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ABSTRACT

This curriculum guide, developed to establish statewide curriculum standards for the Louisiana Competency-based Education Program, contains the minimum competencies and process skills that should be included in a chemistry course. It consists of: (1) a rationale for an effective science program; (2) a list and description of four major goals of science; (3) a list and description of eight basic process skills (such as predicting and classifying) and five integrated processes (such as controlling variables and defining operationally); and (4) a 15-part curriculum outline. These parts provide performance objectives correlated with a concept, process skill(s), and suggested activities for each of the following major topic areas: the science of chemistry; mathematics of chemistry; matter and energy; chemical shorthand; stoichiometry and the mole; atomic structure; periodic classification; chemical bonding; physical states of matter; solutions; reaction rate and chemical equilibrium; acids, bases, and salts; oxidation and reduction reactions; nuclear chemistry; and organic chemistry. Resource materials (including lists of suggested films, demonstration sources, and audiovisual suppliers) and brief comments on evaluation techniques are also provided. (JN)

STATE OF LOUISIANA
DEPARTMENT OF EDUCATION

CHEMISTRY CURRICULUM GUIDE

BULLETIN 1660
1984

Thomas G. Clausen, Ph.D.
Superintendent

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DEPARTMENT OF EDUCATION

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Issued by

Office of Academic Programs

THOMAS G. CLAUSEN, Ph.D.

Superintendent

FOREWORD

Act 750 of the 1979 Louisiana Legislature (R.S. 17:24.4) established the Louisiana Competency-Based Education Program. One of the most important provisions of Act 750 is the mandated development and establishment of statewide curriculum standards for required subjects. These curriculum standards include curriculum guides which contain minimum skills, suggested activities, and suggested materials of instruction.

During the 1979-80 school year, curriculum guides were developed by advisory and writing committees representing all levels of professional education and all geographic areas across the State of Louisiana for the following Science courses: Elementary K-6, Life Science, Earth Science, Physical Science, General Science, Biology, Chemistry, and Physics.

During the 1982-83 school year, the curriculum guides were piloted by teachers in school systems representing the different geographic areas of the State as well as urban, suburban, inner-city, and rural schools. The standard populations involved in the piloting reflect also the ethnic composition of Louisiana's student population. Based upon participants' recommendations at the close of the 1982-83 pilot study, the curriculum guides were revised to ensure that they are usable, appropriate, accurate, comprehensive, relevant, and clear.

Following the mandate of Act 750, the revised curriculum guides will be implemented statewide in the 1984-85 school year. The statewide implementation is not, however, the end of the curricular development process. A continuing procedure for revising and improving curricular materials has been instituted to ensure that Louisiana students have an exemplary curriculum available to them--a curriculum that is current, relevant, and comprehensive. Such a curriculum is essential if we are to provide the best possible educational opportunities for each student in the public schools of Louisiana.

Thomas G. Clausen

Thomas G. Clausen, Ph.D.

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PREFACE

The Chemistry Curriculum Guide contains the minimum competencies and process skills that should be included in a Chemistry course. Each teacher should build on the foundation of these minimum competencies to establish the maximum program possible for his/her students. The teacher must take special care to incorporate all skills contained in this guide within the framework of his/her instructional program. The guide is flexible enough to be adapted to most of the commercial basal programs; and teachers may adjust the sequence of content based on the needs of their students, the available equipment, and the textbooks. Furthermore the committee feels that in order to implement a minimum standards course in chemistry, the students must be actively involved in a minimum of sixteen laboratory situations per school year.

The guide contains suggested activities designed to assist the teacher in teaching each competency; however, the teacher and the students should not be limited to these activities nor bound to utilize all of them. There are many other activities available to the teacher which will help him/her to present each competency and process skill to the student. It is hoped that the teacher will be resourceful in using many types of experiences to teach the topics listed.

Methods of science instruction, to be most effective, must be based upon the development of process skills in critical thinking. An effort has been made to incorporate numerous process skills in the suggested activities, and the teacher should utilize as many of these skills as possible in daily instruction.

This curriculum guide should be of special benefit to the teacher in helping to organize the Chemistry course. It is suggested that additional textbooks, workbooks, and laboratory manuals be consulted for activities, demonstrations, and experiments to supplement those described in this curriculum guide.

RATIONALE

Developments in science technology have improved our way of living and have become a major influence on our culture. No one in our culture escapes the direct influence of science. Because of the impact of science on our social, economic, and political institutions, the education of every responsible citizen must include not only the basic principles of science but also the attitudes and processes of scientific thought.

The nature of science itself determines the way that it should be taught. The definition of science is a two-fold one: It is (1) an unending method or process of seeking new knowledge, and (2) the body of knowledge which results from this search. Science is an intellectual, active process which involves an investigator of any age and something to investigate. The discipline of science taught by the process approach teaches the student how to learn, and that intellectual gain is a permanent one for the student.

The process approach develops the intellectual abilities of students. Some students develop thinking skills in the normal course of growing up in a complex world, but the acquisition of useful skills and attitudes is by no means automatic. Many students succeed in school by repeating what they are told in a slightly different form or by memorizing; such strategies are of little extended value. At present, relatively few students develop persistence in and zest for dealing with new concepts because they are not aware of their intellectual capabilities. Thus, they need literally to experience application of scientific process skills in different situations.

