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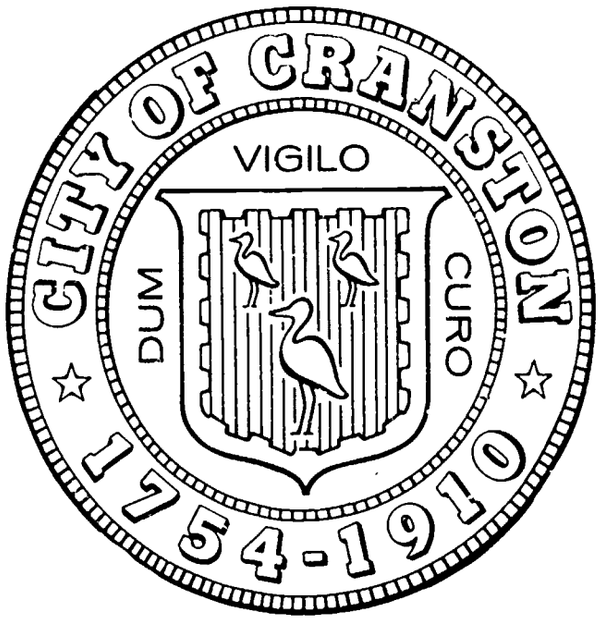
ABSTRACT

This curriculum guide provides instructional objectives and activities for teaching science in grades 10-12. The objectives are stated in behavioral or performance terms and have been arranged in increasing levels of complexity according to Bloom's Taxonomy. The behavioral objectives generally include two major components: (1) the objective statement which specifies the intended behavior of the students as a result of having participated in a set of instructional experiences, and (2) activities which outline what the student should do to attain the objectives. It is stressed that the suggested objectives and activities should not be seen as limiting teacher innovation or what the student is expected to know; rather, they should be added to, deleted, or modified by the teacher according to the needs and characteristics of individual students and the teacher's own experience and knowledge. This work was prepared under an ESEA Title III contract. (Author/JR)

Secondary Schools

CURRICULUM

GUIDE



Cranston School Department
Cranston, Rhode Island
1972

SCIENCE

Grades 10-12 Levels 17-33

Secondary School

CURRICULUM GUIDE

DRAFT COPY

Prepared By

a curriculum writing team

of secondary teachers

Project PACESETTER

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Cranston School Department

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PREFACE

The following levels consist of instructional objectives and activities for each course of study within every curriculum area. These materials were produced by a staff of teachers working on curriculum teams for Project PACESETTER. They are, therefore, the product of the experience of the professionals who will put them to use.

This curriculum guide provides each teacher with curriculum materials organized into behavioral objectives with a scope and sequence. The guide is intended to encourage feedback so that a fully classroom tested curriculum will eventually result from the participation and suggestions of all teachers in the secondary schools of Cranston.

OBJECTIVES IN TERMS OF LEARNING VARIABLES

Bloom and his collegues devised a taxonomy of educational objectives designed to classify the behavior of students in three domains as a result of having participated in a series of instructional experiences. The three domains are the cognitive (intellectual), the affective (emotional). and the psychomotor (physical). Within each of these domains there is a hierarchy which denotes increasing complexity of learning which is shown below.

Cognitive	Affective	Psychomotor
knowledge	receiving	frequency
comprehension	responding	energy
application	valuing	duration
analysis	organization	
synthesis	characterization	
evaluation		

The objectives which appear in these Curriculum guides have been stated in behavioral or performance terms. In addition to the general technique of the behavioral statement, the authors were careful to differentiate the levels at which given behaviors could be expected of the student. Thus, in the cognitive domain, a student's performance in the display of knowledge of a concept is less complex than the student's performance when he applies the concept in a given situation. Similarly, in the affective domain, a response to a situation is not as complex as the display of a value toward a given situation.

In initial classroom trials of this curriculum teachers will evaluate the appropriateness of the objectives and make recommendations for revising, deleting, or adding to the objectives or activities.

LEVELS, OBJECTIVES, AND ACTIVITIES

The curriculum guides provided here are organized into behavioral objectives which generally include two major components. The first is the objective statement which specifies the behavioral variable--the intended behavior of the students as a result of having participated in a set of instructional experiences, the content or topic and the evaluative criterion which is sometimes implicit in the behavioral objective. Curriculum writers have made every effort to classify the intended behaviors in keeping with the work of Bloom and others. The objectives, then, are stated in terms of specific behaviors which range from the simple, such as memorizing or translating, to the most complex, such as synthesizing or evaluating. The second major component is comprised of activities which outline what the student should do to attain the objective. These activities are suggested and should be added to, deleted, or modified by the teacher according to the needs and characteristics of individual students and the teacher's own experience and knowledge.

