0.75
29. Elements, compounds, and mixtures	2.79	0.95	2.74	0.88
30. Physical and chemical changes	2.90	0.94	2.72	0.96
31. Conservation of mass/energy	3.65	0.58	3.59	0.66
32. Forms of energy (e.g., kinetic, potential, magnetic, electrical, light)	3.68	0.55	3.60	0.59
33. Energy transformations	3.55	0.62	3.46	0.68
Heat and Thermodynamics				
34. Historical development of heat and energy	2.14	0.80	1.93	0.76
35. Kinetic molecular theory	3.03	0.85	2.52	0.85
36. Equipartition of energy	2.32	0.99	2.06	0.86
37. Brownian motion	2.24	0.86	1.99	0.87
38. Heat versus temperature	3.30	0.75	3.34	0.73
39. Temperature scales and measurement	3.11	0.82	2.94	0.79
40. Conduction, convection, and radiation	2.99	0.80	2.93	0.71
41. Heat capacity, thermal exch., heat of fusion, and heat of vaporization	3.14	0.79	2.99	0.75
42. Phase changes	3.13	0.78	2.83	0.79
43. Expansion and contraction	2.91	0.82	2.67	0.79
44. Zeroth law of thermodynamics (i.e., direction of heat flow)	2.89	0.86	2.98	0.85
45. First law of thermodynamics (i.e., energy is conserved)	3.36	0.76	3.46	0.76
46. Second law of thermodynamics - entropy	2.97	0.88	3.03	0.89
47. Third law of thermodynamics	2.94	0.90	2.47	0.84
48. Reversibility and irreversibility	2.47	0.90	2.36	0.95
Atomic and Nuclear Structure				
49. Historical discovery of particles (e.g., electron, neutron)	2.33	0.83	2.19	0.82
50. Atomic models and their experimental bases	2.68	0.86	2.85	0.70
51. Structure of the atom	3.19	0.78	3.40	0.61
52. Characteristics of an electron in an atom (e.g., shells, orbitals)	2.94	0.91	2.87	0.82
53. Atomic mass, atomic number, mass number and isotopes	3.00	0.93	3.03	0.79
54. Nuclear forces and binding energy	2.80	0.89	2.65	0.86
55. Types of radioactive decay (e.g., alpha, beta, gamma emission)	2.91	0.87	2.92	0.84

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)				
56. Artificial and natural radioactivity	2.62	0.92	2.71	0.92
57. Half-life of radioactive isotopes	2.81	0.86	2.81	0.91
58. Nuclear reactiona (transmutations, fission, fusion)	2.92	0.88	2.78	0.75
C. MECHANICS				
61. Vector quantities	3.73	0.49	3.52	0.62
62. Rel. among position/velocity/acceleration/time straight line motion	3.81	0.45	3.66	0.54
63. Reference frames and relative velocity (e.g., Galilean relativity)	3.09	0.84	2.59	0.87
64. Rel. position/velocity/constant acceleration/time for projectile motion	3.54	0.63	3.24	0.77
65. Rel. position/velocity/centripetal acceleration for uniform circular motion	3.35	0.73	3.15	0.75
66. Periodic motion (e.g., frequency, period, amplitude)	3.31	0.69	3.24	0.71
67. Simple harmonic motion (oscillations)	3.13	0.74	3.13	0.82
68. Newton's laws of motion	3.87	0.35	3.85	0.36
69. Weight versus mass	3.62	0.60	3.48	0.63
70. Friction (e.g., static and dynamic coefficients)	3.17	0.76	2.83	0.76
71. Static (e.g., equilibrium of forces and/or torques)	3.28	0.77	3.03	0.83
72. Relationships between work and kinetic energy changes	3.56	0.58	3.52	0.54
73. Conservative forcea and potential energy	3.41	0.65	3.36	0.67
74. Springa (e.g., Hooke's law, energy considerations)	2.81	0.83	2.85	0.78
75. Concepts of rigid body motion (e.g., moment or inertia, torque)	2.81	0.79	2.61	0.89
76. Impulse-momentum principle	3.36	0.67	2.88	0.85
77. Conservation of momentum (in both elastic and inelastic collisions)	3.57	0.58	3.54	0.60
78. Conservation of angular momentum	2.75	0.82	3.08	0.78
79. Conservation of energy	3.79	0.42	3.86	0.38
80. Orbital motion (e.g., Copernicus, Galileo, Kepler)	2.64	0.87	2.42	0.72
81. Newton's law of universal gravitation	3.46	0.68	3.32	0.71
82. Fluid mechanics (e.g., Pascal's principle, Bernoulli's principle)	2.48	0.84	2.51	0.80
83. Relativistic effects on length, mass, and time	2.35	0.87	2.16	0.98
D. ELECTRICITY AND MAGNETISM				
86. Electric forcea and Coulomb's law (e.g., pith ball experiments)	3.44	0.68	3.47	0.68
87. Electric fields	3.19	0.69	3.22	0.72
88. Gauss's law	2.52	0.90	2.32	1.01
89. Electric potential energy, electric potential, and potential difference	3.45	0.63	3.31	0.64

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
D. ELECTRICITY AND MAGNETISM (cont.)				
90. Conductors, insulators, semiconductors	3.19	0.75	2.94	0.76
91. Current	3.63	0.57	3.48	0.56
92. Resistance	3.60	0.59	3.41	0.61
93. Series and parallel circuits (e.g., Ohm's law, Kirchhoff's laws)	3.50	0.61	3.14	0.80
94. Internal resistance of batteries	2.60	0.95	2.28	0.93
95. Capacitance	2.83	0.87	2.77	0.91
96. Inductance	2.65	0.96	2.61	0.91
97. Measurement of potential difference/current/resistance/capacitance	3.27	0.72	3.13	0.72
98. Alternating current circuits (e.g., average power, peak, effective current)	2.60	0.88	2.36	0.97
99. Magnetic flux	2.69	0.86	2.69	0.89
100. Faraday's and Lenz's laws of electromagnetic induction	2.79	0.87	2.93	0.92
101. Transformers	2.74	0.86	2.36	0.91
102. Sources of EMF (e.g., batteries, photo cells, generators)	2.97	0.78	2.68	0.82
103. Motors	2.86	0.76	2.29	0.85
104. Large scale generation and transmission of energy and power	2.34	0.88	2.05	0.90
105. n- and p-type semiconductors	2.22	0.91	1.97	0.93
106. Semiconductor devices (e.g., diodes, transistors)	2.35	0.86	2.03	0.99
107. Integrated circuits	2.16	0.91	1.82	1.05
108. Superconductivity	2.49	0.86	1.98	0.81
109. Magnets	3.18	0.71	2.77	0.82
110. Magnetic fields	3.27	0.66	3.16	0.75
111. Gauss's law of magnetism (nonexistence of monopoles)	2.40	0.95	2.05	1.06
112. Magnetic forces	3.08	0.75	3.02	0.82
113. Principle and calibration of electrical meters (e.g., galvanometers)	2.52	0.95	2.17	0.97
114. Types of magnetism (e.g., diamagnetism)	2.13	0.87	1.82	0.82
115. Biot-Savart law and Ampere's law (relating current to magnetic field)	2.49	0.97	2.51	0.99
116. Maxwell's equations	2.13	0.99	2.20	1.16
117. Lorentz force law and applications (force on a charged particle moving in an electric and/or a magnetic field; cyclotron; mass spectrometry)	2.33	0.87	2.69	0.91
E. WAVES				
120. Wave characteristics (speed, amplitude, wavelength, frequency)	3.70	0.51	3.58	0.61
121. Inverse square law for intensity	3.06	0.85	2.72	0.81

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
E. WAVES (cont.)				
122. Transverse and longitudinal waves	3.45	0.67	3.07	0.82
123. Absorption and transmission	2.98	0.79	2.47	0.82
124. Reflection	3.47	0.67	3.06	0.82
125. Scattering	2.79	0.85	2.32	0.87
126. Refraction and Snell's law	3.48	0.64	3.23	0.72
127. Interference and superposition of waves	3.41	0.69	3.24	0.77
128. Standing waves	3.15	0.77	2.96	0.86
129. Diffraction (Fraunhofer and Fresnel)	3.03	0.81	2.73	0.88
130. Dispersion	2.66	0.84	2.39	0.79
131. Resonance and natural frequencies	2.98	0.78	3.04	0.80
132. Doppler effect	3.20	0.75	2.79	0.77
133. Characteristics of sound waves (pitch, loudness [dB], speed)	3.15	0.82	2.60	0.99
134. Sound: air columns and strings (e.g., timbre, beats, harmonics)	2.71	0.97	2.41	0.84
135. The electromagnetic spectrum (gamma rays to radio waves)	3.36	0.74	3.24	0.86
136. Color (addition and subtraction; relationship to frequency)	2.81	0.92	2.21	0.77
137. Coherent radiation (sources and special properties)	2.41	0.93	2.25	0.90
138. Geometric optics (e.g., mirrors, lenses, prisms, fiber optics)	3.37	0.72	3.20	0.79
139. Polarization	2.86	0.79	2.55	0.82
140. Thin films	2.41	0.83	2.01	0.87
F. MODERN PHYSICS				
143. Blackbody radiation	2.36	0.89	2.56	0.94
144. Photoelectric effect	3.02	0.81	2.97	0.82
145. Spectroscopy	2.82	0.84	2.95	0.82
146. Planck's hypothesis	2.74	0.92	2.85	1.02
147. deBroglie's hypothesis	2.51	0.90	2.85	0.98
148. Wave-particle duality	3.05	0.82	3.03	0.93
149. Heisenberg uncertainty principle	2.61	0.89	2.67	0.93
150. Schrödinger's wave equation	2.02	0.94	2.06	1.09
151. Orbital theory - quantum numbers	2.55	0.98	2.46	0.98
152. Pauli exclusion principle	2.36	0.97	2.62	1.00
153. Michelson-Morley experiment (ether and the speed of light)	2.65	0.92	2.52	0.95
154. Special relativity	2.61	0.88	2.62	0.96

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
F. MODERN PHYSICS (cont.)				
155. Lorentz transformations and inertial reference frames	2.14	0.88	2.12	0.95
156. Mass/energy transformations	2.84	0.87	2.74	0.89
157. Elementary particles (e.g., hadrons, leptons)	2.08	0.90	2.17	1.05
158. Strong and weak forces	2.31	0.91	2.09	1.04
G. SCIENCE, TECHNOLOGY, AND SOCIETY				
161. Awareness of ethical and moral responsibilities of scientists	2.94	0.90	2.84	0.96
162. Awareness of ethical issues, risks, and benefits assoc. with the application of science	2.92	0.89	2.88	0.90
163. Detection of environmental haz:	2.88	0.86	2.60	0.99
164. Risk management issues associated with energy production, transmission, and use	2.64	0.88	2.29	0.92
165. Risk mgmt issues associated with production/storage/use/disposal of products	2.64	0.92	2.16	0.91
166. Waste management issues and recycling	2.70	0.97	2.32	0.96
167. Management of resources (e.g., soil, water, metals, and fossil fuels)	2.67	0.96	2.28	0.93
168. Use of science and technology to predict and prepare for natural disasters	2.36	1.04	1.89	1.00
169. Use of technology in everyday life (e.g., lamp, smoke detector, TV, computer)	3.02	0.86	2.71	0.94
170. Technology transfer (e.g., spin-offs from space technology, superconductors)	2.59	0.89	1.98	0.93
171. Social, political, and economic issues arising from science and technology	2.75	0.88	2.34	0.93
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES				
174. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences	2.58	0.98	2.37	1.04
175. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect student's learning of the physical sciences	2.89	0.96	2.65	0.98
Curriculum: Organization and Materials				
176. Reasons for learning the physical sciences	3.22	0.86	2.94	0.94
177. Reasons for teaching a particular topic in the physical sciences	3.19	0.85	2.88	0.95
178. Integration within topics in the physical sciences	2.99	0.81	2.82	0.85
179. Integration among the physical sciences and other disciplines	2.86	0.82	2.64	0.79
180. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	2.63	0.92	2.37	1.00