To be most effective, methods of science instruction must be based upon the development of skills in critical thinking. Guided practice in experimenting, observing, gathering information, organizing facts, and drawing conclusions will help to develop critical thinking skills. Laboratory techniques should be employed whenever possible, and inquiry teaching/learning situations using both deductive and inductive reasoning should be the predominant method used in all classroom activities. The teacher's role in a process-oriented science classroom includes being a provider of problems, a discussion leader, a supplier of clues (when necessary), and a skillful questioner, i.e., a facilitator of learning activities. Thus, the aim of an effective science program should be to equip each child with competencies in the basic processes and concepts of science through individual participation in activities and investigations specifically designed to develop such capabilities.

GOALS

Achieving scientific literacy involves the development of attitudes, process skills, concepts, and social aspects of science and technology. Based upon this belief, the following major goals of science are stated:

1. To Foster Positive Attitudes Toward the Scientific Process

   Students will develop a deep appreciation of the role the scientific process plays in their everyday lives.

2. To Develop Process Skills

   Process skills development should be an integral part of science activities for students. Students should be given opportunities to develop those intellectual processes of inquiry and thought by which scientific phenomena are explained, measured, predicted, organized, and communicated.

   Basic Process Skills: Observing, inferring, classifying, using numbers, measuring, using space-time relationships, communicating, predicting.

   Integrated Process Skills: Controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting.

3. To Acquire Knowledge

   Included in the basic science curriculum should be those scientific facts, principles, concepts, and terms which will enable the students to understand and interpret natural phenomena.

   Areas of Knowledge: Life Science, Physical Science, Earth Science

4. To Recognize Social Aspects of Science and Technology

   The students should (a) understand the interrelationships of science, technology, and social and economic development; and (b) recognize both the limitations and the usefulness of science and technology in advancing human welfare.

PROCESS SKILLS

There are eight basic science process skills which are stressed: (1) observing, (2) inferring, (3) classifying, (4) using numbers, (5) measuring, (6) using space/time relationships, (7) communicating, and (8) predicting. There is a progressive intellectual development within each process category. A brief description of each basic process skill follows:

OBSERVING: To observe is to use one or more of the five senses to perceive properties of objects or events as they are. Statements about observations should be (1) quantitative where possible, (2) descriptive regarding change(s) and rates of change(s), and (3) free of interpretations, assumptions, or inferences.

INFERRING: To infer is to explain or to interpret an observation. Inferences are statements which go beyond the evidence and attempt to interpret or to explain one or more observations. Inferences are based on (1) observations, (2) reasoning, and (3) past experiences of the observer. Inferences require evaluations and judgments, and they may or may not be accurate interpretations or explanations of the observation.

CLASSIFYING: Classifying is the grouping or ordering of phenomena according to an established scheme. Objects and events may be classified on the basis of observations. Classification schemes are based on observable similarities and differences in arbitrarily selected properties. Classification keys are used to place items within a scheme as well as to retrieve information from a scheme.

USING NUMBERS: To use numbers is to describe the measurement, properties, and relationships of quantities through the use of symbols.

MEASURING: To measure is to find out the extent, size, quantity, capacity, and other properties of a given object, especially by comparison with a standard. Once the concept of measuring is introduced and mastered in first grade, the metric and/or SI system should be used exclusively.

USING SPACE/TIME RELATIONSHIPS: Space/Time relationships is the process that develops skills in the description of spatial relationships and how they change with time. This process skill includes the study of shapes, time, direction, spatial arrangement, symmetry, motion, and rate of change.

COMMUNICATING: To communicate is to pass information along from one person to another. Communications may be verbal, nonverbal (i.e., gestures), written, or pictorial (pictures, maps, charts, and graphs). Communications should be concise, accurate, clear, precise descriptions of what is perceived.

PREDICTING: Predicting is forecasting what future observations might be; it is closely related to observing, inferring, and classifying. The reliability of predictions depends upon the accuracy of past and present observations and upon the nature of the event being predicted.

As basic progressive, intellectual development proceeds in each basic process skill, the interrelated nature of the processes is manifested in the five integrated processes: (1) controlling variables, (2) defining operationally, (3) formulating hypotheses, (4) interpreting data, and (5) experimenting. A brief description of each integrated process skill follows:

CONTROLLING VARIABLES: A variable is any factor in a situation that may change or vary. Investigators in science and other disciplines try to determine what variables influence the behavior of a system by manipulating one variable, called the manipulated (independent) variable and measuring its effect on another variable, called the responding (dependent) variable. As this is done, all other variables are held constant. If there is a change in only one variable and an effect is produced on another variable, then the investigator can conclude that the effect has been brought about by the changes in the manipulated variable. If more than one variable changes, there can be no certainty at all about which of the changing variables causes the effect on the responding variable.

DEFINING OPERATIONALLY: To define operationally is to choose a procedure for measuring a variable. In a scientific investigation, measurements of the variables are made; however, the investigator must decide how to measure each variable. An operational definition of a variable is a definition determined by the investigator for the purpose of measuring the variable during an investigation; thus, different operational definitions of the same variable may be used by different investigators.