It is important to note here that the objectives serve the purpose of helping each teacher select appropriate learning experiences, communicate to others what is expected, and provide both student and teacher with a standard for evaluating progress. Objectives should not be seen as limiting teacher innovation or what the student is expected to know.

Each of the curriculum areas is divided into major topics or "Levels." Each level begins with a level objective which is followed by numbered objectives subordinate to it. Suggested activities follow each of these specific objectives and are numbered consecutively throughout the level.

EVALUATIVE CRITERIA

Many of the evaluative statements included in the behavioral objectives are teacher oriented; final decisions on evaluation have traditionally been the prerogative of the teacher. As we move toward continuous progress and, eventually, individualized instruction, it is hoped that the evaluation component increasingly becomes the shared responsibility of both teacher and student.

TABLE OF CONTENTS

SCIENCE

Grades 10-12

* levels 22-25 and 26-29 are offered as alternatives.

* pages are numbere within levels only.

Title	Level*	Suggested Grade
Chemistry: Principles of Chemical Reactions	SC 28 ,	10-12
Chemistry: Waves, Light, Bonding, and Molecular Geometry	SC 29	10-12
Physics: Motion and Force	SC 30	10-12
Physics: Fluid Dynamics, Kinetic Molecular, Theory and Wave Motion	SC 31	10-12
Physics: Light	SC 32	10-12
Physics: Magnetism and Electricity	SC 33	10-12

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE STRUCTURAL AND CHEMICAL NATURE OF LIVING THINGS BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. What is Biology?

Objective #1: The student will respond positively to the question "why study biology?" by stating either orally or writing valid reasons for studying biology.

Activities:

1. Describe in a paragraph the subject matter of biology.
2. Prepare in writing a list of occupations related directly and indirectly to the field of biology.
3. Participate in a class or small group discussion on the question "Why study biology?" to be evaluated by teacher observation
4. Devise in writing controlled scientific experiments dealing with biological problems and be prepared to explain these experiments orally to the class.

II. The Nature of Life

Objective #2: The student will display knowledge of the biogenesis-abiogenesis controversy by performing the following activities.

Activities:

5. Define in writing biogenesis and abiogenesis.
6. Discuss in writing the contributions of Van Helmont, Redi, Spallanzani, Pouchet, and Pasteur to the biogenesis-abiogenesis debate.
7. Write an essay entitled "Can spontaneous generation be entirely disproved?
8. Create, execute or take part in a play concerning the biogenesis-abiogenesis controversy.

III. The Cell as the Unit of Structure and Function

Objective #3: The student will demonstrate comprehension of the structural and functional unit of life by completing the following activities.

Activities:

9. Identify and explain the parts of the compound microscope using a diagram.

10. Perform an exercise in the use and care of the microscope to be evaluated by teacher observation and testing.

11. Repeat Robert Hooke's classic experiment with cork and record observations in a laboratory notebook.

12. Read Hooke's description of cork "cells" and compare in class discussion with the student's own investigation.

13. Examine microscopically cells from onion epidermis, Elodea leaves, human squamoas epithelium, and cells from various tissues in freshly killed frogs.

14. Develop a definition of a "cell" based on observation of living and dead tissue and evaluate his definition on the basis of those of his classmates and his teacher.

15. State in writing the cell theory of Schleiden and Schwann.

16. Label a diagram of a "typical" cell based on studies made with the electron microscope.

17. Prepare a chart summarizing the major cellular organelles and their functions.

18. Differentiate in writing between animal and plant cells, citing both similarities and differences.

19. Make three-dimensional models of selected cellular organelles and present oral reports regarding these structures to his class.

IV. The Chemical Basis of Life

Objective #5: The student will demonstrate comprehension of fundamental principles of chemistry applicable to biological phenomena by performing the following activities.

Activities:

20. Define an atom and describe three fundamental particles of an atom as measured by teacher tests.

21. Describe the relationship between chemical properties of atoms and their electron configuration either orally or in writing.

22. Differentiate in writing between covalent and ionic bonding.

23. Define in writing the following terms: acid, base, pH, and buffer.

24. Identify, experimentally, acids and bases using litmus paper or pH paper.

25. Define in writing the term "energy" and differentiate between potential and kinetic energy.

26. Devise a working model to illustrate "energy" of activation."

27. Differentiate between endergonic and exergonic reactions either orally or in writing.

28. Explain the nature of chemical bond energy in writing.

29. Differentiate by means of chemical or word formulas between dehydration synthesis and hydrolysis reactions.

30. Predict the reactions of biological systems to changes in ph by performing an investigation demonstrating the effects of acids and bases on living cells.