	TEACHERS N = 191		TEACHER EDUCATORS N = 95	
	Mean	SD	Mean	SD
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)				
181. Lesson plans in the physical sciences curricula for all students, justification for the plans	2.51	1.00	2.07	1.10
182. Selection and use of curricular materials and resources (e.g., textbooks, and other printed materials, computer software, laboratory materials) for the physical sciences	3.10	0.80	2.80	0.87
183. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences	2.83	0.85	2.49	0.93
184. Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	2.95	0.80	2.59	0.94
Instruction				
185. Prerequisite knowledge/experience/skills that students need for the physical sciences	3.00	0.82	2.90	0.94
186. Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	2.94	0.87	2.99	0.99
187. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	3.33	0.74	3.26	0.76
188. Design of appropriate lab experiences for various instructional goals and student learning needs	3.24	0.80	3.10	0.87
189. Strategies for motivating and encouraging students to succeed in the physical sciences	3.38	0.72	3.36	0.77
190. Strategies for addressing controversial and/or sensitive issues in the physical sciences	2.70	0.92	2.56	0.92
Assessment and Evaluation				
191. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	3.22	0.77	2.98	0.76
192. Errors in stúdent work/performance from prior conceptions about the physical sciences	2.95	0.87	2.87	0.78
Professional Concerns				
193. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	2.82	0.82	2.74	0.83
194. Professional and scholarly organizations for science educators	2.76	0.88	2.78	0.87
195. Legal responsibilities/liabilities for teachers in the physical sciences	3.06	0.98	2.52	0.97
196. Responsibilities for continuing education in the physical sciences/in science education	3.00	0.81	2.67	0.95
197. Resources available in the community	2.75	0.95	2.66	1.04
198. Science-related career information	2.86	0.85	2.71	0.88

Appendix G

Ga1 <u>Percent of Responses by Level of Understanding Category - Chemistry</u>

	Level of Understanding % Responding 0	1	2	3	4
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
Methodology					
1 Scientific methods (e.g., formulation of problem, hypotheses, etc.)	.00	1.82	12.16	37.08	48.94
2 Science process skills (e.g., qualitative/quantitative observations)	.00	.61	10.03	41.34	48.02
3 Assumptions, models, laws, and theories	.00	2.45	19.27	44.65	33.64
4 Design of experiments (e.g., independent/dependent variables)	.00	3.06	17.43	39.45	40.06
History and Philosophy of Science					
5 Historical roots of science	2.78	19.44	56.79	17.59	3.40
6 Contributions of individuals	3.08	24.62	53.23	16.31	2.77
7 Contributions of ethnic groups and cultures	19.50	29.41	40.56	8.98	1.55
Mathematics, Measurement, and Data Manipulation					
8 The metric and SI systems	.00	1.53	5.50	37.00	55.96
9 Scientific notation	.00	2.15	7.67	40.49	49.69
10 Estimation and approximation	.31	2.45	19.88	53.21	24.16
11 Significant figures in measurement and calculations	.31	1.23	16.56	47.24	34.66
12 Unit/dimensional analysis	.92	2.45	9.48	37.61	49.54
13 Experimental errors (e.g., sources, precision, accuracy)	.00	3.37	23.93	44.48	28.22
14 Mathematical relationships and patterns in numerical data	.31	4.91	21.78	43.56	29.45
15 Statistics of distributions	6.42	16.21	42.81	29.97	4.59
16 Simple digital (binary) logic	17.30	28.30	32.39	17.30	4.72
17 Organization and interpretation of data and equations	.00	1.54	11.69	46.77	40.00
18 Differentiation and simple integration	15.00	16.88	35.63	27.50	5.00
Laboratory and Safety					
19 Use and calibration of laboratory equipment	.00	1.23	10.80	51.85	36.11
20 Maintenance of laboratory equipment	1.54	4.62	26.15	45.85	21.85
21 Preparation and set-up of reagents, materials, and apparatus	.62	.62	12.46	48.29	38.01
22 Laboratory safety	.00	.62	6.46	36.31	56.62
23 Emergency procedures for laboratory accidents	.00	.31	5.85	40.00	53.85

Level of Understanding: 0 = An understanding of the knowledge area is not needed; 1 = Define the terms used in the knowledge area; 2 = Comprehend the essential properties of the knowledge area; 3 = Apply/Utilize the knowledge area to address problems or questions; 4 = Analyze the knowledge area into component parts and explain the interrelationships among the parts.

Ga2

	Level of Understanding				
	% Responding				
	0	1	2	3	4
B. BASIC TOPICS IN PHYSICAL SCIENCE					
Matter and Energy					
26 Physical and chemical properties	.00	2.79	15.17	40.25	41.80
27 Particulate nature of matter	.00	.31	6.83	31.99	60.87
28 Elements, compounds, and mixtures	.00	.00	9.03	32.40	58.57
29 Physical and chemical changes	.00	1.56	10.28	37.07	51.09
30 Conservation of mass/energy	.00	.63	14.42	36.99	47.96
31 Forms of energy	.00	3.11	26.40	38.20	32.30
32 Energy transformations	.31	4.05	24.30	43.93	27.41
Heat and Thermodynamics					
33 Historical development of heat and energy concepts	3.45	20.69	51.72	20.38	3.76
34 Kinetic molecular theory	.31	4.64	22.60	38.39	34.06
35 Brownian motion	2.16	16.98	48.15	24.07	8.64
36 Heat <u>versus</u> temperature	.00	6.44	20.25	34.66	38.65
37 Temperature scales and measurement	.00	4.00	18.46	46.15	31.38
38 Conduction, convection, and radiation	1.55	14.55	38.08	29.41	16.41
39 Heat capacity/thermal exchange/heat of fusion and vaporization	.00	3.07	23.01	45.40	28.53
40 Concepts of enthalpy and entropy	.31	4.60	27.91	34.97	32.21
41 Phase changes	.00	3.68	19.33	42.33	34.66
42 Expansion and contraction	1.25	12.85	36.05	33.86	15.99
43 Zeroth law of thermodynamics	2.45	11.66	35.28	34.66	15.95
44 First law of thermodynamics	.61	5.52	23.01	37.12	33.74
45 Second law of thermodynamics	.62	5.54	29.23	39.69	24.92
46 Third law of thermodynamics	.61	7.95	32.42	36.39	22.63
47 Reversibility and irreversibility	.62	9.32	30.75	38.51	20.81
Atomic and Nuclear Structure					
48 Historical discovery of particles	1.23	16.62	44.31	25.23	12.62
49 Atomic models and their experimental bases	.62	7.72	35.49	32.72	23.46
50 Structure of the atom	.00	1.25	11.84	32.40	54.52

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Ga3

		Level of Understanding				
		% Responding				
		0	1	2	3	4
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)						
51	Planck's hypothesis	1.55	11.46	37.15	35.60	14.24
52	deBroglie's hypothesis	1.85	13.54	40.00	33.54	11.08
53	Heisenberg uncertainty principle	1.85	12.35	39.81	31.79	14.20
54	Schrödinger's wave equation	8.02	20.37	41.67	23.15	6.79
55	Orbital theory - quantum numbers	1.54	5.85	21.23	42.77	28.62
56	Characteristics of an electron in an atom	.00	2.45	12.58	41.72	43.25
57	Properties of electromagnetic radiation	.92	6.75	30.98	40.49	20.86
58	Spectroscopy	.61	8.28	37.12	35.89	18.10
59	Pauli exclusion principle	1.53	9.48	32.72	37.00	19.27
60	Hund's rule	1.85	10.15	31.38	38.15	18.46
61	Chemical properties related to electron configuration	.00	.61	6.69	31.91	60.79
62	Atomic mass, atomic number, mass number and isotopes	.00	2.14	7.03	31.19	59.63
63	Nuclear forces and binding energy	2.15	12.00	37.54	36.00	12.31
64	Mass/energy transformation	.92	10.12	41.41	33.44	14.11
65	Types of radioactive decay	.30	12.80	35.37	38.72	12.80
66	Artificial and natural radioactivity	1.24	17.65	37.15	34.67	9.29
67	Half-life of radioactive isotopes	.92	12.27	37.12	36.50	13.19
68	Nuclear reactions	.92	14.07	36.09	35.78	13.15
C. CHEMICAL PERIODICITY						
71	The development of the periodic table	.61	8.87	31.50	33.03	25.99
72	The position of metals, nonmetals, and metalloids	.00	2.45	15.64	35.58	46.32
73	Trends in melting and boiling temperatures	.61	7.06	32.21	40.80	19.33
74	Trends in atomic radii/ionization energy/electron affinity/ electronegativity	.31	4.00	16.92	43.08	35.69
75	Relationship of periodic table to electron configurations	.00	.61	9.51	31.90	57.98
76	Oxidation numbers for elements in a compound	.00	1.54	11.08	43.08	44.31
77	Periodicity of the oxidation states of the elements	.00	2.47	20.68	41.36	35.49
78	Chemical properties/reactions of elements as reflected by their positions in the periodic table	.00	.31	9.54	42.15	48.00

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Ga4

	Level of Understanding				
	% Responding				
	0	1	2	3	4
D. NOMENCLATURE					
81 Inorganic nomenclature of ionic compounds and acids	.00	4.36	15.58	46.42	33.64
82 Nomenclature of the classes of organic compounds	.63	7.52	30.72	44.83	16.30
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY					
85 Mole concept and mass-mole-number relationships	.00	.31	2.81	23.13	73.75
86 Information conveyed by a chemical formula	.00	.31	4.72	25.16	69.81
87 Law of constant composition and law of multiple proportions	.31	3.14	18.55	42.14	35.85
88 Percent composition of elements in a compound	.00	1.57	11.95	43.71	42.77
89 Information conveyed by empirical and molecular formulas	.00	1.89	11.04	37.54	49.53
90 Ionic, covalent, and metallic bonds	.00	2.20	9.75	35.22	52.83
91 Rules for calculating oxidation numbers of atoms in a compound	.32	2.84	14.51	44.16	38.17
92 Electron dot formulas and structural formulas	.00	1.58	12.30	45.43	40.69
93 Multiple bonds	.31	3.14	25.47	41.51	29.56
94 Types of bonding related to electronegativity differences	.00	2.53	20.25	42.41	34.81
95 Valence shell electron pair repulsion model (VSEPR)	1.57	9.12	31.45	35.22	22.64
96 Simple structures of isomers	.31	5.97	32.70	40.25	20.75
97 Chemical/physical properties of compounds related to type of bonding/geometry	.94	3.76	31.97	39.50	23.82
98 Hybrid orbitals	1.57	7.23	37.42	37.11	16.67
99 Resonance and delocalization	1.89	12.89	36.79	32.08	16.35
The Kinetic Theory and States of Matter					
100 Assumptions of the kinetic molecular theory of gases	.32	3.48	22.78	35.13	38.29
101 Maxwell-Boltzmann velocity distributions	5.38	18.67	42.09	26.58	7.28
102 Diffusion of gases	.00	6.69	35.99	42.99	14.33
103 Relationships among volume/pressure/temperature/quantity for ideal gases	.00	.31	7.23	31.45	61.01
104 Dalton's law of partial pressures	.00	1.57	14.78	49.06	34.59
105 Real <u>versus</u> ideal gases	.95	6.62	27.76	38.17	26.50
106 Forces of attraction among molecules	.63	4.39	24.76	41.07	29.15
107 Phase changes for a pure substance	.63	5.02	34.17	39.81	20.38
108 Relationships among evaporation rate/boiling temperature/vapor pressure	.94	5.03	27.99	44.65	21.38

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)						
109	Special properties of water	.00	2.81	27.50	40.31	29.38
110	Relationships among phases of matter, forces between particles/particle energy	1.25	6.27	34.80	34.80	22.88
111	Characteristics of crystals	1.86	17.65	51.08	23.84	5.57
Chemical Reactions						
112	Equation balancing from written description of chemical reaction	.00	.62	6.54	28.66	64.17
113	General types of chemical reactions	.31	3.10	16.10	33.44	47.06
114	Stoichiometry	.00	.31	5.59	23.29	70.81
115	Endothermic and exothermic reactions	.00	1.24	14.91	40.68	43.17
116	Spontaneity in chemical reactions	.31	10.49	31.79	35.49	21.91
117	Collision theory and reaction rates	.62	7.14	33.23	36.65	22.36
118	Activation energy and the effects of a catalyst	.31	3.74	27.73	42.37	25.86
119	Rate-influencing factors in chemical reactions	.00	1.86	24.22	41.30	32.61
120	Rate expressions and orders of reactions	.93	12.11	33.54	37.89	15.53
121	Reaction mechanisms	1.25	13.44	39.06	31.25	15.00
122	Chemical equilibria	.00	1.86	15.79	36.53	45.82
123	Le Châtelier's principle and factors that disturb the equilibrium systems	.00	2.48	14.55	36.84	46.13
124	Properties and production of ammonia	4.35	18.94	44.41	24.84	7.45
125	Oxidation and reduction reactions	.00	.62	13.89	40.74	44.75
126	Electrochemical cells and electrode reactions	.31	4.64	27.24	42.72	25.08
127	Metallurgical properties of the transition metals	4.63	25.31	46.30	20.06	3.70
128	Redox properties of the halogens and the halide ions	2.79	13.31	44.58	30.96	8.36
129	Faraday's law of electrolysis	3.09	12.04	40.43	32.72	11.73
130	Practical applications of electrochemistry	.92	9.85	35.69	39.69	13.85
Solutions and Solubility						
131	Types of solutions	.00	7.12	33.44	36.22	23.22
132	Solutes, solvents and solubility	.00	2.47	17.28	44.75	35.49
133	Effects of temperature	.31	2.15	27.08	39.08	31.38
134	Dissolving process	.00	4.92	33.23	35.69	26.15
135	Solubility product (K_{sp})	.00	6.19	22.60	45.82	25.39