FORMULATING HYPOTHESES: To formulate a hypothesis is to make a guess about the relationships between variables. A hypothesis is usually stated before any sensible investigation or experiment is performed because the hypothesis provides guidance to an investigator about the data to collect. A hypothesis is an expression of what the investigator thinks will be the effect of the manipulated variable on the responding variable. A workable hypothesis is stated in such a way that, upon testing, its credibility can be established.

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INTERPRETING DATA: The process of interpreting data may include many behaviors such as (1) recording data in a table, (2) constructing bar and line graphs, (3) making and interpreting frequency distributions, (4) determining the median, mode, mean, and range of a set of data, (5) using slope or analytical equations to interpret graphs, and (6) constructing number sentences describing relationships between two variables. Interpreting data requires going beyond the use of skills of tabulating, charting, and graphing to ask questions about the data which lead to the construction of inferences and hypotheses and the collecting of new data to test these inferences and hypotheses. Interpretations are always subject to revision in the light of new or more refined data.

EXPERIMENTING: (Using the scientific method): Experimenting is the process of designing a procedure that incorporates both the basic and integrated process skills. An experiment may begin as a question for the purpose of testing a hypothesis. The basic components of experimenting are as follows:

1. Constructing a hypothesis based on a set of data collected by the person from observations and/or inferences.

2. Performing a test of the hypothesis. The variables must be identified and controlled as much as possible. Data must be collected and recorded.

3. Describing or interpreting how the data support or do not support the hypothesis, i.e., deciding whether the hypothesis is to be accepted, modified, or rejected.

4. Constructing a revised hypothesis if the data do not support the original hypothesis.

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        2. Halogen derivatives

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COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
I. THE SCIENCE OF CHEMISTRY			
The student will be able to:			
1. Differentiate between the fields of chemistry and the fields of biology and physics.	Relationship of chemistry to other sciences	Observing, classifying, communicating	1. Collect science related articles from newspapers and magazines and classify into fields of chemistry, biology, and physics. 2. Prepare posters showing chemistry in everyday living.
2. Identify and give the use of basic laboratory equipment.	Lab equipment	Observing, classifying	Examine, handle, and/or sketch basic laboratory equipment using proper names for each.
3. Recognize and apply the basic safety rules for laboratory procedures.	Lab safety	Observing, classifying	1. Film/filmstrip on laboratory safety. 2. Prepare posters on laboratory safety. Optional--sign lab safety contracts. Students should receive copies of safety rules, equipment identification sheet, and first aid procedure for the laboratory.
4. Locate and know how to use safety equipment in the laboratory.	Lab safety	Observing, classifying, communicating	Teacher demonstration of how to use safety equipment (fire extinguisher, fire blanket, eyewash station, etc.).
5. Demonstrate the correct laboratory techniques.	Lab techniques	Communicating, measuring, using numbers	Experiment: Laboratory techniques (use of Bunsen burners, glass manipulation, balances, measuring liquids, etc.).

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
6. Identify the following steps of of the scientific method given an experimental situation: problem arising from observation and curosity, hypothesis, design experiment, experimentation, conclusion, and predictions.	Scientific method	Classifying, observing, inferring, using numbers, measuring, using space/time relationships, communicating, predicting, controling variables, formulating hypothesis, interpreting data, experimenting	1. Using literature describing a scientific experiment, students will identify the steps of the scientific method. 2. Experiment in which the student writes a laboratory report using the scientific method.
7. Identify the dependent and independent variables given a set of data.	Variable identification	Classifying, interpreting data, communicating, using numbers, measuring, using space/time relation-ships, observing	Experiment: Heat water to boiling and record the temperature at one minute intervals. (Variables: dependent, temperature; independent, time.)
8. Construct a graph from a given set of data.	Graphing	Classifying, interpreting data, communicating, using numbers, controlling variables	Using data from the preceding experiment, construct a graph.
9. Interpret the data from a graph.	Data interpretation	Interpreting, communicating, predicting, inferring, using numbers	Interpret graphs selected from scientific literature

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
II. MATHEMATICS OF CHEMISTRY			
10. Identify the basic metric units and at least one instrument for measuring each.	Metric system Fundamental and derived units	Observing, using numbers, classifying, measuring	1. Experiment: Determine the density of a regularly shaped solid, irregularly shaped solid, and a liquid using metric instruments. 2. Experiment: Calculate the thickness of a 10 cm X 10 cm piece of aluminum foil using density, mass, and area.
11. Measure length, volume, mass, temperature, and time using metric units.		Measuring, using numbers, observing, classifying	Same as #10
12. Convert units within the metric system involving length, mass, and volume using the factor-label method.	Conversion	Using numbers	Exercise: Solve problems using the factor-label method.
13. Differentiate between accuracy and precision.	Measurements and calculations Accuracy and precision	Classifying, observing, using numbers, measuring, interpreting data	1. Experiment: Determine the density of a common metal and compare with the accepted value from a handbook of chemistry. Calculate the percent of error to determine accuracy.
14. Convert common numbers to scientific notation and vice versa.	Scientific notation	Using numbers	Exercise: Problems on scientific notation
15. Record measurements with the proper number of significant figures.	Significant figures	Observing, measuring, using numbers	Perform a measurement using two instruments of different precision (millimeter vs. centimeter; 10 milliliters vs. 50 millileters).