31. Differentiate by means of structural diagrams and/or models among the organic compounds found in living cells (fats, proteins, carbohydrates and nucleic acids).

32. Identify the various organic functional groups from structural diagrams drawn on the chalk board.

33. Devise and use a series of tests to determine experimentally the presence of fats, proteins, simple sugars, and starch to be evaluated by analysis of an "unknown."

34. Investigate experimentally the nature of biological catalysts by studying the breakdown of hydrogen peroxide by catalase; record observations and conclusions in notebook for teacher evaluation.

Objective #6: The student will display knowledge of current theories concerning the chemical evolution of life by performing the following activities.

Activities:

35. Discuss in small groups the basic assumptions of the antotroph and heterotroph hypotheses for the origin of life.

36. Explain either orally or in writing Miller's experiment with the spark-discharge apparatus.

37. List in writing or at the chalk board the compounds believed to have existed in the primitive atmosphere.

Objective #7: The student will demonstrate comprehension of the basic chemical and physical mechanisms involved in the transfer of materials in biological systems.

Activities:

38. Perform an experiment illustrating the principle of diffusion of substances through a selectively permeable membrane and will record results in a laboratory notebook.

39. Observe and discuss results of a teacher performed demonstration of diffusion.

40. Demonstrate using a felt board or other appropriate visuals the process of phagocytosis.

41. Develop through inference the concept of active transport.

Objective #8: The student will demonstrate knowledge and comprehension of energy relations in metabolism by completing the following activities.

Activities:

42. Define in writing respiration and distinguish between aerobic and anaerobic respiration.

43. Write an overall equation for both aerobic and anaerobic respiration.

44. Eaplain in writing how energy released from chemical bonds in respiration is used to form "energy-rich" ATP molecules.

45. Explain by means of a simplified diagram the Krebs Citric Acid Cycle.

46. Evaluate an experiment in which respiration rates of bacteria under aerobic and anaerobic conditions are measured in terms of the utilization of glucose.

47. Demonstrate by means of an appropriate worksheet comprehension of oxidation-reduction reactions.

48. Relate knowledge of oxidation-reduction reactions to the transfer of energy in the terminal respiratory pathway to be measured by teacher tests.

LEVEL OBJECTIVE:

THE STUDENT WILL DISPLAY COMPREHENSION OF THE DIVERSITY AND PROBABLE EVOLUTIONARY RELATIONSHIPS AMONG REPRESENTATIVE ORGANISMS FROM THE KINGDOMS MONERA, PROTISTA, METADHYTA AND METAZOA BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Classification

Objective #1: The [illegible]ill demonstrate comprehension of basic principles of classification by performing the following activities.

Activities:

1. Discuss in writing Linnaeus' contributions to the science of taxonomy.

2. State and describe in writing the bases of scientific classification used today.

3. List the groupings of the Linnaean system in order, from the largest to the smallest.

4. Develop the concept of a "species" to be evaluated by teacher tests.

5. Discuss in class several problems in classifying organisms.

6. Identify unknown plant or animal specimens using an appropriate taxonomic key and report information for teacher evaluation.

7. Develop through laboratory study the concept of the biological leves of organization to be evaluated by teacher-directed class or small group discussion.

8. State and describe in writing the three basic forms of bacteria.

9. State the four phyla of related protists and the bases of each classification.

10. Describe in writing some of the basic structures and functions of fungi.

11. Describe in writing some of the basic structures and functions of algae.

12. Describe in writing some of the basic structures and functions of lichens.

13. Describe in writing some of the basic structures and functions of mosses and liverworts.

14. Describe in writing several general characteristics of the vascular plants.

15. Describe in writing some of the basic structures and functions of ferns.

16. Give examples in writing of the four orders of gymnosperms.

17. Name and describe certain structures which are characteristic of gymnosperms.

18. List the characteristics of the angiosperms.

19. Describe the differences between the monocotylendons and the dicotyledons.

20. State the importance of flowering plants in providing food for man and other animals.

21. Describe basic structures and functions of sponges.

22. Describe basic structures and functions in coelenterates.

23. Describe basic structures and functions in flatworms after studying living planaria.

24. Describe in writing the basic structures and functions in roundworms.

25. Describe in writing the basic structures and functions in annelids.

26. Describe in writing the basic structures and functions in melluses.

27. Describe basic structures and functions in echinoderms.

28. Diagram a phylogenetic tree showing possible relationship of the various groups of invertebrates, as well as their supposed relationship to the protists and chordates.