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	Level of Understanding				
	% Responding				
	0	1	2	3	4
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)					
136 Concentration of solutes	.00	.62	13.23	35.38	50.77
137 Conductivity of solutions and the ionization process	.00	4.33	24.77	42.41	28.48
138 Strong and weak eletrolytes; non-electrolytes	.00	5.59	23.60	41.30	29.50
139 Colligative properties of solutions	.62	7.43	30.34	39.63	21.98
140 Characteristic properties of acids, bases, and salts	.00	.93	10.84	36.53	51.70
141 Arrhenius, Brønsted-Lowry, and Lewis acid-base theories	.00	5.85	19.08	36.92	38.15
142 pH of solutions of strong and weak acids and bases	.00	2.77	11.38	44.92	40.92
143 Relative strengths of acids and bases	.00	1.54	19.14	43.52	35.80
144 Production, properties, and use of the common acids	3.08	17.23	40.00	28.00	11.69
145 Acid-base titration and indicators	.00	.92	16.92	44.62	37.54
146 Buffer solutions	.31	4.62	26.46	42.77	25.85
F. BIOCHEMISTRY					
149 Organic functional groups and their reactions	1.25	8.13	34.06	39.69	16.88
150 Monomers and polymers	.62	12.15	43.30	31.46	12.46
151 Biologically important compounds	.94	11.29	39.18	34.17	14.42
152 Biologically important chemical processes	2.82	15.67	41.69	27.27	12.54
153 Structure and replication of nucleic acids	5.99	17.98	43.85	21.77	10.41
154 Energy storage and release in biological systems	6.94	18.93	39.43	24.29	10.41
155 Overall importance of Biochemistry					
G. SCIENCE, TECHNOLOGY, AND SOCIETY					
157 Awareness of ethical and moral responsibilities of scientists	.31	9.20	30.37	27.61	32.52
158 Awareness of ethical issues/risks/benefits associated with the application of science	.31	7.33	31.08	30.46	30.77
159 Detection of environmental hazards	.61	6.44	33.74	30.98	28.22
160 Risk management issues assoc. with energy production/transmission/use	2.78	10.49	39.81	28.40	18.52
161 Risk mgmt issues assoc. with production/storage/use/disposal of cons. products	1.55	7.43	34.98	33.44	22.60
162 Waste management issues and recycling	.93	6.79	33.64	34.26	24.38
163 Management of resources	1.85	9.23	31.38	33.54	24.00
164 Use of science and technology to predict and prepare for natural disaster	6.15	18.46	41.23	22.77	11.38

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	Level of Understanding				
	% Responding				
	0	1	2	3	4
G. SCIENCE, TECHNOLOGY, AND SOCIETY (cont.)					
165 Use of technology in everyday life	1.86	9.29	34.98	33.13	20.74
166 Technology transfer	2.79	14.24	47.06	23.84	12.07
167 Issues assoc. with the use of chemicals in agriculture/food preparation/ preservation	1.23	10.46	39.69	32.31	16.31
168 Social, political and economic issues arising from science and technology	2.46	11.38	37.23	30.46	18.46
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES					
171 Recognition of/compensation for complex factors - teaching	2.55	8.60	36.62	31.85	20.38
172 Recognition of/compensation for complex factors - learning	1.58	6.96	30.38	32.59	28.48
Curriculum: Organization, Materials and Management					
173 Reasons for learning the physical sciences	.31	5.00	22.50	38.13	34.06
174 Reasons for teaching a particular topic in the physical sciences	.00	5.66	25.47	38.68	30.19
175 Integration within topics in the physical sciences	.00	2.81	24.69	40.94	31.56
176 Integration among the physical sciences and other disciplines	.00	3.74	29.60	38.94	27.73
177 Scope and sequence of topics in the physical sciences	.64	6.69	30.89	37.26	24.52
178 Lesson plans in the physical sciences curricula	1.89	6.92	32.08	36.16	22.96
179 Selection and use of curricular materials and resources	.62	2.79	19.50	41.49	35.60
180 Selection and use of mass media	1.24	5.90	33.54	45.96	13.35
181 Selection and use of current technologies	.31	5.92	28.66	48.60	16.51
Instruction					
182 Prerequisite knowledge, experience, and skills	.63	4.06	22.50	50.00	22.81
183 Recognition of and accommodation to the prior conceptions, experience, and skills	.31	4.40	26.10	46.23	22.96
184 Identification/selection of appropriate lab experiences for various instructional goals	.31	.93	13.04	47.83	37.89
185 Design of appropriate lab experiences for various instructional goals	.62	2.18	11.84	47.66	37.69
186 Strategies for motivating and encouraging students to succeed	.00	1.25	13.08	46.42	39.25
187 Strategies for addressing controversial and/or sensitive issues	.93	4.67	25.55	43.93	24.92
Assessment and Evaluation					
188 Assessment strategies for student performance in the physical sciences	.00	1.55	13.98	45.03	39.44
189 Errors in student work and performances that arise from prior conceptions	1.25	4.05	30.53	40.81	23.36

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Ga8

	Level of Understanding				
	% Responding				
	0	1	2	3	4
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)					
Professional Concerns					
190 Professional and scholarly literature	.94	6.58	33.86	43.89	14.73
191 Professional and scholarly organizations for science educators	1.26	8.18	34.28	42.14	14.15
192 Legal responsibilities and liabilities for teachers in the physical sciences	.94	3.76	25.08	40.75	29.47
193 Responsibilities for continuing education	.63	5.02	24.76	45.45	24.14
194 Resources available in the community	.95	8.20	29.65	44.48	16.72
195 Science-related career information	.00	5.96	34.48	39.50	20.06
196 Overall importance of Pedagogy Specific to the Physical Sciences					

Level of Understanding: 0 = An understanding of the knowledge area is not needed; 1 = Define the terms used in the knowledge area; 2 = Comprehend the essential properties of the knowledge area; 3 = Apply/Utilize the knowledge area to address problems or questions; 4 = Analyze the knowledge area into component parts and explain the interrelationships among the parts.

Gb1 Percent of Responses by Level of Understanding Category - Physics

	Level of Understanding				
	% Responding				
	0	1	2	3	4
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
Methodology					
1 Scientific methods (e.g., formulation of problem, hypotheses. etc.)	.00	2.15	10.46	41.85	45.54
2 Science process skills (e.g., qualitative/quantitative observations)	.00	1.84	11.66	40.18	46.32
3 Assumptions, models, laws, and theories	.31	3.07	19.94	44.48	32.21
4 Design of experiments (e.g., independent/dependent variables)	.00	2.75	19.88	42.51	34.86
History and Philosophy of Science					
5 Historical roots of science	2.48	12.38	55.42	25.08	4.64
6 Contributions of individuals	2.80	18.01	52.80	23.29	3.11
7 Contributions of ethnic groups and cultures	12.69	25.39	45.51	14.24	2.17
Mathematics, Measurement, and Data Manipulation					
8 The metric and SI systems	.00	2.44	4.88	32.01	60.67
9 Scientific notation	.00	1.83	6.10	36.28	55.79
10 Estimation and approximation	.00	1.83	17.43	43.43	37.31
11 Significant figures in measurement and calculations	.00	3.07	18.40	47.85	30.67
12 Unit/dimensional analysis	.31	1.83	9.48	44.04	44.34
13 Experimental errors (e.g., sources, precision, accuracy)	.00	2.45	22.02	51.99	23.55
14 Mathematical relationships and patterns in numerical data	.31	1.83	14.98	42.20	40.67
15 Statistics of distributions	3.98	12.84	44.34	33.03	5.81
16 Simple digital (binary) logic	10.28	22.74	43.93	19.00	4.05
17 Organization and interpretation of data and equations	.00	.93	9.29	39.94	49.85
18 Differentiation and simple integration	3.42	11.80	32.30	37.89	14.60
19 Vector algebra	.62	1.87	15.89	43.30	38.32
Laboratory and Safety					
20 Use and calibration of laboratory equipment	.00	2.17	17.08	54.35	26.40
21 Maintenance of laboratory equipment	1.24	6.19	29.41	48.92	14.24
22 Preparation and set-up of reagents, materials, and apparatus	.00	1.87	17.76	46.11	34.27
23 Laboratory safety	.62	1.24	13.31	45.51	39.32
24 Emergency procedures for laboratory accidents	.62	.31	12.77	45.17	41.12

Level of Understanding: 0 = An understanding of the knowledge area is not needed; 1 = Define the terms used in the knowledge area; 2 = Comprehend the essential properties of the knowledge area; 3 = Apply/Utilize the knowledge area to address problems or questions; 4 = Analyze the knowledge area into component parts and explain the interrelationships among the parts.

Gb2

	Level of Understanding				
	% Responding				
	0	1	2	3	4
B. BASIC TOPICS IN PHYSICAL SCIENCE					
Matter and Energy					
27 Physical and chemical properties	.31	4.64	26.63	43.34	25.08
28 Particulate nature of matter	.00	1.54	18.83	45.37	34.26
29 Elements, compounds, and mixtures	.00	4.66	29.19	40.06	26.09
30 Physical and chemical changes	.00	5.28	26.71	41.61	26.40
31 Conservation of mass/energy	.00	.31	8.64	36.73	54.32
32 Forms of energy	.00	.93	7.10	35.19	56.79
33 Energy transformations	.31	.62	7.74	41.49	49.85
Heat and Thermodynamics					
34 Historical development of heat and energy concepts	2.18	13.71	53.58	25.86	4.67
35 Kinetic molecular theory	.62	2.79	27.55	44.89	24.15
36 Equipartition of energy	2.58	16.77	37.74	34.84	8.06
37 Brownian motion	1.56	14.02	45.17	33.64	5.61
38 Heat versus temperature	.00	1.86	14.24	40.25	43.65
39 Temperature scales and measurement	.31	2.78	16.36	52.78	27.78
40 Conduction, convection, and radiation	.31	2.78	21.91	48.46	26.54
41 Heat capacity/thermal exchange/heat of fusion and vaporization	.00	.93	15.17	51.08	32.82
42 Phase changes	.00	2.48	18.58	48.92	30.03
43 Expansion and contraction	.00	3.41	25.70	50.15	20.74
44 Zeroth law of thermodynamics	.62	4.97	26.40	45.65	22.36
45 First law of thermodynamics	.93	.00	12.42	45.65	40.99
46 Second law of thermodynamics	1.25	4.98	24.92	42.37	26.48
47 Third law of thermodynamics	.93	5.90	31.37	40.68	21.12
48 Reversibility and irreversibility	2.48	9.29	37.15	37.77	13.31
Atomic and Nuclear Structure					
49 Historical discovery of particles	.93	15.74	46.30	29.32	7.72
50 Atomic models and their experimental bases	.62	6.17	31.79	45.99	15.43
51 Structure of the atom	.00	2.48	18.89	43.96	34.67
52 Characteristics of an electron in an atom	.62	4.01	26.23	43.83	25.31