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
III. MATTER AND ENERGY			
16. Distinguish between elements, compounds, and mixtures.	Classification of matter	Observing, predicting, inferring, classifying, formulating hypotheses, defining operationally	1. Experiment: General classes of matter (use iron and sulfur to illustrate element, compound, and mixture). 2. Using contained samples of elements, compounds, and mixtures, by observation only classify: a. as homogeneous/heterogeneous b. solid/solution/unable to determine c. element/compound/unable to determine 3. Film/filmstrip, transparencies--classification of matter.
17. Distinguish between homogeneous and heterogeneous substances.	Homogenous/heterogeneous solution	Classifying, observing, inferring	Same as #16, parts 2 and 3
18. Classify properties of matter as either physical or chemical.	Properties of matter	Classifying, observing	Demonstration of selected physical and chemical properties.
19. Describe the three normal states of matter in terms of properties and classify matter into these categories.	Phases of matter.	Using space/time relationships, observing, controlling variables, classifying, using numbers, communicating, measuring, interpreting data, predicting, formulating hypotheses	Experiment: Melting point of a pure substance. Heat and cool a tube of paradichlorobenzene which has been placed in water bath. The temperature should be recorded every minute until melting occurs. Plot the data on a graph.
20. Recognize examples of physical, chemical, and nuclear changes.	Changes	Inferring, classifying, observing	Experiment: Physical and chemical changes (melt ice or wax; dissolve sugar or salt in water; burn wood or paper; react acid with a metal).

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
21. State the law of conservation of matter and energy and give examples of its application.	Conservation of matter and energy	Inferring, measuring, using numbers, observing	Experiment: Determine the mass before and after a chemical reaction. React lead nitrate and sodium in a closed system.
IV. CHEMICAL SHORTHAND			
22. Recognize the symbols for elements with atomic numbers 1-30 with their common oxidation numbers.	Elements and symbols	Observing, classifying, communicating	Play a game based on names and symbols of elements.
23. Distinguish between symbol and formulas; atomic weights and molecular weights.	Compounds, formulas and nomenclature	Classifying, using numbers	Exercise: Calculate molecular weights using atomic weights.
24. Use Greek prefixes or Roman numerals in naming simple binary compounds.	Compounds, formulas and nomen clature	Classifying, using numbers	Exercises on naming compounds using Greek prefixes and Roman numerals.
25. Write a simple formula of chemical compounds using oxidation numbers (atomic numbers 1 through 30).	Compounds, formulas and nomenclature	Classifying, using numbers	Write formulas for the resulting compounds from reactants given.
26. Calculate the percentage composition of any given compound.	Percentage composition	Using numbers, interpreting data, observing, measuring, predicting	1. Exercise: Solve problems on percentage composition. 2. Experiment: Determine the percentage of oxygen in a compound; water in a hydrate.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
27. Determine an empirical formula from percentage composition data.	Empirical formula	Using numbers, interpreting data, observing, measuring, predicting, controlling variables	1. Exercise: Solve problems on empirical formula. 2. Experiment: Determine the empirical formula of an oxide. Quantitatively, determine the empirical formula of the tin-oxygen compound resulting from heating tin and nitric acid.
28. Determine the molecular formula given the molecular mass and the empirical formula.	Molecular formula	Using numbers, interpreting data	Exercise: Given percent composition and molecular weight, calculate the molecular formula of combining elements.
29. Balance equations representing four different classifications of reactions.	Balancing equations	Classifying, using numbers, observing, measuring, interpreting data, predicting, formulating hypothesis	1. Exercise: Balance simple chemical equations for assigned reactants. Identify each of the equations as representing composition, decompoosition, single replacement, or double replacements. 2. Experiment: Types of chemical reactions.
V. STOICHIOMETRY AND THE MOLE			
30. State Avogado's number.	Avogado's numbers and the mole	Observing, inferring, measuring, using numbers, interpreting data	Demonstration: Determine Avogadro's number. Use oleic acid which will spread over water in a thin film (length of the molecule). Calculate the number of molecules/mole of oleic acid (Avogadro's number).

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
31. Determine the number of moles and number of particles in the mass of a given substance.	Mole	Using numbers, observing	1. Display mole quantities of elements and compounds. An alternative display is a "Guess the number of moles in the flask" exhibit. For this have two identical, stoppered Erlenmeyer flasks. One should be about half full of some chemical. the formula of which is written on the flask.
32. Solve mass-mass/mass-bala ce problems based on a balanced equation.	Mass-mass mass balance relationship	Using numbers, measuring, observing, interpreting data formulating hypotheses	1. Exercise: Solve mass-mass problems 2. Experiment: Determine the mass-mass relationships of a reaction quantitatively collecting the precipitate, lead chromate, from solutions made from .01 moles of lead nitrate and potassium chromate. Calculate the theoretical and percentage yield.
VI. ATOMIC STRUCTURE			
33. Differentiate among the properties: charge, relative mass, location of the electron, proton, and neutron.	Fundamental particles	Classifying, observing	1. Show film/filmstrip on atomic structure. 2. Construct atomic models.
34. Compare the approximate dimensions (radii or diameters) of the nucleus and the atom.	Atomic dimensions	Using numbers, using space/time relationships	Same as #33
35. Select isotopes from a list of elements using the atomic numbers and atomic mass numbers.	Isotopes	Inferring, using numbers	Exercise: Determine the number of protons, electrons, and neutrons in isotopes of elements.