29. List the characteristics of the arthropods.

30. Name and give examples of the five classes of arthropods.

31. Dissect representative arthropod specimens and answer appropriate questions on a teacher prepared worksheet.

32. Discuss orally or in writing insect diversity and economic importance.

33. List and describe in writing the unique characteristics of the Chordates.

34. List and give examples orally or in writing of the seven classes of vertebrates.

35. List in writing the unique characteristics of the vertebrates.

36. Discuss in writing highly developed behavior in vertebrates.

LEVEL OBJECTIVE

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF HOW MULTI-CELLULAR PLANTS PERFORM BASIC LIFE FUNCTIONS AND THE INTERRELATIONSHIPS AMONG PLANTS AND ANIMALS IN THEIR ENVIRONMENT BY COMPLETING THE FOLLOWING LEVEL.

I. Photosynthesis

Objective #1: The student will demonstrate comprehension of photosynthesis as the principal mechanism by which energy from the sun is made available to living things by performing the following activities:

Activities:

1. Identify in writing the work of Van Helmont, Priestly, Ingen-Housz and Engelmann, whose contributions lead us to present knowledge about photosynthesis.

2. Perform an investigation to determine The Significance of Leaf Color by removing leaf pigments and counter-staining with iodine.

3. Diagram and label a cross-section of a chloroplast.

4. Compare the light absorbing qualities of Chlorophyll a and Chlorophyll b, using a graph to be evaluated by teacher tests.

5. Extract chlorophylls from spinach leaves and separate pigments by paper or thin layer chromatography.

6. Devise and execute experiments to show the effect of light color and intensity on photosynthetic rates of Elodea plants.

7. Summarize photosynthesis in terms of a chemical equation to be evaluated by teacher tests.

8. Outline the steps in the light reaction of photosynthesis, identifying the raw materials and end products.

9. Outline the steps in the dark reaction of photosynthesis and the end products.

10. State in writing several factors which influence the rate of photosynthesis.

II. Plant Nutrition

Objective #2: The student will demonstrate comprehension

of how plants meet their nutritional requirements by performing the following activities:

Activities:

11. Distinguish between autotrophs and heterotrophs.

12. State in writing the problems of non-photosynthetic plants such as fungi, in obtaining food.

13. Define and give examples of saprophytic and parasitic relationships of fungi.

14. Describe in writing the special structures and processes by which fungi obtain food.

III. Plant Anatomy and Physiology

Objective #3: The student will demonstrate comprehension of the anatomy and physiology of roots, stems, and leaves by performing the following activities:

15. Describe in writing the types and functions of various types of roots and root systems.

16. Define meristematic region, elongation region, and maturation region of a root.

17. Prepare a table summarizing the root tissues and their special functions.

18. Give examples of aquatic, aerial, adventitious, prop and climbing roots.

19. Devise and execute an experiment to determine the function of roots.

20. Draw and label the external structure of a woody stem.

21. Prepare a table summarizing the regions of a woody stem, the tissue or cell types included in each region and the activity associated with each.

22. Perform and graphically analyze transpiration rate in plants using a potometer to be evaluated by teacher observation and tests.

23. Discover the functions of the leaf by examining, microscopically, cross sections of the leaf which he has prepared to be evaluated by teacher directed discussion.

24. Explain in writing capillary pressure and atmospheric pressure and transpiration pull as possible factors involved in upward transport.

25. Compare in writing respiration and photosynthesis as to processes, raw materials, products, energy sources and occurrence.

26. Describe in writing growth in length at the tips of stems and roots.

27. Describe in writing growth in width of the stem and root.

IV. Plant Behavior

Objective #4: The student will demonstrate comprehension of how plants respond to various environmental stimuli by performing the following activities:

Activities:

28. List several plant hormones, affecting growth and the functions of each to be evaluated by teacher tests.

29. Define in writing tropism.

30. Plan and execute an experiment in which plant responses to environmental stimuli are studied (e.g. gravity and light) to be evaluated by teacher observation and tests.

31. Define in writing and describe thigmotropism, chemotropism, hydrotropism, and photoperiodism.

V. Ecology

Objective #5: The student will demonstrate comprehension of basic principles of ecology, emphasizing both the abiotic and biotic factors which act on organisms and influence their lives by performing the following activities:

Activities:

32. Define and describe in writing biosphere, ecosystem, biotic community, population, habitat, niche, limiting factor, producer, consumer, food chain, food web, food pyramid.