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Gb3

	Level of Understanding				
	% Responding				
	0	1	2	3	4
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)					
53 Atomic mass, atomic number, mass number and isotopes	.00	5.61	18.69	43.30	32.40
54 Nuclear forces and binding energy	.31	7.79	33.02	39.56	19.31
55 Types of radioactive decay	.31	4.95	31.27	43.34	20.12
56 Artificial and natural radioactivity	.31	8.02	36.42	42.28	12.96
57 Half-life of radioactive isotopes	.31	5.25	28.70	47.22	18.52
58 Nuclear reactions	.31	6.48	25.93	48.15	19.14
C. MECHANICS					
61 Vector quantities	.00	.62	3.42	33.85	62.11
62 Rel. among position, velocity, acceleration, and time for straight line motion	.00	.31	1.86	27.95	69.88
63 Reference frames and relative velocity (e.g., Galilean relativity)	.62	3.74	26.17	41.74	27.73
64 Rel. among position/velocity/constant acceleration/time for projectile motion	.00	.93	6.50	38.08	54.49
65 Rel. among position, velocity, centripetal acceleration for uniform circular motion	.31	1.24	8.39	44.72	45.34
66 Periodic motion	.00	.93	11.15	49.23	38.70
67 Simple harmonic motion (oscillations)	.62	1.55	13.35	51.55	32.92
68 Newton's law of motion	.00	.31	.93	21.98	76.78
69 Weight <u>versus</u> mass	.00	.93	7.12	28.79	63.16
70 Friction (e.g., static and dynamic coefficients)	.00	2.17	16.77	50.00	31.06
71 Statics (e.g., equilibrium of forces and/or torques)	.00	1.86	14.60	44.10	39.44
72 Relationships between work and kinetic energy changes	.31	.31	5.57	41.49	52.32
73 Conservative forces and potential energy	.00	.93	9.03	42.68	47.35
74 Springs (e.g., Hooke's law)	.00	2.80	23.60	52.17	21.43
75 Concepts of rigid body motion	.00	3.74	28.66	46.11	21.50
76 Impulse-momentum principle	.31	2.80	14.29	45.65	36.96
77 Conservation of momentum	.00	.62	6.50	39.32	53.56
78 Conservation of angular momentum	.00	4.33	23.22	46.75	25.70
79 Conservation of energy	.00	.31	2.77	26.46	70.46
80 Orbital motion	.00	5.25	39.20	41.67	13.89
81 Newton's law of universal gravitation	.00	1.55	13.62	39.94	44.89

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
C. MECHANICS (cont.)						
82	**Fluid mechanics**	.31	8.05	29.72	49.23	12.69
83	**Relativistic effects on length, mass, and time**	1.85	12.35	38.58	37.65	9.57
D. ELECTRICITY AND MAGNETISM						
86	**Electric forces and Coulomb's law**	.00	.62	9.63	47.52	42.24
87	**Electric fields**	.00	1.55	16.41	50.77	31.27
88	**Gauss's law**	4.10	6.62	32.18	43.22	13.88
89	**Electric potential energy, electric potential, and potential difference**	.00	.95	9.84	48.89	40.32
90	**Conductors, insulators, semiconductors**	.00	1.59	27.30	47.30	23.81
91	**Current**	.00	.32	6.35	46.67	46.67
92	**Resistance**	.00	.32	6.69	48.41	44.59
93	**Series and parallel circuits**	.00	.32	8.28	46.82	44.59
94	**Internal resistance of batteries**	2.22	6.35	36.19	41.90	13.33
95	**Capacitance**	.32	5.10	24.84	50.00	19.75
96	**Inductance**	.32	7.96	27.07	47.45	17.20
97	**Measurement of potential difference, current, resistance, and capacitance**	.00	.96	14.65	50.96	33.44
98	**Alternating current circuits**	1.27	6.05	31.85	46.82	14.01
99	**Magnetic flux**	.32	6.05	31.53	43.95	18.15
100	**Faraday's and Lenz's laws of electromagnetic induction**	.64	4.14	28.03	46.18	21.02
101	**Transformers**	.96	5.41	33.12	46.82	13.69
102	**Sources of EMF**	.00	3.18	28.34	51.91	16.56
103	**Motors**	.64	5.10	33.44	47.45	13.38
104	**Large scale generation and transmission of energy and power**	1.27	11.15	50.32	28.03	9.24
105	**n- and p-type semiconductors**	4.82	12.86	43.41	34.08	4.82
106	**Semiconductor devices**	3.49	13.02	43.81	33.65	6.03
107	**Integrated circuits**	5.38	18.67	44.62	26.58	4.75
108	**Superconductivity**	1.60	14.74	47.76	30.13	5.77
109	**Magnets**	.00	.95	29.75	46.84	22.47
110	**Magnetic fields**	.00	1.27	17.72	49.37	31.65

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
D. ELECTRICITY AND MAGNETISM (cont.)						
111	Gauss's law of magnetism	5.41	11.15	40.45	33.76	9.24
112	Magnetic forces	.32	1.90	22.47	51.58	23.73
113	Principle and calibration of electrical meters	3.83	8.31	35.78	38.34	13.74
114	Types of magnetism	2.56	21.73	47.28	23.96	4.47
115	Biot-Savart law and Ampere's law	2.23	11.15	35.35	35.99	15.29
116	Maxwell's equations	5.71	18.10	39.05	26.03	11.11
117	Lorentz force law and applications	1.61	10.29	37.62	35.37	15.11
E. WAVES						
120	Wave characteristics	.00	.93	5.86	33.64	59.57
121	Inverse square law for intensity	.62	2.48	20.74	46.13	30.03
122	Transverse and longitudinal waves	.00	3.10	17.03	41.80	38.08
123	Absorption and transmission	.31	5.56	31.48	42.28	20.37
124	Reflection	.00	1.23	14.51	47.53	36.73
125	Scattering	.93	5.56	31.48	48.15	13.89
126	Refraction and Snell's law	.00	.62	9.57	46.30	43.52
127	Interference and superposition of waves	.00	1.23	12.96	47.84	37.96
128	Standing waves	.31	.93	19.14	53.09	26.54
129	Diffraction	.62	5.56	25.93	50.00	17.90
130	Dispersion	.31	9.01	37.89	42.24	10.56
131	Resonance and natural frequencies	.00	1.54	25.31	50.00	23.15
132	Doppler effect	.31	2.17	22.67	49.07	25.78
133	Characteristics of sound waves	1.55	4.02	27.24	38.39	28.79
134	Sound: air columns and strings	1.85	5.25	37.35	37.04	18.52
135	The electromagnetic spectrum	.00	3.09	20.37	39.20	37.35
136	Color	1.24	6.19	38.08	37.46	17.03
137	Coherent radiation	2.19	10.00	44.69	34.69	8.44
138	Geometric optics	.00	.62	11.76	47.06	40.56
139	Polarization	.00	5.64	30.72	50.47	13.17
140	Thin films	2.51	10.03	42.32	35.74	9.40

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
F. MODERN PHYSICS						
143	Blackbody radiation	1.56	8.75	46.56	34.38	8.75
144	Photoelectric effect	.00	2.50	32.50	44.38	20.63
145	Spectroscopy	.31	3.75	35.94	42.81	17.19
146	Planck's hypothesis	.63	7.21	33.86	40.44	17.87
147	deBroglie's hypothesis	.94	8.75	34.69	40.94	14.69
148	Wave-particle duality	.31	4.97	28.26	42.24	24.22
149	Heisenberg uncertainty principle	.31	9.35	36.76	38.94	14.64
150	Schrödinger's wave equation	4.08	20.38	41.69	27.59	6.27
151	Orbital theory - quantum numbers	1.25	9.66	37.69	38.01	13.40
152	Pauli exclusion principle	1.25	11.29	41.07	35.74	10.66
153	Michelson-Morley experiment	1.57	8.46	40.44	36.68	12.85
154	Special relativity	.31	10.31	36.88	41.25	11.25
155	Lorentz transformations and inertial reference frames	3.44	16.56	44.06	30.00	5.94
156	Mass/energy transformations	.63	7.21	31.66	44.51	15.99
157	Elementary particles	2.50	22.19	46.25	24.38	4.69
158	Strong and weak forces	3.14	22.64	40.57	28.30	5.35
G. SCIENCE, TECHNOLOGY, AND SOCIETY						
161	Awareness of ethical and moral responsibilities of scientists	1.25	6.54	33.96	36.45	21.81
162	Awareness of ethical issues/risks/benefits assoc. with the application of science	1.24	6.21	34.47	38.51	19.57
163	Detection of environmental hazards	1.25	8.10	40.50	32.71	17.45
164	Risk management issues assoc. with energy production/transmission/use	1.57	11.95	42.77	31.13	12.58
165	Risk mgmt issues assoc. with production/storage/use/disposal of cons. products	3.13	12.85	42.32	29.47	12.23
166	Waste management issues and recycling	3.13	10.31	42.19	32.19	12.19
167	Management of resources	2.51	12.85	39.18	32.29	13.17
168	Use of science and technology to predict and prepare for natural disaster	7.23	15.41	41.82	26.73	8.81
169	Use of technology in everyday life	1.25	5.63	31.56	43.44	18.13
170	Technology transfer	1.88	15.63	40.31	32.81	9.38
171	Social, political and economic issues arising from science and technology	2.19	8.44	38.44	37.50	13.44

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES						
174	Recognition of/compensation for complex factors - teaching	4.17	9.62	37.18	33.97	15.06
175	Recognition of/compensation for complex factors - learning	3.54	6.11	28.94	40.84	20.58
Curriculum: Organization, Materials and Management						
176	Reasons for learning the physical sciences	1.60	3.19	22.04	41.21	31.95
177	Reasons for teaching a particular topic in the physical sciences	.64	4.78	24.20	41.72	28.66
178	Integration within topics in the physical sciences	.31	5.03	28.62	39.94	26.10
179	Integration among the physical sciences and other disciplines	.31	6.60	31.76	42.14	19.18
180	Scope and sequence of topics in the physical sciences	2.55	8.92	34.71	39.49	14.33
181	Lesson plans in the physical sciences curricula	3.81	9.84	35.87	35.87	14.60
182	Selection and use of curricular materials and resources	1.58	4.73	21.45	52.05	20.19
183	Selection and use of mass media	1.91	6.05	29.30	49.04	13.69
184	Selection and use of current technologies	1.59	4.76	29.21	48.25	16.19
Instruction						
185	Prerequisite knowledge, experience, and skills	1.60	5.43	23.64	45.05	24.28
186	Recog. of and accommodation to the prior conceptions, experience, and skills	1.58	6.33	26.58	40.51	25.00
187	Identification/selection of approp. lab experiences for various instructional goals	.95	1.89	15.77	43.85	37.54
188	Design of appropriate lab experiences for various instructional goals	1.27	2.53	17.09	43.35	35.76
189	Strategies for motivating and encouraging students to succeed	.94	2.20	16.67	40.25	39.94
190	Strategies for addressing controversial and/or sensitive issues	2.83	6.60	30.50	40.88	19.18
Assessment and Evaluation						
191	Assessment strategies for student performance in the physical sciences	.63	3.16	19.62	44.30	32.28
192	Errors in student work and performances that arise from prior conceptions	.95	4.43	25.00	46.52	23.10
Professional Concerns						
193	Professional and scholarly literature	2.22	7.28	37.97	39.24	13.29
194	Professional and scholarly organizations for science educators	3.18	8.28	35.03	40.13	13.38
195	Legal responsibilities and liabilities for teachers in the physical sciences	.32	7.94	35.87	32.38	23.49
196	Responsibilities for continuing education	1.92	6.73	33.33	38.78	19.23
197	Resources available in the community	2.56	8.31	34.19	39.94	15.02
198	Science-related career information	.32	7.72	35.69	39.87	16.40

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Gb8

Appendix H

Ha1 Mean Importance Ratings by Subgroups - Chemistry

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY								
Methodology								
1. Scientific methods (e.g., formulation of problem, hypotheses, experiments)	3.49	3.44	3.53	3.51	3.41	3.63	3.55	3.52
2. Science process skills (e.g., qualitative and quantitative observations)	3.59	3.55	3.51	3.44	3.40	3.68	3.64	3.62
3. Assumptions, models, laws, and theories	3.23	3.26	3.36	3.30	3.22	3.40	3.15	3.41
4. Design of experiments (e.g., independent and dependent variables)	3.25	3.17	3.22	3.19	3.13	3.38	3.39	3.27
History and Philosophy of Science								
5. Historical roots of science	2.23	2.09	2.32	2.28	2.26	2.22	2.21	2.27
6. Contributions of individuals	2.23	1.96	2.25	2.16	2.25	2.07	2.09	2.18
7. Contributions of ethnic groups and cultures	1.44	1.55	1.41	1.70	1.48	1.70	1.76	1.70
Mathematics, Measurement, and Date Manipulation								
8. The metric and SI systems	3.61	3.68	3.75	3.69	3.63	3.73	3.73	3.74
9. Scientific notation	3.56	3.63	3.63	3.56	3.53	3.67	3.64	3.65
10. Estimation and approximation	3.17	3.01	3.12	3.08	2.95	3.15	3.00	3.14
11. Significant figures in measurement and calculations	3.26	3.17	3.38	3.24	3.11	3.45	3.30	3.30
12. Unit/dimensional analysis	3.47	3.30	3.57	3.48	3.34	3.60	3.55	3.56
13. Experimental errors (e.g., sources, quantifications, precision, accuracy)	3.09	2.99	3.05	2.93	3.00	3.11	3.18	3.09
14. Mathematical relationships and patterns in numerical data	3.09	2.95	3.16	2.94	2.75	3.24	3.06	3.19
15. Statistics of distributions	2.09	1.96	2.16	2.00	2.04	2.04	2.06	1.99
16. Simple digital (binary) logic	1.53	1.49	1.75	1.62	1.50	1.68	1.38	1.59