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COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
36. Write the electron configuration electron dot notation, and orbital notation for elements with atomic number 1-20.	Energy levels and electron distribution	Using space/time relationships, inferring, using numbers, observing, interpreting data	1. Using atomic numbers and an "Order of Filling" chart, illustrate the distribution of electrons by doing the following for elements atomic numbers 1-20: electron configuration, orbital notation, and electron dot diagrams. 2. Experiment: Flame tests.
VII. PERIODIC CLASSIFICATION			
37. Identify the chemical and physical properties of elements in the alkali, halogen, and nobel gas and locate these families on the periodic chart.	Periodic properties	Classifying, observing, predicting	1. Film on properties of periodic families of elements. 2. Demonstration: Preparation and properties of chlorine.
38. Predict the common oxidation numbers of elements in Groups IA to VIIA through use of the periodic chart.	Oxidation numbers	Predicting, inferring, interpreting, using numbers	1. Conduct exercises on determining the oxidation number of elements in compounds. 2. Demonstrate the use of ionization energy to predict oxidation numbers.
39. Identify by location on the periodic chart chemical family (group), period (series), transition elements, and rare earth elements.	Periodic groups	Interpreting, classifying	Label specified areas on a blank periodic chart.
40. Locate metals and nonmetals on the periodic chart.	Periodic groups	Classifying	Label specified areas on a blank periodic chart.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
VIII. CHEMICAL BONDING			
41. Distinguish among and recognize examples of ionic, covalent, and and metallic bonding.	Chemical bonding	Observing, predicting, classifying, inferring, defining operationally, formulating hypotheses, experimenting	1. Demonstration: Conductivity of ionic and covalent compounds. 2. Construct molecular models. 3. Examine classroom models of covalent and ionic compounds. 4. View film/filmstrip on chemical bonding. 5. Draw ionic and covalent compounds using electron dots and orbital notation. 6. Devise an experiment to test substances and classify them as ionic, covalent, or metallic.
42. Compare the extent to which hydrogen bonding and Van-der Waals forces affect boiling and melting points.	Intermolecular	Observing, predicting, inferring, interpreting, classifying	Same as #41
IX. PHYSICAL STATES OF MATTER			
43. Relate the three states of matter to be basic assumptions of the Kinetic molecular theory.	Kinetic theory	Observing, classifying, inferring, interpreting	1. View film/filmstrip on the Kinetic molecular theory (properties of solids, liquids, and gases). 2. Demonstrate the diffusion of: a. liquid in a liquid (ink in water) b. a solid in a liquid (potassium permanganate in water) c. a gas in a gas (ammonia in air).
44. Classify examples of solids as either amorphous or crystalline.	Properties of solids	Classifying, observing	Examine samples of amorphous and crystalline solids under magnifying lens.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
45. Predict the relative boiling point of some common liquids when given their vapor pressure.	Properties of liquids	Predicting, interpreting data, observing	1. Demonstrate the effect of lowering the vapor pressure on the boiling point of a liquid such as water (use a vacuum pump or aspirator). 2. Experiment: Boil water in test tube; remove from flame and stopper; invert; water boils at reduced pressure.
46. Determine the relationship between energy and phase changes.	Energy and phase change	Interpreting, observing	Demonstrate sublimation by using dry ice.
47. Solve volume, temperature, and pressure variation problems.	Boyle's Law, Charles' Law, and combined gas law	Interpreting data, using numbers, measuring, observing, communicating, controlling variables, formulating hypotheses	1. Experiment: Charle's Law--Use a flask of air at room temperature. Invert it into a deep container of ice water mixture. Notice the amount of water that enters the flask as the confined air cools. This can be done quantitatively by equalizing the pressure and correcting for water vapor pressure. Resultant volumes can be graphed to determine type of variation. 2. Experiment: a. Use plastic syringes sealed at the tip to illustrate the effect of temperature on volume (use hot water and ice both). b. Heat a 250 ml flask equipped with a one hole stopper and short glass tubing in a water bath at three different

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COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
			temperatures. Place finger over opening on glass tube and invert in tap water. Observe the water level differences. 3. Experiment: Boyle's Law (use plastic syringes to illustrate the effect of pressure on gas volume). 4. Demonstration: Heat a flask with a balloon attached to the top. 5. Exercise: Solve gas law problems.
48. Solve problems relating to mixtures of gases.	Dalton's Law	Using numbers	Exercise: Solve problems related to Dalton's Law.
49. Predict the relative rates of diffusion of gases using Graham's Law.	Graham's Law	Predicting, interpreting data, observing, measuring	Experiment: Compare relative diffusion rates of HCL and NH_4OH by inserting cotton (Q-tips) soaked in equal amounts respectively at either end of a 30-60 cm clean glass tubing. A smoke ring of NH_4Cl will form where vapors meet. Mark the spot where the ring forms. Measure the distance from the stopper to the mark for each gas. Calculate the rate of diffusion of the faster molecules to the rate of diffusion of slower molecules.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
50. Determine the molar volume of a gas by means of Avogadro's principle.	Molar volume of a gas	Using numbers, observing, measuring	E..periment: The molar volume of a gas (react magnesium with HCL in a gas measuring tube).
51. Determine the molecular mass from the gas density at S.T.P. and use the molecular mass to determine density.	Mole-cular weight	Using numbers	Exercise: Solve problems on gas density and molecular mass.
52. Solve mass-gas volume and gas volume-gas volume problems based on a balanced equation.	Mass/volume volume/volume	Using numbers	Exercise: Solve mass-gas volume and gas volume-gas volume pro..lems.
X. Solutions			
53. Define the terms solute, solvent, and solution (concentrated and and dilute).	Nature of solutions	Defining operationally, observing, measuring, using numbers, classifying, experimenting	Experiment on the preparation of unsaturated, saturated, and supersaturated solutions (four grams of sodium thiosulfate in 3 ml of water will produce a saturated solution, and 15 grams will produce a supersaturated solution).
54. Distinguish among saturated, unsaturated, and supersaturated solutions	Concentration	Interpreting, classifying, observing, measuring, using numbers, experimenting	Same as #53