33. Analyze in writing the energy relationship in a food web, food chain, and food pyramid to be evaluated by teacher tests.

34. Make a diagram of a food web that exists in the local area.

35. List and describe in writing several limiting factors in an environment.

36. Participate in a team study of a quadrant near your school, identifying all the abiotic and biotic factors. Present data collected in a report to be discussed in class and evaluated by the teacher.

37. Design and execute an experiment to estimate the size of an animal population using the Lincoln-Peterson index to be evaluated by teacher observation.

38. Describe in writing ecological succession in biotic comminities.

39. Name and describe in writing the major climatic zones of North America.

40. Display a value for cooperative action by citizens to prevent continued exploitation of our natural resources and environment to be evaluated by teacher observation of student's participation in class discussion.

41. Present orally or in writing plans for conserving our natural and wildlife resources to be evaluated by teacher observation.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF HOW DIVERSE ANIMAL ORGANISMS PERFROM BASIC LIFE FJNCTIONS AND HOW THESE FUNCTIONS AND HOW THESE FUNCTIONS AT THE CELLULAR LEVEL ARE ESSENTIALLY THE SAME THROUGHOUT THE HIERARCHY OF ANIMAL LIFE BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Digestion in Multicellular Animals

Objective #1: The student will demonstrate comprehension of how digestion is accomplished by diverse animal organisms by performing the following suggested activities.

Activities:

1. Explain in writing the basic problem confronting multicellular animals in terms of obtaining and using food.
2. Define in writing "digestion" and differentiate between extracellular and intracellular digestion.
3. Define and give examples of autotrophism and heterotrophism.
4. Define a food and give examples of the various types in writing.
5. Define a nutritional calorie in writing.
6. Discuss orally or in writing the need for and phases of digestion.
7. Describe in chart form ingestion and digestion in lower animals.
8. List, in order, the divisions of the alimentary canal in man.
9. List and describe in chart form the roles of the secretions of the accessory glands of digestion in man.
10. Describe in writing the activities occurring in each division of the alimentary canal.
11. Dissect and correctly identify the digestive structures in the earthworm and the frog to be evaluated by teacher-prepared tests.
12. Perform a laboratory experiment in which the digestion of a food substance is studied.

II. Transportation in Multicellular Animals.

Objective #2: The student will demonstrate comprehension of how diverse animal organisms perform the basic life function of transportation by performing the following activities.

Activities:

13. Summarize in chart form circulation in lower animals.

14. Describe in writing the composition of blood.

15. State and describe in writing the protective functions of blood viz. clotting and defense against disease.

16. Identify the 4 major blood groups on the basis of the antigens or antibodies present.

17. Discuss in writing the Rh factor and significance during pregnancy.

18. Prepare a table comparing structure and blood flow in arteries, veins and capillaries.

19. Prepare a chart showing the path of circulation in man.

20. Draw and label a cross-sectional diagram of the human heart.

21. Examine microscopically capillary circulation in tailfin of a fish or in the webbing of a frog's foot.

22. State in writing the function of lymph and describe its circulation.

III. Respiration in Multicellular Animals

Objective #3: The student will demonstrate comprehension of how animals diverse in structure perfrom the basic life function of respiration by performing the following activities.

Activities:

23. Describe external respiration at the organism level in lower animals.

24. List the structures of the respiratory system in man.

25. Outline in writing the process occurring during inspiration an expiration.

26. Define external and internal respiration in writing.

27. Experimentally determine and report the amount of carbon dioxide he exhales per minute and relate findings to class data.

IV. Excretion in Multicellular Animals

Objective #4: The student will demonstrate comprehension of how animals which are diverse in structure perfrom the basic life function of excretion by performing the following activities.

Activities:

28. Summarize in chart form excretion in lower animals.

29. Draw and label the structure of a nephron.

30. Explain in writing how the nephron functions.

31. Summarize in writing the functions of the skin.

V. Coordination in Multicellular Animals

Objective #5: The student will demonstrate comprehension of how animals diverse in structure coordinate their life processes by performing the following activities which deal with the nervous and endocrine systems.

Activities:

32. Summarize in chart form the nervous systems of lower animals.

33. Illustrate the basic structural features of a neuron on a teacher prepared diagram.

34. List and describe the parts of the nervous system of man to be evaluated by teacher tests.

35. Identify in writing the parts of the human brain and list the functions of each.

36. Illustrate the structure of the spinal cord (cross-sectional) and state its relationship to the spinal cord and the spinal nerves.