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)								
17. Organization and interpretation of data and equations (e.g., tables, graphs,)	3.23	3.22	3.38	3.30	3.25	3.41	3.41	3.40
18. Differentiation and simple integration	1.78	1.67	1.88	1.75	1.82	1.64	1.81	1.46
Laboratory and Safety								
19. Use and calibration of laboratory equipment (e.g., laboratory burners)	3.47	3.47	3.53	3.38	3.46	3.60	3.78	3.56
20. Maintenance of laboratory equipment (e.g., laboratory burners, glassware)	2.74	3.05	3.08	3.08	2.99	3.16	3.16	3.16
21. Preparation and set-up of reagents, materials, and apparatus	3.46	3.52	3.44	3.52	3.38	3.65	3.72	3.73
22. Laboratory safety (e.g., storage and disposal of materials)	3.87	3.77	3.85	3.82	3.79	3.89	3.91	3.89
23. Emergency procedures for laboratory accidents	3.81	3.76	3.82	3.84	3.76	3.86	3.91	3.85
24. Overall evaluation of the importance of Scientific Methodology/ Techniques/History	3.19	3.22	3.36	3.34	3.24	3.33	3.39	3.32
B. BASIC TOPICS IN PHYSICAL SCIENCE								
Matter and Energy								
26. Physical and chemical properties (e.g., states of matter, homogeneous,)	3.22	3.29	3.49	3.24	3.24	3.41	3.26	3.34
27. Particulate nature of matter (e.g., atoms, ions, molecules)	3.71	3.61	3.78	3.64	3.61	3.76	3.71	3.72
28. Elements, compounds, and mixtures	3.59	3.56	3.71	3.52	3.46	3.72	3.71	3.63
29. Physical and chemical changes	3.47	3.48	3.59	3.43	3.36	3.60	3.45	3.56
30. Conservation of mass/energy	3.37	3.47	3.44	3.43	3.36	3.51	3.55	3.49
31. Forms of energy (e.g., kinetic, potential, magnetic, electrical, light)	2.93	3.02	3.15	3.14	3.03	3.09	3.26	3.01
32. Energy transformations	2.94	2.86	2.97	3.05	2.91	2.94	3.00	3.01

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

Ha3

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)								
Heat and Thermodynamics								
33. Historical development of heat and energy	1.72	1.78	2.08	2.05	1.91	1.90	1.88	1.94
34. Kinetic molecular theory	3.35	3.01	3.01	3.20	3.00	3.25	3.19	3.43
35. Brownian motion	2.13	2.14	2.22	2.29	2.04	2.30	2.41	2.26
36. Heat versus temperature	3.14	3.08	3.16	3.17	3.10	3.17	2.94	3.26
37. Temperature scales and measurement	2.93	3.23	3.26	3.07	3.04	3.28	3.30	3.26
38. Conduction, convection, and radiation	2.27	2.28	2.50	2.60	2.46	2.44	2.64	2.37
39. Heat capacity, thermal exchange, heat of fusion, and heat of vaporization	2.99	2.84	2.99	3.07	2.96	3.00	2.85	3.04
40. Concepts of enthalpy and entropy	3.11	2.86	2.88	3.10	2.95	3.00	2.88	3.09
41. Phase changes	3.26	3.11	3.03	3.27	3.06	3.33	3.24	3.36
42. Expansion and contraction	2.40	2.35	2.46	2.52	2.38	2.63	2.58	2.49
43. Zeroth law of thermodynamics (i.e., direction of heat flow)	2.70	2.51	2.64	2.64	2.66	2.70	2.55	2.60
44. First law of thermodynamics (i.e., energy is conserved)	3.21	3.03	3.09	3.30	3.19	3.10	3.06	3.12
45. Second law of thermodynamics - entropy	2.97	2.77	2.95	3.01	2.90	2.89	2.88	2.86
46. Third law of thermodynamics	2.90	2.65	2.76	2.92	2.77	2.81	2.82	2.91
47. Reversibility and irreversibility	2.86	2.67	2.71	2.75	2.60	2.74	2.66	2.74
Atomic and Nuclear Structure								
48. Historical discovery of particles (e.g., electron, neutron)	2.31	2.33	2.37	2.46	2.36	2.56	2.45	2.59
49. Atomic models and their experimental bases	2.86	2.67	2.68	2.98	2.83	2.89	2.79	3.08
50. Structure of the atom	3.64	3.59	3.55	3.59	3.52	3.71	3.69	3.70
51. Planck's hypothesis	2.70	2.33	2.70	2.72	2.55	2.71	2.67	2.60

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

Ha4

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=70	N=94	N=76	N=87	N=105	N=222	N=33	N=141
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)								
52. deBroglie's hypothesis	2.60	2.20	2.50	2.57	2.40	2.61	2.48	2.47
53. Heisenberg uncertainty principle	2.70	2.32	2.57	2.61	2.53	2.66	2.61	2.57
54. Schrödinger's wave equation	2.29	1.73	2.12	2.16	2.02	2.21	2.15	2.14
55. Orbital theory - quantum numbers	3.09	2.83	2.99	3.02	2.92	3.07	3.21	3.09
56. Characteristics of an electron in an atom (e.g., shells, orbitals)	3.44	3.37	3.31	3.45	3.38	3.49	3.58	3.51
57. Properties of electromagnetic radiation	2.80	2.67	2.96	2.88	2.80	2.83	2.94	2.86
58. Spectroscopy	2.61	2.48	2.71	2.76	2.67	2.62	2.67	2.63
59. Pauli exclusion principle	2.77	2.65	2.83	2.89	2.66	2.97	2.82	2.87
60. Hund's rule	2.71	2.55	2.75	2.75	2.60	2.84	2.70	2.79
61. Chemical properties related to electron configuration	3.59	3.65	3.53	3.70	3.57	3.73	3.52	3.78
62. Atomic mass, atomic number, mass number and isotopes	3.57	3.72	3.64	3.55	3.58	3.75	3.67	3.76
63. Nuclear forces and binding energy	2.51	2.35	2.55	2.48	2.40	2.56	2.79	2.56
64. Mass/energy transformation	2.65	2.32	2.64	2.56	2.39	2.71	2.79	2.59
65. Types of radioactive decay (e.g., alpha, beta, gamma emission)	2.66	2.54	2.66	2.66	2.61	2.62	2.73	2.74
66. Artificial and natural radioactivity	2.43	2.29	2.42	2.40	2.27	2.48	2.61	2.46
67. Half-life of radioactive isotopes	2.51	2.42	2.57	2.55	2.44	2.50	2.58	2.60
68. Nuclear reactions (transmutations, fission, fusion)	2.47	2.42	2.55	2.69	2.59	2.51	2.59	2.62
69. Overall evaluation of the importance of Basic Topics in Physical Science	3.31	3.16	3.26	3.30	3.22	3.33	3.24	3.33
C. CHEMICAL PERIODICITY								
71. The development of the periodic table	2.52	2.78	2.74	2.85	2.68	2.89	2.97	2.94
72. The position of metals, nonmetals, and metalloids	3.32	3.50	3.45	3.44	3.36	3.63	3.52	3.60

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

Ha5

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=70	N=94	N=76	N=87	N=105	N=222	N=33	N=141
C. CHEMICAL PERIODICITY (cont.)								
73. Trends in melting and boiling temperatures	2.52	2.50	2.79	2.78	2.59	2.83	2.73	2.75
74. Trends in atomic radii, ionization energy, electron affinity, and electronegativity	3.04	3.10	3.08	3.14	3.08	3.24	3.03	3.22
75. Relationship of period table to electron configurations of the atoms	3.66	3.53	3.46	3.61	3.45	3.68	3.45	3.70
76. Oxidation numbers for elements in a compound	3.35	3.43	3.41	3.43	3.36	3.58	3.61	3.58
77. Periodicity of the oxidation states of the elements	3.19	3.18	3.05	3.16	2.99	3.37	3.30	3.24
78. Chem. prop./reactions of elements as reflected by positions in periodic table	3.55	3.59	3.47	3.56	3.46	3.57	3.42	3.64
79. Overall evaluation of the importance of Chemical Periodicity	3.39	3.45	3.29	3.49	3.36	3.46	3.42	3.55
D. NOMENCLATURE								
81. Inorganic nomenclature of ionic compounds and acids	3.06	3.32	3.34	3.14	3.05	3.34	3.27	3.44
82. Nomenclature of the classes or organic compounds	2.49	2.67	2.62	2.51	2.59	2.46	2.45	2.50
83. Overall evaluation of the importance of Nomenclature	2.87	3.11	3.12	2.87	2.92	2.99	2.94	3.13
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY								
85. Mole concept and mass-mole-number relationships	3.84	3.82	3.73	3.74	3.70	3.81	3.68	3.86
86. Information conveyed by a chemical formula	3.77	3.74	3.68	3.78	3.60	3.79	3.65	3.82
87. Law of constant composition and law of multiple proportions	3.10	3.07	3.14	3.15	3.08	3.16	3.23	3.18
88. Percent composition of elements in a compound	3.19	3.21	3.31	3.13	3.18	3.27	3.13	3.37
89. Information conveyed by empirical and molecular formulas	3.46	3.37	3.34	3.43	3.35	3.44	3.16	3.53
90. Ionic, covalent, and metallic bonds	3.51	3.46	3.48	3.45	3.44	3.57	3.42	3.55
91. Rules for calculating oxidation numbers of atoms in a compound	3.09	3.31	3.27	3.11	3.07	3.35	3.19	3.34
92. Electron dot formulas and structural formulas	3.17	3.32	3.19	3.26	3.20	3.34	3.19	3.37
93. Multiple bonds	3.06	3.03	3.11	2.98	3.00	3.03	2.77	3.04

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Ha6

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=70	N=94	N=76	N=87	N=105	N=222	N=33	N=141
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)								
94. Types of bonding related to electronegativity differences	3.14	3.11	3.08	3.09	2.96	3.17	2.94	3.18
95. Valence shell electron pair repulsion model for molecular shapes (VSEPR)	2.61	2.73	2.64	2.73	2.85	2.57	2.63	2.62
96. Simple structures of isomers	2.78	2.73	2.74	2.69	2.80	2.57	2.42	2.72
97. Chem./physical properties of compounds rel. to type of bonding and geometry	2.91	2.89	2.81	2.81	2.89	2.78	2.65	2.81
98. Hybrid orbitals	2.49	2.43	2.54	2.65	2.52	2.39	2.39	2.47
99. Resonance and delocalization	2.37	2.32	2.50	2.51	2.43	2.35	2.32	2.26
The Kinetic Theory and States of Matter								
100. Assumptions of the kinetic molecular theory of gases	3.17	3.03	3.19	3.25	3.06	3.32	3.10	3.40
101. Maxwell-Blotzmann velocity distributions	2.16	1.80	2.10	2.21	2.16	1.97	1.83	2.04
102. Diffusion of gases	2.68	2.55	2.82	2.71	2.53	2.83	2.71	2.79
103. Relationships among volume/pressure/temperature/quantity for ideal gases	3.64	3.55	3.57	3.56	3.52	3.71	3.42	3.73
104. Dalton's law of partial pressures	3.24	3.04	3.20	3.20	3.13	3.20	3.16	3.27
105. Real versus ideal gases	2.83	2.70	2.88	2.81	2.68	2.91	2.81	2.93
106. Forces of attraction among molecules (e.g., dipole-dipole interactions)	3.00	2.98	3.03	3.00	3.02	2.99	2.97	2.96
107. Phase changes for a pure substance (e.g., pressure and temperature effects)	2.79	2.67	2.84	2.90	2.73	2.89	3.00	2.83
108. Relationships among evaporation rate, boiling temperature, and vapor pressure	2.77	2.67	2.84	2.93	2.72	2.84	2.73	2.89
109. Special properties of water (e.g., density of solid versus liquid)	2.93	2.99	3.14	3.12	3.08	3.06	3.00	2.99
110. Rel. among phases of matter/forces between particles and particle energy	2.64	2.54	2.64	2.82	2.59	2.84	2.87	2.73
111. Characteristics of crystals	2.07	2.13	2.21	2.15	2.02	2.29	2.36	2.19