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COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
55. Relate solution equilibrium to saturated solutions.	Equilibrium	Inferring, experimenting	Same as #53
56. Determine the effect of temperature on solubility.	Solubility	Communicating, measuring, observing, controlling variables	Experiment: Determine the solubility of a salt such as KCL, or NH_4CL at different temperatures and plot the solubility curve.
57. Determine the molarity, normality, and molality of a solution given sufficient data.	Molarity and normality	Using numbers, defining operationally, classifying, measuring	1. Conduct exercises on calculating solutions concentrations (molarity, normality and molality). 2. Experiment: Perform calculations and prepare solutions of given concentrations.
58. Distinguish between electrolytes and nonelectrolytes in terms of conductivity.	Ionization	Defining operationally, observing, experimenting, formulating hypotheses	1. Demonstrate conductivity of solutions including electrolytes and nonelectrolytes. 2. Design experimental methods for classifying substances such as electrolytes and nonelectrolytes.
59. Write simple dissociation equations.	Equations	Communicating, using numbers	Exercise: Balance simple dissociation equations.
60. Compare the freezing and boiling points of solutions and pure substances.	Colligative properties	Classifying, predicting, observing, measuring, controlling variables	1. Experiment: Place salt in ice and water and record the coldest temperature; then heat the water to boiling and record the temperature.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
			2. Experiment: Given two unlabeled samples, one pure water and the other salt water, heat both liquids to the boiling point. Record the temperature at one minute intervals and plot the data on a graph. Identify the pure solution by interpreting the graph.
XI. <u>REACTION RATE AND CHEMICAL EQUILIBRIUM</u>			
61. Predict the effect of changing temperature, pressure, concentration, nature of the reactants, and surface area on reaction rate.	Reaction rate	Observing, predicting, controlling variables, using space/time relationships, measuring, using numbers, communicating, interpreting data	Experiments: 1. Perform a "clock" reaction, such as the iodine reaction. Vary temperature, concentration, and use of a catalyst. Interpret results in terms of effect on rate. 2. Use three Erlenmeyer flasks that have equal volumes of water (one hot one, tap water, one cold). Simultaneously add one alka-seltzer tablet to each flask. Cover mouth of each flask with a balloon. Observe the volume of gas in each balloon.
62. Illustrate the relationship between LeChatelier's principle and chemical equilibrium.	Chemical equilibrium	Observing, predicting, communicating	1. Demonstration: $2NO_2$-N_2O_4 equilibrium. Use temperature equilibrium tubes for the $2NO_2N_2O_4$ system by immersing in a. hot water b. cold water 2. Demonstation: Complexion equilibrium

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
XII. ACIDS, BASES, AND SALTS			
63. Define acids and bases in terms of the Arrhenius, Lewis, and Bronsted-Lowry theories.	Arrhenius, Lewis, Bronsted-Lowry	Defining operationally, formulating hypotheses, observing, classifying, predicting, inferring, controlling variables, experimenting	1. Experiment: Perform simple tests to identify common household acids, bases, and salts. 2. Exercise: Identify the Bronsted-acid base pairs in an acid base reaction. 3. Design laboratory methods for classifying substances as acids and bases.
64. Name binary and ternary acids and their salts.	Nomenclature	Classifying	1. Exercise: Naming acids and their salts.
65. Predict the products of a neutralization reaction.	Neutralization	Predicting, observing, measuring, using numbers	1. Experiment: Neutralization reaction (HCL + NaOH). 2. Experiment: Acid-base titration.
66. Classify solutions of various substances as acidic, basic, or neutral given their pH.	pH scale	Classifying, interpreting data, defining operationally, observing	Experiment: Use indicators or pH paper to determine the pH of several solutions.
67. Distinguish between acids and bases given their degree of ionization.	Strengths of acids	Classifying, interpreting data, defining operationally, observing	Demonstration: Determine the conductivity of weak and strong acids of the same concentration. (.1M HCl and .1M $HC_2H_3O_2$)