37. Explain in writing the role of the spinal cord and the spinal nerves.

38. Describe in class discussion the various sensations of the skin to be evaluated by teacher observation.

39. Describe orally or in writing the sense of taste and the role of the tongue.

40. Draw and label the structure of the human ear and relate anatomy to the physiology of hearing to be evaluated by teacher tests.

41. Describe orally or in writing the sense of smell and the role of the nose.

42. Describe in diagrams and models the structure of the human eye.

43. Demonstrate by means of a written paragraph comprehension of the physiology of vision.

44. Display a value for proper care of eyes, ears, as measured by teacher observation of student led discussion.

45. Perform a series of experiments concerned with certain aspects of the senses involved in touch, sight, smell, and taste.

46. Prepare a table indicating the glands of the endocrine system, their locations, secretions and the functions of their secretions.

47. Describe for class discussion some of the disorders which may occur in the endocrine glands and their resulting manifestations to be evaluated by teacher observation.

VI. Support and Locomotion in Multicellular Animals

Objective #6: The student will demonstrate comprehension of how diverse animal organisms perform the life functions of support and locomotion by completing the following activities.

Activities:

48. Explain in writing the advantages of motility in an animal's struggle for survival.

49. Summarize in chart form locomotion in lower animals.

50. Describe in writing ossification of the human skeleton.

51. Describe in writing the structure of a bone.

52. List, describe, and give examples of the various kinds of joints in the human skeleton.

53. Label on a diagram the major bones in a front and back view of the human skeleton.

54. List several functions of the skeleton of man.

55. List and describe the three types of muscles found in man and give examples where each may be found.

56. Define, state the functions and give examples of flexors and extensors.

57. Perform an experiment in muscle physiology to show the relationship between muscle contraction and oxygen supply.

58. Explain current theory regarding contraction of muscle fibers to be evaluated by teacher tests.

59. Apply knowledge of cellular respiration to explanation of muscle fatigue for teacher evaluation by testing.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE BASIC PATTERNS OF PLANT AND ANIMAL REPRODUCTION AND THE HEREDITARY MECHANISMS RESPONSIBLE FOR GENETIC CONTINUITY.

I. Reproductive Patterns

Objective #1: The student will demonstrate comprehension of basic patterns of asexual reproduction by completing the following suggested activities.

Activities

1. Distinguish in writing between sexual and asexual reproduction.
2. Investigate the process of mitosis by making and studying slides of pollen smears and onion roots under the microscope to be evaluated by teacher tests.
3. Viewing and interpreting a film loop on mitosis to be evaluated by test observation and/or tests.
4. Explain the stages of mitosic division by using models to be evaluated by teacher observation.
5. Define and describe in writing the composition of a chromosome.
6. Compare mitosis in animal and plant cells on the basis of laboratory investigation and present findings to class for evaluation.
7. Define and describe in writing binary fission in amoeba and paramecium.
8. Define and describe in writing budding in yeast and hydra.
9. Define and describe in writing sporulation in bacteria.
10. Define and describe in writing regeneration in planaria and starfish.
11. Define and describe in writing vegetative propagation in bulbs, tubers, runners and rhizomes.

Objective #2: The student will demonstrate comprehension of the basic patterns of sexual reproduction in plants and animals by performing the following activities.

Activities

12. Define and describe in writing conjugation in paramecium.

13. Define and describe in writing fertilization between heterogametes.

14. Explain using work sheets and/or models, the major events of Meiotic division to be evaluated by teacher observation.

15. Infer the importance of meiosis in maintaing a constant chromosome number in organisms which reproduce sexually to be evaluated by teacher tests.

16. Prepare a schematic diagram illustrating spermatogenesis.

17. Prepare a schematic diagram illustrating oogenisis.

18. Distinguish in writing between internal and external fertilization and give example of each.

19. List and describe in writing the human female reproductive structures.

20. List and describe in writing the male reproductive structures.

21. Outline the menstrual cycle and the hormones affecting menstruation to be evaluated by teacher tests.

22. Describe in writing the embryonic membranes and the functions of each.

23. Describe in writing alternation of generations using the fern plant as an example.

24. Diagram the generalized structure of a flower showing receptacle, sepals, petals, stamens and pistil.

25. Define in writing pollination and state several ways in which it occurs.

26. Describe in writing double fertilization in flowering plants.

27. Define <u>seed</u> and <u>fruit</u>.

28. Draw and label the parts of a bean seed.

29. List in writing the conditions necessary for seed germination.

II. <u>The Hereditary Material-DNA</u>

Objective #3: The student will demonstrate comprehension of the chemical and physical nature of DNA and its rule in determining cell structure and function by performing the following activities.