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)								
Chemical Reactions								
112. Equation balancing from written descriptions of chemical reactions	3.66	3.67	3.65	3.54	3.45	3.77	3.67	3.75
113. General types of chemical reactions (i.e., decomposition, ionic replacement)	3.21	3.38	3.33	3.23	3.14	3.44	3.52	3.49
114. Stoichiometry	3.75	3.72	3.63	3.72	3.63	3.72	3.42	3.78
115. Endothermic and exothermic reactions	3.31	3.28	3.28	3.18	3.21	3.37	3.30	3.32
116. Spontaneity in chemical reactions (e.g., entropy, Gibbs-Helmholtz equation)	2.71	2.54	2.69	2.69	2.63	2.58	2.52	2.59
117. Collision theory and reaction rates	2.76	2.61	2.79	2.79	2.66	2.71	2.56	2.94
118. Activation energy and the effects of a catalyst	2.90	2.80	2.93	3.05	2.85	2.91	2.88	2.97
119. Rate-influencing factors in chemical reactions (e.g., pressure, catalyst)	3.18	3.13	3.17	3.21	3.13	3.15	2.97	3.24
120. Rate expressions and orders of reactions	2.68	2.20	2.57	2.54	2.46	2.44	2.55	2.47
121. Reaction mechanisms	2.37	2.12	2.39	2.57	2.37	2.29	2.48	2.39
122. Chemical equilibria	3.35	3.18	3.25	3.32	3.30	3.14	3.03	3.30
123. Le Châtelier's principle and factors that disturb the equilibrium of systems	3.34	3.29	3.32	3.36	3.38	3.25	3.15	3.40
124. Properties and production of ammonia (e.g., the Haber equilibrium)	1.84	1.89	2.19	2.03	2.02	1.96	1.94	2.15
125. Oxidation and reduction reactions	3.32	3.26	3.44	3.29	3.27	3.33	3.21	3.37
126. Electrochemical cells and electrode reactions	2.99	2.80	2.87	2.86	2.85	2.76	2.76	2.92
127. Metallurgical properties of the transition metals	1.82	1.83	1.93	1.99	1.82	1.89	2.09	1.94
128. Redox properties of the halogens and the halide ions	2.20	2.27	2.39	2.28	2.20	2.23	2.33	2.26
129. Faraday's laws of electrolysis	2.32	2.25	2.49	2.28	2.37	2.20	2.09	2.31
130. Practical applications of electrochemistry (e.g., electroplating, pH meter)	2.57	2.51	2.71	2.56	2.64	2.51	2.73	2.53

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
E. THE MOLE, CHEMICAL BONDING, AND MOLECULAR GEOMETRY (cont.)								
Solutions and Solubility								
131. Types of solutions (e.g., solid-solid, solid-liquid, liquid-gas)	2.81	2.82	2.85	2.83	2.68	3.06	3.09	2.98
132. Solutes, solvents and solubility	3.20	3.30	3.29	3.29	3.22	3.35	3.33	3.38
133. Effects of temperature and pressure on solubility	3.06	2.96	3.05	2.98	2.81	3.20	2.94	3.21
134. Dissolving process	2.88	2.81	2.92	2.89	2.72	2.99	2.91	3.12
135. Solubility product (K_{sp})	2.77	2.66	2.89	2.97	2.82	2.76	2.52	2.97
136. Concentration of solutes (e.g., dilute, concentrated, saturated; molarity)	3.36	3.54	3.47	3.37	3.37	3.49	3.42	3.53
137. Conductivity of solutions and the ionization process	2.84	2.89	2.97	2.91	2.86	2.92	2.82	3.04
138. Strong and weak electrolytes; non-electrolytes	2.91	2.98	3.13	3.05	2.95	3.09	2.94	3.14
139. Colligative properties of solutions	2.74	2.58	2.88	2.66	2.63	2.75	2.45	2.84
140. Characteristics of properties of acids, bases, and salts	3.51	3.70	3.61	3.52	3.60	3.65	3.52	3.66
141. Arrhenius, Brønsted-Lowery, and Lewis acid-base theories	3.10	3.18	3.17	3.10	3.15	3.06	2.82	3.21
142. pH of solutions of strong and weak acids and bases	3.43	3.44	3.37	3.33	3.39	3.39	3.21	3.44
143. Relative strengths of acids and bases	3.13	3.24	3.31	3.17	3.22	3.20	3.12	3.22
144. Production, properties, and use of the common acids (e.g., sulfuric,)	2.01	2.37	2.48	2.25	2.24	2.33	2.41	2.27
145. Acid-base titration and indicators	3.20	3.26	3.28	3.09	3.12	3.25	3.22	3.25
146. Buffer solutions	2.84	2.85	2.93	2.86	2.89	2.74	2.63	2.72
147. Overall evaluation of the Importance of the Mole, Chemical Bonding, and Molecular Geometry	3.58	3.51	3.56	3.47	3.48	3.56	3.48	3.57

NE = Northeast; C = Central; S = Southern; FW = Far West; F = Female; M = Male; ≤5 = Less than or equal to 5 years teaching experience; >5 = Greater than 5 years teaching experience

Ha9

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=70	N=94	N=76	N=87	N=105	N=222	N=33	N=141
F. BIOCHEMISTRY								
149. Organic functional groups and their reactions	2.64	2.69	2.66	2.59	2.70	2.54	2.25	2.59
150. Monomers and polymers	2.39	2.40	2.61	2.55	2.54	2.42	2.28	2.39
151. Biologically important compounds (e.g., sugar, amino acids, proteins)	2.59	2.56	2.73	2.52	2.56	2.52	2.69	2.45
152. Biologically important chemical processes	2.21	2.32	2.39	2.36	2.39	2.28	2.59	2.21
153. Structure and replication of nucleic acids	2.03	1.94	2.28	2.23	2.21	2.02	2.16	2.01
154. Energy storage and release in biological systems	2.07	1.94	2.22	2.25	2.20	2.11	2.34	2.04
155. Overall evaluation of the importance of Biochemistry	2.12	2.27	2.47	2.36	2.35	2.20	2.34	2.16
G. SCIENCE, TECHNOLOGY, AND SOCIETY								
157. Awareness of ethical and moral responsibilities of scientists	2.89	2.94	3.03	3.09	2.90	3.13	2.94	3.06
158. Awareness of ethical issues/risks/benefits assoc. with the applic. of science	2.91	3.02	2.91	3.15	2.99	3.13	3.00	3.06
159. Detection of environmental hazards	2.99	2.73	3.03	3.06	2.89	3.19	3.22	3.07
160. Risk mgmt issues associated with energy production, transmission, and use	2.46	2.38	2.61	2.74	2.47	2.62	2.61	2.69
161. Risk mgmt issues associated with production/storage/use/disposal of products	2.69	2.66	2.85	2.90	2.74	2.92	3.06	2.94
162. Waste management issues and recycling	2.76	2.69	3.05	2.92	2.83	2.98	3.06	2.96
163. Management of resources (e.g., soil, water, metals, and fossil fuels)	2.73	2.55	3.04	2.86	2.73	2.92	3.03	2.89
164. Use of science and technology to predict and prepare for natural disasters	1.84	1.98	2.37	2.30	2.09	2.28	2.44	2.27
165. Use of technology in everyday life (e.g., lamp, smoke detector, TV, computer)	2.59	2.77	2.84	2.65	2.71	2.75	2.70	2.74
166. Technology transfer (e.g., spin-offs from space technology, superconductors)	2.03	2.27	2.45	2.40	2.35	2.30	2.30	2.42
167. Issues assoc. with chemicals in agriculture/food preparation/preservation	2.41	2.56	2.72	2.64	2.69	2.58	2.67	2.66
168. Social, political, and economic issues arising from science and technology	2.43	2.48	2.59	2.64	2.61	2.69	2.73	2.65
169. Overall evaluation of the importance of Science, Technology, and Society	2.52	2.60	2.77	2.76	2.68	2.71	2.81	2.73

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Ha10

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES								
171. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences	2.60	2.63	2.56	2.58	2.62	2.65	2.63	2.64
172. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect student's learning of the physical sciences	2.87	2.88	2.75	2.86	2.89	2.91	2.91	2.90
Curriculum: Organization and Materials								
173. Reasons for learning the physical sciences	3.12	3.09	3.12	3.21	3.11	3.19	3.09	3.25
174. Reasons for teaching a particular topic in the physical sciences	2.90	2.98	3.14	3.19	3.08	3.16	3.38	3.15
175. Integration within topics in the physical sciences	3.14	3.08	3.17	3.15	3.05	3.26	3.24	3.24
176. Integration among the physical sciences and other disciplines	2.97	2.96	3.05	3.03	2.98	3.17	3.21	3.06
177. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	2.67	2.74	2.92	2.92	2.73	3.00	3.00	2.94
178. Lesson plans in the physical sciences curricula for all students, justification for the plans	2.58	2.62	2.76	2.81	2.54	2.93	3.09	2.80
179. Selection and use of curricular materials and resources (e.g., textbooks, and other printed materials, computer software, laboratory materials) for the physical sciences	2.97	3.13	3.25	3.09	2.99	3.13	3.18	3.12
180. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences	2.50	2.51	2.61	2.63	2.54	2.69	2.66	2.70
181. Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	2.69	2.79	2.87	2.85	2.78	2.90	2.81	2.91

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Ha11

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)								
Instruction								
182. Prerequisite knowledge/experience/skills that students need for the physical sciences	3.00	3.09	3.04	3.07	3.02	3.22	3.19	3.13
183. Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	2.99	2.93	2.95	2.94	2.89	3.17	3.13	3.02
184. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	3.29	3.28	3.48	3.41	3.33	3.52	3.50	3.52
185. Design of appropriate lab experiences for various instructional goals and student learning needs	3.19	3.21	3.26	3.41	3.21	3.35	3.31	3.41
186. Strategies for motivating and encouraging students to succeed in the physical sciences	3.36	3.35	3.35	3.56	3.31	3.49	3.41	3.47
187. Strategies for addressing controversial and/or sensitive issues in the physical sciences	2.80	2.74	2.97	3.01	2.85	2.97	3.03	2.92
Assessment and Evaluation								
188. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	3.38	3.33	3.36	3.26	3.29	3.51	3.59	3.40
189. Errors in student work/performance from prior conceptions about the physical sciences	2.84	2.67	2.72	2.81	2.71	2.91	2.91	2.77
Professional Concerns								
190. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	2.87	2.63	3.00	2.91	2.80	2.86	2.81	2.83
191. Professional and scholarly organizations for science educators	2.60	2.68	2.99	2.72	2.77	2.76	2.84	[illegible]
192. Legal responsibilities/liabilities for teachers in the physical sciences	3.20	3.12	3.21	3.14	3.03	3.46	3.53	[illegible]

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=70	C N=94	S N=76	FW N=87	F N=105	M N=222	≤5 N=33	>5 N=141
H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)								
193. Responsibilities for continuing education in the physical sciences/in science education	2.90	3.01	3.14	3.18	3.00	3.21	3.09	3.20
194. Resources available in the community	2.75	2.74	2.85	2.98	2.80	2.93	3.06	2.92
195. Science-related career information	2.75	2.77	2.85	3.04	2.86	2.85	2.97	2.80
196. Overall evaluation of the importance of Pedagogy Specific to the Physical Sciences	2.92	2.97	2.91	3.13	2.97	3.09	3.27	3.07

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Hb1 Mean Importance Ratings by Subgroups - Physics

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=78	C N=96	S N=80	FW N=72	F N=60	M N=266	≤5 N=37	>5 N=153
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY								
Methodology								
1. Scientific methods (e.g., formulation of problem, hypotheses, experiments)	3.38	3.36	3.41	3.38	3.48	3.45	3.32	3.41
2. Science process skills (e.g., qualitative and quantitative observations)	3.44	3.45	3.46	3.44	3.45	3.57	3.49	3.43
3. Assumptions, models, laws, and theories	3.13	3.21	3.27	3.17	3.23	3.26	3.16	3.20
4. Design of experiments (e.g., controls, independent and dependent variables)	3.03	3.18	3.25	3.19	3.00	3.37	3.30	3.18
History and Philosophy of Science								
5. Historical roots of science	2.46	2.28	2.46	2.35	2.28	2.30	2.19	2.35
6. Contributions of individuals	2.33	2.23	2.40	2.14	2.18	2.28	2.14	2.31
7. Contributions of ethnic groups and cultures	1.68	1.69	1.74	1.69	1.40	1.92	1.76	1.71
Mathematics, Measurement, and Date Manipulation								
8. The metric and SI systems	3.71	3.72	3.78	3.69	3.68	3.70	3.76	3.78
9. Scientific notation	3.55	3.70	3.68	3.60	3.58	3.63	3.70	3.64
10. Estimation and approximation	3.17	3.05	3.28	3.35	3.12	3.17	3.19	3.16
11. Significant figures in measurement and calculations	2.94	3.08	3.18	2.97	2.98	3.18	2.92	3.07
12. Unit/dimensional analysis	3.21	3.43	3.48	3.49	3.33	3.43	3.53	3.44
13. Experimental errors (e.g., sources, quantifications, precision, accuracy)	2.77	2.92	3.13	2.83	2.88	2.98	3.00	2.91
14. Mathematical relationships and patterns in numerical data	3.30	3.25	3.31	3.24	3.20	3.34	3.35	3.30
15. Statistics of distributions	2.03	2.19	2.29	2.13	2.05	2.23	2.38	2.04
16. Simple digital (binary) logic	1.51	1.71	1.97	1.76	1.63	1.98	1.94	1.67
17. Organization and interpretation of data and equations	3.49	3.34	3.39	3.39	3.47	3.46	3.43	3.43