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
XII. OXIDATION-REDUCTION			
68. Define oxidation and reduction in terms of increasing and decreasing oxidation number and in terms of loss or gain of electrons.	Oxidation numbers	Classifying, using numbers, communicating, observing	1. Experiment: Oxidation-Reduction Reaction numbers, communicating, (zinc + $Cu(NO_3)_2$) identifying what is oxidized and reduced). 2. Exercise: Write half-reactions for simple oxidation-reduction reactions.
69. Define anode and cathode and discuss activity series.	Half cell and activity series	Classifying, inferring, communicating, observing, and experimenting	1. Experiment: Fe (nail) + $CuSO_4$ (aq).
70. Illustrate or recognize examples of the conversion of chemical energy to electrical energy.	Energy changes	Classifying, observing, measuring, using numbers	1. Experiment: Electrochemical cell 2. Demonstration: Construct a lead acid cell and relate it to the car battery.
XIV. NUCLEAR CHEMISTRY			
71. Describe the three basic types of emissions in radioactive decay.	Radio-activity	Defining operationally, space/time relationships	1. Demonstration: Use a nuclear scaler (Geiger counter) to illustrate the three types of radiation. 2. Demonstration: Contact the Civil Defense for a demonstration on radioactivity, etc. 3. Demonstration: Cloud chamber.
72. Define half-life and give an example of its use.	Half-life	Defining operationally, space/time relationships	Illustrate the use of half-life in carbon dating.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
73. Interpret the Uranium-238 decay series.	Nuclear reactions	Interpreting, predicting	Transparency on Uranium-238 decay series (students will follow the radioactive scheme).
74. Distinguish between fission and fusion reactions and recognize examples of each.	Fission and fusion	Classifying, interpreting	Film, filmstrip on nuclear reactions.
75. Identify the basic parts of a nuclear reactor and their functions.	Nuclear reactor	Classifying, communicating	1. Students will prepare posters of reports on nuclear reactors. 2. View film on nuclear energy. 3. Track the energy transformation from the reactor to the consumer.
76 Compare the magnitude of energy changes of physical, chemical, and nuclear reaction.		Inferring, interpreting	Same as #74
XV. ORGANIC*			
77. Define organic chemistry and recognize differences between organic and inorganic compounds.	Hydrocarbons	Defining operationally, observing, classifying	1. Display examples of organic and inorganic substances. 2. Demonstration: Show characteristic differences in solubility (NaCl in water and oil in water); decomposition (heat, sugar, and NaCl); rate of reaction (precipitation reaction contrasted with fermentation). 3. Experiment: Heat samples of paraffin, salt, and naphthalene in separate test tubes in a water bath. Compare the melting points of organic and organic substances.

*Teacher Note: Section XV pertaining to organic chemistry can be incorporated with previous sections and is neither necessarily taught independently nor is it taught in depth at the expense of previous subject matter.

COMPETENCY/PERFORMANCE OBJECTIVE	CONCEPT	PROCESS SKILLS	SUGGESTED ACTIVITY
78. Classify hydrocarbons as alkanes, alkenes, alkynes, or aromatics and recognize their molecular formulas.	Classification	Classifying, observing, space/time relationships	Construct models of simple hydrocarbons.
79. Name and draw structural formulas for saturated and unsaturated hydrocarbons containing five or fewer carbon atoms.	Nomenclature	Classifying, using space/time relationships, observing	Same as #78
80. Identify isomers when given several structural formulas.	Isomers	Interpreting data,	Same as #78
81. Draw the structural formula for a halogenated hydrocarbon containing five or fewer carbon atoms.	Halogen derivatives	Observing, classifying, space/time relationships	Construct models of halogenated hydrocarbons and simple organic alcohols and acids.
82. Recognize functional groups in organic alcohols and acids.	Organic alcohols and acids	Classifying	1. Same as #81 2. Demonstration: React ethyl alcohol with acetic acid to form an ester.

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JOURNALS

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The Science Teacher, National Science Teachers Association, 1201 Sixteenth Street, NW, Washington, D.C. 20036.

HANDBOOKS

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Dean, J.A., Ed. Lange's Handbook of Chemistry, Ace Scientific Supply Co., Inc., 1420 E. Linden Avenue, Linden, NJ 07036.

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FILMS

Educational Film Catalog, Louisiana State Department of Education Bulletin No. 1406 revised.

Teachers should consult this catalog for addresses of Regional Film Libraries in order to obtain films.

I. The Science of Chemistry

Research Problem A -Inert Gas Compounds
Science Skills Film No. 3 - Defining, Classifying and Identifying Using the Scientific Method
Film on Lab Safety may be obtained from Don McGehee, State Department of Education, Science Section
How a Scientist Works

II. Mathematics of Chemistry

Metric System, The, Part I
Metric System, The, Part II
Metric System, The
What Are Metrics

III. Matter and Energy

Energy and Reaction
Matter and the Molecular Theory Definite and Multiple Properties
Molecular Theory of Matter (2nd ed)
Kinetic - Molecular Theory
Chemical Changes All About Us
Conservation of Mass - An Inquiry

IV. Chemical Shorthand

Elements, Compounds and Mixtures
Bromine - Element from the Sea
Determining Molecular Formulas
Chemical Families

V. Stoichiometry and the Mole Gases and How They Combine

VI. Atomic Structure

Structure of Atoms, The
Hydrogen Arom, The - As Viewed by Quantum Mechanics - advanced version
Hydrogen Arom, The - As Viewed by Quantum Mechanics - standard version
Chemical Bonding and Atomic Structure
Rimented Discusses the Hydrogen Atom
Determination of Atomic Weight
Molecular Spectroscopy