Activities:

30. Draw and label a diagram of the ladder structure of DNA.

31. Given a strand of DNA bases, predict the bases present on the complimentary strand of the DNA to be evaluated by teacher tests.

32. Describe in a paragraph DNA replication.

33. List in writing the differences between DNA and RNA.

34. Distinguish in writing between "messenger" and "transfer" RNA.

35. Given a strand of DNA bases, predict the bases present on a complimentary strand of messenger RNA.

36. Outline in writing the process of protein synthesis.

37. Given several amino acids with their triplet codes and several messenger RNA codons, predict the arrangement of the amino acids in the formation of protein to be evaluated by teacher tests.

38. Define in writing a gene and its relation to a chromosome.

III. Genetics

Objective #4: The student will demonstrate application of general principles of genetics by completing the following activities.

Activities:

39. Describe in writing the work of Gregor Mendel and his studies of garden peas.

40. Define in writing the basic terminology used in genetics to

41. State and apply the major laws of probability upon which genetic problems are based as judged by student performance on a teacher-prepared worksheet.

42. State and apply Mendel's Law of Dominance and Law of Segregation to be evaluated by teacher tests.

43. Using the Punnett square method, calculate the results of several crosses of organisms both homzygous for a single trait and state the genotypic and phenotypic frequencies for each cross.

44. Using the Punnett square method, calculate the results of several crosses or organisms involving 2 traits and state the genotypic and phenotypic frequencies for each cross.

45. State in writing Mendel's Law of Independent Assortment.

46. Using the Punnett square method, calculate the results of several crosses of four-o'clock flowers to illustrate incomplete dominance and state the genotypic and phenotypic frequencies for each cross.

47. State and explain in writing the significance of the autosome and sex chromosome numbers in humans.

48. Calculate the chances of having either a male or female using the Punnett square method.

49. Define and given examples in writing of sex-influenced and sex-linked traits.

50. Define in writing multiple alleles.

51. Determine whether parents with type A blood and type B blood could have a type O offspring.

52. Describe in writing the various types of chromosomal abberations.

IV. Evolution

Objective #5: The student will demonstrate comprehension of evolution as the major unifying theme of biology by performing the following activities.

Activities:

53. State and explain in writing the evolutionary theories of Lamarck and Darwin.

54. Apply Darwin's theory of evolution to hypothetical problems to be discussed in class and evaluated by teacher observation.

55. Explain in writing "natural selection" in light of modern evolutionary theories based on genetics.

56. Explain in writing the major sources of variation which serve as raw materials for evolution.

57. Define a species and cite various isolating mechanisms which cause "speciation" to be evaluated by teacher tests.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE METHOD OF CHEMICAL INVESTIGATION, THE STRUCTURE OF MATTER, AND THE PERIODICITY OF ELEMENTS BY COMPLETING THE FOLLOWING ACTIVITIES

I. Introduction to Chemistry

Objective #1: The student will demonstrate application of qualitative procedures used in chemical investigation of matter by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Interpret data and observations of experiments and develop models (theories).
2. Present evidence that changes in matter are integrated with changes in energy.
3. Review basic terms such as matter, energy, inertia, potential or kinetic energy differences.
4. Distinguish between theories and laws.
5. Demonstrate application of significant figures to measurements.
6. Use exponentially written numbers.
7. Distinguish between volume, mass, and length in the Metric system.
8. Use a chemical balance to interpret the meanings of mass, volume, and density.
9. Use linear measuring tools to convert units of length from the English system in to Metric system.
10. Determine experimentally the difference between accuracy and precision of measuring instruments.
11. Explain the difference in concepts of heat and temperature.
12. Use temperature conversions.
13. Perform calculations involving units of heat.
14. Solve chemical problems with the aide of a slide rule.

II. Investigating Matter and Its Changes

Objective #2: The student will demonstrate comprehension of the nature of matter in terms of its classification and changes by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

15. Classify all matter as being either homogeneous or hetergeneous and given examples.

16. Design a procedure to differentiate compounds from mixtures.

17. Compare by properties compounds to elements.

18. Comapre solutions to mixtures by observing properties.

19. Display a value for the role of scientific investigations to distinguish properties of matter.

20. Define mixture, compound, solution, and element.

21. Recognize differences between symbols and formulas.

22. Observe and describe differences between physical and chemical changes.

23. Design and execute and experiment to illustrate the Law of Definite Composition.

24. Develop the concept of entropy in relation to energy diagrams.

III. Atomic Structure

Objective #3: The student will demonstrate comprehension of the structure of matter by investigation of the atomic theory. He will perform the following activities to be evaluated by teacher observation and/or tests.