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Hb2

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=78	C N=96	S N=80	FW N=72	F N=60	M N=266	≤5 N=37	>5 N=153
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)								
18. Differentiation and simple integration	2.32	2.22	2.37	2.46	2.35	2.17	2.14	2.11
19. Vector algebra	3.04	3.18	3.26	3.18	3.31	3.29	3.38	3.20
Laboratory and Safety								
20. Use and calibration of laboratory equipment (e.g., balances, laboratory burners)	3.13	3.23	3.38	3.14	3.23	3.37	3.25	3.21
21. Maintenance of laboratory equipment (e.g., laboratory burners, glassware)	2.51	2.88	2.80	2.65	2.70	2.75	2.68	2.72
22. Preparation and set-up of reagents, materials, and apparatus	3.26	3.33	3.35	3.17	3.20	3.39	3.35	3.33
23. Laboratory safety (e.g., laboratory hazards, storage and disposal of materials)	3.33	3.49	3.55	3.46	3.18	3.71	3.65	3.47
24. Emergency procedures for laboratory accidents	3.47	3.55	3.65	3.39	3.37	3.83	3.65	3.61
25. Overall evaluation of the importance of Scientific Methodology/Techniques/History	3.16	3.23	3.13	3.10	3.19	3.28	3.23	3.14
B. BASIC TOPICS IN PHYSICAL SCIENCE								
Matter and Energy								
27. Physical and chemical properties (e.g., states of matter, heterogeneous)	2.79	2.87	2.92	2.81	2.78	2.97	3.03	2.78
28. Particulate nature of matter (e.g., atoms, ions, molecules)	3.12	3.28	3.23	3.17	3.10	3.15	3.16	3.21
29. Elements, compounds, and mixtures	2.77	2.84	2.88	2.82	2.63	2.95	2.89	2.75
30. Physical and chemical changes	2.71	2.95	3.04	2.79	2.71	3.00	3.11	2.84
31. Conservation of mass/energy	3.67	3.53	3.68	3.64	3.64	3.81	3.81	3.61
32. Forms of energy (e.g., kinetic, potential, mechanical, magnetic, electrical, light)	3.69	3.63	3.76	3.57	3.61	3.73	3.62	3.69
33. Energy transformations	3.65	3.47	3.58	3.38	3.56	3.51	3.54	3.55

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=78	N=96	N=80	N=72	N=60	N=266	N=37	N=153
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)								
Heat and Thermodynamics								
34. Historical development of heat and energy	2.10	2.04	2.28	1.97	2.07	2.07	1.95	2.17
35. Kinetic molecular theory	2.95	2.77	3.00	3.00	2.88	2.98	2.97	3.04
36. Equipartition of energy	2.28	2.08	2.53	2.36	2.24	2.46	2.33	2.31
37. Brownian motion	2.15	2.16	2.32	2.24	2.17	2.29	2.19	2.25
38. Heat versus temperature	3.36	3.29	3.43	3.28	3.43	3.25	3.19	3.32
39. Temperature scales and measurement	3.05	3.06	3.28	2.89	3.05	3.12	3.00	3.13
40. Conduction, convection, and radiation	3.06	2.91	3.24	2.82	2.93	3.03	3.03	2.98
41. Heat capacity, thermal exchange, heat of fusion, and heat of vaporization	3.09	3.08	3.34	2.91	3.07	3.14	3.03	3.16
42. Phase changes	2.99	2.99	3.33	2.86	3.00	3.20	3.14	3.13
43. Expansion and contraction	2.85	2.78	3.10	2.69	2.78	3.00	2.83	2.92
44. Zeroth law of thermodynamics (i.e., direction of heat flow)	2.99	2.92	3.06	2.87	3.13	3.05	2.81	2.91
45. First law of thermodynamics (i.e., energy is conserved)	3.50	3.38	3.35	3.46	3.65	3.25	3.19	3.40
46. Second law of thermodynamics - entropy	2.95	3.06	3.05	3.10	3.27	2.95	2.86	2.99
47. Third law of thermodynamics (i.e., the concept of absolute zero temperature)	2.76	2.77	2.99	2.94	2.87	2.93	2.78	2.97
48. Reversibility and irreversibility	2.46	2.45	2.59	2.55	2.39	2.58	2.44	2.46
Atomic and Nuclear Structure								
49. Historical discovery of particles (e.g., electron, neutron)	2.27	2.29	2.44	2.21	2.32	2.25	2.08	2.39
50. Atomic models and their experimental bases (Thomson, Rutherford, and Bohr)	2.85	2.76	2.73	2.83	2.78	2.57	2.50	2.71
51. Structure of the atom	3.25	3.27	3.33	3.32	3.25	3.30	3.19	3.19
52. Characteristics of an electron in an atom (e.g., shells, orbitals)	2.88	2.95	3.00	2.94	2.70	3.07	2.95	2.93

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=78	N=96	N=80	N=72	N=60	N=266	N=37	N=153
B. BASIC TOPICS IN PHYSICAL SCIENCE (cont.)								
53. Atomic mass, atomic number, mass number and isotopes	2.97	3.03	3.14	3.11	2.83	3.12	2.97	3.00
54. Nuclear forces and binding energy	2.64	2.69	2.97	2.78	2.75	2.87	2.78	2.79
55. Types of radioactive decay (e.g., alpha, beta, gamma emission)	2.94	2.99	2.96	2.82	2.87	2.95	2.62	2.97
56. Artificial and natural radioactivity	2.67	2.70	2.69	2.62	2.63	2.72	2.41	2.66
57. Half-life of radioactive isotopes	2.74	2.90	2.85	2.79	2.78	2.68	2.68	2.83
58. Nuclear reactions (transmutations, fission, fusion)	2.86	2.89	2.96	2.89	2.90	2.90	2.92	2.91
59. Overall evaluation of the Importance of Basic Topics in Physical Science	3.13	3.17	3.20	3.10	3.11	3.12	3.15	3.15
C. MECHANICS								
61. Vector quantities	3.64	3.64	3.69	3.59	3.63	3.72	3.73	3.72
62. Rel. among position, velocity, acceleration, and time for straight line motion	3.83	3.70	3.74	3.75	3.75	3.77	3.78	3.81
63. Reference frames and relative velocity (e.g., Galilean relativity)	3.00	2.88	3.03	2.94	3.00	3.00	3.05	3.09
64. Rel. among position/velocity/constant acceleration/time for projectile motion	3.51	3.33	3.62	3.40	3.39	3.48	3.57	3.53
65. Rel. of position/velocity/centripetal acceleration for uniform circular motion	3.47	3.23	3.38	3.17	3.27	3.23	3.41	3.33
66. Periodic motion (e.g., frequency, period, amplitude)	3.33	3.33	3.41	3.25	3.29	3.42	3.43	3.28
67. Simple harmonic motion (oscillations)	3.16	3.19	3.24	3.13	3.16	3.28	3.32	3.08
68. Newton's laws of motion	3.87	3.82	3.88	3.92	3.90	3.90	3.89	3.87
69. Weight versus mass	3.56	3.55	3.69	3.51	3.46	3.58	3.68	3.60
70. Friction (e.g., static and dynamic coefficients)	2.97	2.95	3.44	2.86	3.07	3.31	3.27	3.14
71. Static (e.g., equilibrium of forces and/or torques)	3.17	3.13	3.44	3.08	3.15	3.32	3.35	3.26
72. Relationships between work and kinetic energy changes	3.64	3.49	3.62	3.51	3.56	3.54	3.54	3.56
73. Conservative forces and potential energy	3.42	3.33	3.53	3.39	3.39	3.51	3.56	3.38

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Hb5

	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=78	N=96	N=80	N=72	N=60	N=266	N=37	N=153
C. MECHANICS (cont.)								
74. Springs (e.g., Hooke's law, energy considerations)	2.87	2.73	3.03	2.71	2.71	2.92	3.00	2.76
75. Concepts of rigid body motion (e.g., moment or inertia, center of mass, torque)	2.70	2.69	3.01	2.69	2.73	2.92	2.92	2.78
76. Impulse-momentum principle	3.31	3.06	3.37	3.13	3.09	3.31	3.22	3.39
77. Conservation of momentum (in both elastic and inelastic collisions)	3.58	3.55	3.56	3.58	3.54	3.59	3.54	3.58
78. Conservation of angular momentum	2.75	2.94	3.01	2.86	2.85	2.92	2.92	2.70
79. Conservation of energy	3.90	3.75	3.80	3.85	3.92	3.83	3.84	3.78
80. Orbital motion (e.g., Copernicus, Galileo, Kepler)	2.68	2.64	2.61	2.62	2.58	2.67	2.75	2.61
81. Newton's law of universal gravitation	3.53	3.36	3.44	3.49	3.42	3.43	3.50	3.45
82. Fluid mechanics (e.g., Pascal's principle, Bernoulli's principle)	2.43	2.55	2.76	2.41	2.61	2.68	2.67	2.43
83. Relativistic effects on length, mass, and time (e.g., Lorentz transformations)	2.32	2.27	2.54	2.21	2.36	2.39	2.35	2.34
84. Overall evaluation of the importance of Mechanics	3.72	3.73	3.70	3.61	3.72	3.68	3.68	3.69
D. ELECTRICITY AND MAGNETISM								
86. Electric forces and Coulomb's law (e.g., electroscope, pith ball experiments)	3.62	3.40	3.49	3.38	3.47	3.43	3.43	3.44
87. Electric fields	3.34	3.17	3.20	3.21	3.10	3.23	3.24	3.17
88. Gauss's law	2.45	2.45	2.61	2.47	2.29	2.67	2.89	2.42
89. Electric potential energy, electric potential, and potential difference	3.45	3.42	3.38	3.33	3.25	3.46	3.53	3.42
90. Conductors, insulators, semiconductors	3.06	3.13	3.14	3.10	3.05	3.20	3.21	3.18
91. Current	3.62	3.63	3.59	3.45	3.47	3.70	3.62	3.64
92. Resistance	3.57	3.59	3.61	3.35	3.38	3.70	3.55	3.61
93. Series and parallel circuits (e.g., Ohm's law, Kirchhoff's laws)	3.42	3.38	3.53	3.14	3.32	3.63	3.44	3.51
94. Internal resistance of batteries	2.51	2.40	2.63	2.30	2.23	2.66	2.68	2.57

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE	C	S	FW	F	M	≤5	>5
	N=78	N=96	N=80	N=72	N=60	N=266	N=37	N=153
D. ELECTRICITY AND MAGNETISM (cont.)								
95. Capacitance	2.83	2.80	2.92	2.75	2.68	2.82	2.91	2.80
96. Inductance	2.65	2.67	2.74	2.59	2.60	2.78	2.85	2.59
97. Measurement of potential difference, current, resistance, and capacitance	3.27	3.28	3.29	3.07	3.08	3.38	3.12	3.30
98. Alternating current circuits (e.g., average power, peak, effective current)	2.47	2.58	2.69	2.48	2.35	2.89	2.74	2.56
99. Magnetic flux	2.77	2.68	2.73	2.67	2.65	2.86	2.88	2.64
100. Faraday's and Lenz's laws of electromagnetic induction	2.82	2.88	2.92	2.88	2.83	2.96	2.94	2.75
101. Transformers	2.66	2.62	2.72	2.54	2.67	2.79	2.79	2.72
102. Sources of EMF (e.g., batteries, photo cells, generators)	3.00	2.92	2.87	2.83	2.78	2.96	2.97	2.96
103. Motors	2.75	2.65	2.76	2.62	2.82	2.84	2.85	2.86
104. Large scale generation and transmission of energy and power	2.34	2.27	2.34	2.15	2.30	2.54	2.39	2.32
105. n- and p-type semiconductors	2.19	2.28	2.13	2.16	2.23	2.38	2.12	2.23
106. Semiconductor devices (e.g., diodes, transistors)	2.31	2.34	2.31	2.25	2.37	2.46	2.32	2.34
107. Integrated circuits	2.17	2.16	2.13	1.99	2.10	2.43	2.21	2.14
108. Superconductivity	2.17	2.48	2.40	2.41	2.46	2.66	2.59	2.45
109. Magnets	3.06	3.04	3.10	3.01	3.20	3.20	3.00	3.22
110. Magnetic fields	3.26	3.16	3.28	3.26	3.27	3.36	3.24	3.27
111. Gauss's law of magnetism (nonexistence of monopoles)	2.17	2.36	2.43	2.42	2.28	2.65	2.56	2.35
112. Magnetic forces	3.18	3.05	3.14	3.00	3.05	3.25	3.12	3.07
113. Principle and calibration of electrical meters (e.g., voltmeters, ammeters)	2.32	2.48	2.59	2.34	2.35	2.66	2.42	2.53
114. Types of magnetism (e.g., diamagnetism)	2.03	2.04	2.19	2.00	1.93	2.36	2.12	2.12
115. Biot-Savart law and Ampere's law (relating current to magnetic field)	2.65	2.53	2.47	2.50	2.47	2.66	2.74	2.42