VII. Periodic Classification

Chemical Families - Halogens, The
Transuranium Elements
Vanadium - A Transition Element
Family of Halogens, The

VIII. Chemical Bonding

Chemical Bonding and Atomic Structure
Chemical Bonding/Pimented discusses Chemical Bonding
Vibration of Molecules
Shapes and Polarities of Molecules
Molecular Motions

IX. Physical States of Matter

Determination of the Molecular Weight of Gases
Temperature and Matter
High Temperature Research
Gases and How They Combine
Demonstrating the Gas Laws

X. Solutions

Dynamics of Solution
Heat of Solution
Properties of Solutions
Ionization Energy
Liquids in Solution

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XI. Reaction Rate and Chemical Equilibrium

Catalysis
Equilibrium
Introduction to Reaction Kinetics
Introduction to the CHEM Study Film - Introduction to Reaction Kinetics

XII. Acids, Bases and Salts

Nitric Acid
Indicators and pH
Acid-Base Indicators
Properties of Acids, Bases and Salts

XIII. Oxidation - Reduction

Electromotive Force Series, The
Oxidation and Reduction
Electricity from Chemicals, Faraday's Law
Electrochemical Reactions
Electrochemical Cells

XIV. Nuclear Chemistry

About Fallout
Atom Smashers (2nd ed.)
Isotopes in Action
Controlling Atomic Energy
Cosmic Rays
Ruthertard Atom
Exploring the Atomic Nucleus
Mighty Atom, The
Mass of Atoms, Part I
Mass of Atoms, Part II
Energy - The Nuclear Alternative
Radioisotopes - Tools of Discovery

XV. Organic Chemistry

Synthesis of an Organic Compound
Biochemistry and Molecular Structure
Mechanism of an Organic Reaction

AUDIOVISUAL SUPPLIERS

The audiovisual materials suggested in the curriculum guide can be obtained from the following suppliers:

Association Instructional Materials
347 Madison Avenue (Department DC)
New York, New York 10017

BFA-Ealing Corporation
2211 Michigan Avenue
Post Office Box 1795
Santa Monica, California 90406

BFA-Educational Media
2211 Michigan Avenue
Post Office Box 1795
Santa Monica, California 90406

Beckman Instruments Inc.
Attention: New Dimensions
2500 Harbor Boulevard
Fullerton, California 92634

Coronet Films
65 East South Water Street
Chicago, Illinois 60601

Education Audio-Visual Inc.
Pleasantville, New York 10570

Encyclopaedia Britannica
Educational Corp.
425 North Michigan Avenue
Chicago, Illinois 60611

Inquiry Audio Visuals
1754 West Farragut Avenue
Chicago, Illinois 60640

International Communication Films
1371 Reynolds Avenue
Santa Ana, California 92705

John Wiley and Sons, Inc.
605 Third Avenue
New York, New York 10016

Kalmia
Department C1
Concord, Massachusetts 01742

Lansford Publishing Co.
Post Office Box 8711
1088 Lincoln Avenue
San Jose, California 95155

McGraw-Hill Films
CRM/McGraw-Hill
110 15th Street
Del Mar, California 92014

Modern Learning Aids
1212 Avenue of the Americas
New York, New York 10036

Harper and Row Media
10 East 53rd Street
New York, New York 10022

Holt, Rinehart, and Winston, Inc.
383 Madison Avenue
New York, New York 10017

Indiana University
Audio-Visual Center
Office for Learning Resources
Bloomington, Indiana 47401

Prentice Hall Media
Servode HC236
150 White Plains Road
Terrytown, New York 10591

Scholarly Audio-Visuals Inc.
5 Beekman Street
New York, New York 10038

Science Software Systems Inc.
11899 West Pico Boulevard
West Los Angeles, California 90064

Shell Oil Film Library
1433 Sadlier Circle W. Drive
Indianapolis, Indiana 46239

Modern Talking Picture Service
2323 New Hyde Park Road
New Hyde Park, New York 11040

Peter M. Robeck and Company
230 Park Avenue
New York, New York, 10017

James J. Ruhl and Association
Post Office Box 4301
Fullerton, California 92631

Thorne Films
1229 University Avenue
Boulder, Colorado 80302

Universal Education and Visual Arts
100 Universal City Plaza
Universal City, California 91608

Westwood Educational Productions
701 Westport Road
Kansas City, Missouri 64111

Sutherland Educational Films
201 North Occidental Boulevard
Los Angeles, California 90026

Since these materials vary from quite simple to complex, teachers are urged to preview materials before presenting them to the class.

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EVALUATION TECHNIQUES

Methods for evaluating pupils' achievement and progress are an integral part of the instructional program. Evaluation techniques must reflect (1) the objectives to be reached, and (2) the activities employed to reach those objectives. Since the objectives are stated clearly, the method of evaluation is indicated within the objective. The objectives are stated in behavioral terms, the process skills are identified, and suggested activities are listed. Thus, it is clear what the student is expected to be able to do after successful completion of a learning activity. The successful attainment of an objective can be demonstrated by having the student do specific things which can be observed.

Therefore, evaluation should consist of more than just paper and pencil tests on recall of factual knowledge. A variety of evaluation activities should be used.