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=78	C N=96	S N=80	FW N=72	F N=60	M N=266	≤5 N=37	>5 N=153
D. ELECTRICITY AND MAGNETISM (cont.)								
116. Maxwell's equations	2.12	2.14	2.31	2.36	2.10	2.30	2.38	2.05
117. Lorentz force law and applications (force on a charged particle moving in an electric and/or a magnetic field; cyclotron; mass spectrometry)	2.43	2.60	2.41	2.70	2.52	2.30	2.33	2.32
118. Overall evaluation of the importance of Electricity and Magnetism	3.36	3.31	3.31	3.31	3.28	3.31	3.19	3.26
E. WAVES								
120. Wave characteristics (speed, amplitude, wavelength, frequency)	3.76	3.65	3.66	3.64	3.77	3.73	3.72	3.69
121. Inverse square law for intensity	3.12	2.89	3.10	2.88	3.08	3.03	2.94	3.09
122. Transverse and longitudinal waves	3.40	3.41	3.37	3.19	3.38	3.47	3.42	3.46
123. Absorption and transmission	2.91	2.81	2.97	2.69	2.80	3.22	3.00	2.97
124. Reflection	3.38	3.29	3.44	3.27	3.32	3.53	3.44	3.47
125. Scattering	2.72	2.68	2.80	2.57	2.63	2.88	2.97	2.74
126. Refraction and Snell's law	3.44	3.40	3.46	3.31	3.33	3.51	3.42	3.49
127. Interference and superposition of waves	3.50	3.43	3.19	3.35	3.30	3.31	3.31	3.43
128. Standing waves	3.19	3.07	3.06	3.03	3.00	3.14	3.06	3.17
129. Diffraction (Fraunhofer and Fresnel)	3.00	3.03	2.96	2.79	2.97	2.95	2.72	3.09
130. Dispersion	2.64	2.64	2.67	2.49	2.65	2.81	2.49	2.69
131. Resonance and natural frequencies	3.12	2.98	2.97	3.06	3.10	2.95	2.83	3.01
132. Doppler effect	3.05	3.04	3.29	2.96	2.95	3.32	3.28	3.17
133. Characteristics of sound waves (pitch, loudness [dB], speed)	2.90	2.96	3.15	2.84	2.82	3.27	3.08	3.16
134. Sound: air columns and strings (e.g., timbre, beats, harmonics)	2.50	2.65	2.84	2.50	2.57	2.76	2.64	2.72
135. The electromagnetic spectrum (gamma rays to radio waves)	3.41	3.46	3.24	3.21	3.32	3.44	3.17	3.40

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
	NE N=78	C N=96	S N=80	FW N=72	F N=60	M N=266	≤5 N=37	>5 N=153
E. WAVES (cont.)								
136. Color (addition and subtraction; relationship to frequency)	2.60	2.60	2.66	2.72	2.65	2.92	2.75	2.82
137. Coherent radiation (sources and special properties)	2.36	2.46	2.47	2.33	2.28	2.59	2.17	2.45
138. Geometric optics (e.g., mirrors, lenses, prisms, fiber optics)	3.40	3.36	3.28	3.21	3.22	3.37	3.28	3.39
139. Polarization	2.79	2.86	2.82	2.75	2.77	2.96	2.80	2.87
140. Thin films	2.27	2.39	2.44	2.27	2.23	2.49	2.42	2.40
141. Overall evaluation of the importance of Waves	3.40	3.38	3.37	3.21	3.39	3.33	3.23	3.42
F. MODERN PHYSICS								
143. Blackbody radiation	2.53	2.38	2.53	2.49	2.37	2.61	2.57	2.30
144. Photoelectric effect	3.14	2.91	3.08	3.01	2.95	3.18	2.97	3.02
145. Spectroscopy	2.92	2.88	2.86	2.91	2.95	2.95	2.83	2.81
146. Planck's hypothesis	2.87	2.77	2.77	2.86	2.77	2.84	2.77	2.72
147. deBroglie's hypothesis	2.73	2.67	2.66	2.63	2.60	2.74	2.63	2.48
148. Wave-particle duality	3.14	3.03	3.13	3.12	3.13	3.16	3.00	3.06
149. Heisenberg uncertainty principle	2.67	2.62	2.75	2.81	2.72	2.79	2.66	2.58
150. Schrödinger's wave equation	2.10	1.98	2.23	2.17	1.97	2.33	2.25	1.95
151. Orbital theory - quantum numbers	2.55	2.49	2.73	2.54	2.50	2.79	2.59	2.53
152. Pauli exclusion princip:	2.50	2.39	2.58	2.62	2.40	2.59	2.36	2.35
153. Michelson-Morley experiment (ether and the speed of light)	2.71	2.68	2.66	2.61	2.67	2.64	2.47	2.68
154. Special relativity	2.66	2.63	2.71	2.70	2.68	2.64	2.44	2.64
155. Lorentz transformations and inertial reference frames	2.18	2.07	2.31	2.21	2.08	2.11	2.11	2.13
156. Mass/energy transformations	2.94	2.82	2.85	2.82	2.85	2.98	2.78	2.84

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	GEOGRAPHIC REGION				SEX		TEACHING EXPERIENCE	
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F. MODERN PHYSICS (cont.)								
157. Elementary particles (e.g., hadrons, leptons)	2.19	2.23	2.09	2.06	2.18	2.16	1.97	2.09
158. Strong and weak forces	2.21	2.26	2.40	2.30	2.29	2.49	2.22	2.32
159. Overall evaluation of the importance of Modern Physics	2.94	2.88	2.89	2.91	2.91	2.82	2.72	2.83
G. SCIENCE, TECHNOLOGY, AND SOCIETY								
161. Awareness of ethical and moral responsibilities of scientists	2.81	2.97	2.97	2.91	2.90	3.05	3.00	2.92
162. Awareness of ethical issues, risks, and benefits associated with the application of science	2.81	2.96	3.03	2.87	2.92	3.10	2.97	2.90
163. Detection of environmental hazards	2.70	2.83	3.00	2.70	2.92	3.00	3.16	2.80
164. Risk mgmt issues associated with energy production, transmission, and use	2.57	2.48	2.69	2.51	2.63	2.59	2.78	2.60
165. Risk mgmt issues associated with production/storage/use/disposal of products	2.44	2.48	2.73	2.43	2.60	2.71	2.83	2.59
166. Waste management issues and recycling	2.51	2.57	2.82	2.50	2.71	2.84	2.78	2.67
167. Management of resources (e.g., soil, water, metals, and fossil fuels)	2.41	2.55	2.83	2.55	2.52	2.86	2.94	2.60
168. Use of science and technology to predict and prepare for natural disasters	2.09	2.24	2.59	2.09	2.17	2.62	2.61	2.29
169. Use of technology in everyday life (e.g., lamp, smoke detector, TV, computer)	2.83	2.93	3.13	2.88	2.85	3.26	3.17	2.97
170. Technology transfer (e.g., spin-offs from space technology, superconductors)	2.17	2.51	2.74	2.26	2.22	2.91	2.78	2.53
171. Social, political and economic issues arising from science and technology	2.53	2.72	2.79	2.51	2.72	2.91	2.83	2.72
172. Overall evaluation of the importance of Science, Technology, and Society	2.57	2.75	2.87	2.60	2.72	2.91	2.86	2.74

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H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES								
174. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect the teaching of the physical sciences	2.41	2.66	2.64	2.49	2.58	2.91	2.56	2.59
175. Recognition of and compensation for complex factors associated with societal and school-related issues that may affect student's learning of the physical sciences	2.74	2.89	2.94	2.75	2.86	3.16	2.76	2.91
Curriculum: Organization and Materials								
176. Reasons for learning the physical sciences	3.14	3.14	3.23	3.10	3.34	3.32	3.19	3.23
177. Reasons for teaching a particular topic in the physical sciences	3.06	3.12	3.24	2.96	3.28	3.32	3.17	3.19
178. Integration within topics in the physical sciences	2.92	2.93	3.09	3.06	2.97	3.22	3.17	2.95
179. Integration among the physical sciences and other disciplines	2.73	2.75	3.04	2.90	2.78	3.18	3.00	2.83
180. Scope and sequence of topics in the physical sciences curricula for all students and justification for the scope and sequence	2.54	2.56	2.80	2.57	2.55	2.92	2.58	2.64
181. Lesson plans in the physical sciences curricula for all students, justification for the plans	2.21	2.46	2.61	2.35	2.50	2.73	2.44	2.52
182. Selection and use of curricular materials and resources (e.g., textbooks, and other printed materials, computer software, laboratory materials) for the physical sciences	2.88	3.03	3.10	3.07	2.98	3.10	3.06	3.11
183. Selection/use of mass media (e.g., film) appropriate for topics in the physical sciences	2.60	2.77	2.87	2.64	2.66	3.02	2.64	2.87
184. Selection and use of current technologies (e.g., computer, videodisc, interactive television, video) appropriate for laboratory data collection and other instructional purposes in the physical sciences	2.74	2.90	2.97	2.87	2.77	3.12	2.71	2.99

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H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)								
Instruction								
185. Prerequisite knowledge/experience/skills that students need for the physical sciences	2.91	2.98	3.01	3.12	3.08	3.22	3.14	2.96
186. Recognition of and accommodation to the prior conceptions, experience, and skills that students bring to various topics in the physical sciences	3.00	3.01	3.00	2.94	3.07	3.13	3.00	2.91
187. Identification and selection of appropriate lab experiences for various instructional goals and student learning needs	3.38	3.29	3.46	3.28	3.30	3.45	3.26	3.34
188. Design of appropriate lab experiences for various instructional goals and student learning needs	3.21	3.20	3.29	3.22	3.23	3.30	3.12	3.26
189. Strategies for motivating and encouraging students to succeed in the physical sciences	3.40	3.38	3.50	3.37	3.45	3.60	3.37	3.38
190. Strategies for addressing controversial and/or sensitive issues in the physical sciences	2.64	2.74	2.76	2.78	2.75	2.97	2.68	2.70
Assessment and Evaluation								
191. Assessment strategies (e.g., laboratory reports, portfolios, observations, oral discussions, written tests, performance-based assessments, projects) to evaluate student performance in the physical sciences	3.24	3.23	3.28	2.96	3.20	3.40	3.15	3.24
192. Errors in student work/performance from prior conceptions about the physical sciences	2.83	2.99	3.04	2.99	3.00	3.13	3.03	2.92
Professional Concerns								
193. Professional and scholarly literature (e.g., journals, reference works) appropriate for teachers and students in the physical sciences	2.73	2.80	2.91	2.88	2.68	2.83	3.03	2.76
194. Professional and scholarly organizations for science educators	2.73	2.82	2.91	2.78	2.61	2.97	2.88	2.73
195. Legal responsibilities/liabilities for teachers in the physical sciences	2.87	2.84	3.18	2.82	2.78	3.20	2.94	3.08

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H. PEDAGOGY SPECIFIC TO THE PHYSICAL SCIENCES (cont.)								
196. Responsibilities for continuing education in the physical sciences/in science education	2.90	2.93	3.06	2.86	2.81	3.30	3.21	2.95
197. Resources available in the community	2.56	2.72	3.08	2.60	2.47	3.14	3.03	2.68
198. Science-related career information	2.57	2.89	3.05	2.76	3.08	2.77	3.21	2.78
199. Overall evaluation of the Importance of Pedagogy Specific to the Physical Sciences	2.83	2.95	2.96	2.87	3.16	2.89	2.94	2.88

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