Activities:

25. Demonstrate a value for the interplay of historical scientific contributions leading to modern atomic theory.

26. Develop a conceptual model of atomic structure based on experiments involving:

a. electrostatics
b. tubes
c. radioactive sources with Geiger counter
d. the "black box" experiment

27. Identify by symbol and properties the three basic subatomic particles which make up the atom.

28. Realte particle number information to atomic numbers and atomic masses on the periodic chart.

29. Develop the concept of electronic energy levels in atoms.

30. Apply appropriate symbols and models to define the term isotope.

31. Develop the mole concept through the use of Avogadro's number.

IV. Electron Configuration of Atoms

Objective #4: The student will demonstrate comprehension of the theoretical basis of electron configuration by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

32. Apply the principles of electromagnetic radiation to explain atomic spectra.

33. Differentiate spectra of elements through use of the spectroscope.

34. Explain how Bohr-DeBroglie theory led to new model for the atom.

35. Develop a variety of models representing conceptual structures of atoms.

36. Describe the qualitative aspects of the Quantum Theory.

37. Define main energy levels, sublevels and space orbitals.

38. Relate energy equivalents to respective energy levels using diagrams or charts.

39. Write electron configurations for any element.

40. Explain the Principle of Maximum Multiplicity or Hunds Rule.

41. Illustrate, by diagramming atoms, the Aufbou Process of electron population.

42. Describe and trace the development of x-ray diffraction in predicting structures of atoms.

V. Periodic Law

Objective #5: The student will demonstrate application of the periodic table by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

43. Segregate by properties metals, nonmetals, and metalloids.

44. Realate properties of elements with their electronic configurations.

45. Relate properties of atoms to their group numbers and series numbers.

46. Locate the position of solids, liquids and gases on the periodic table.

47. Construct styrofoam models of atoms scaled to size representing radii in a series and in a row.

48. Explain observed chemical-physical properties of elements in terms of atomic radii.

49. Explain reactivity of elements using trends in ionization energy given a chart of ionization energies of elements.

50. Develop the concept of electron affinity.

51. Predict possible valence states given the group numbers on the periodic table.

52. Relate group number and series to trends in periodicity.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE AN INCREASED COMPREHENSION OF THE NATURE OF MATTER BY INVESTIGATION CHEMICAL BONDS, CHEMICAL COMPOSITION, CHEMICAL EQUATIONS, THE PHYSICAL STATES OF MATTER, AND THE MOLECULAR COMPOSITION OF GASES BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Bonding

Objective #1: The student will demonstrate comprehension of the nature of chemical bonding by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Explain chemical bonding in terms of electron configurations.
2. Define the chemical bond in terms of energy requirements and changes.
3. Relate properties of compounds produced when 2 atoms combine to their resultant bonds.
4. Describe how molecules may be held together by Van Der Wall's forces or hydrogen bonding.
5. Present evidence that shapes of molecules are related to bond angles, bond types, and bonding capacity.
6. Describe the make-up of ionic compounds through the use of plastic models.
7. Describe the spacial orientation of hybrids using sytrofoam models.
8. Correlate written formulas with plastic models of compounds through construction.
9. Draw Lewis structure for sample formulas.
10. Develop the concept of electronegativity given charts of electronegativities.
11. Illustrate differences between polar, nonpolar and ionic compounds using styrofoam models and electronegativities.
12. Develop the concept of electron transfer in chemical reaction by discussing oxidation and reduction.
13. Apply the principles of valence electrons, oxidation numbers, and charge to formulas writing.

14. Explain the difference between molecular and empirical formulas.

15. Describe the concept and logic of hybridization of orbitals.

16. Identify properties of elements with localized and dilocalized electrons.

II. Chemical Composition

Objective #2: The student will demonstrate application of chemical symbolism in formula writing and in analysis of chemical composition by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

17. Recognize the role of exact measurements in quantitative experimentation.

18. Calculate the molecular masses from formulas.

19. Apply classical system of formula writing.

20. Recognize and be able to use the stock system of nomenclature.

21. Apply the concepts of cation and anion in formula writing.

22. Compare the law of Multiple Proportions and Definite Composition.

23. Determine mathematically percantage composition of compounds.

24. Determine mathematically the difference between molecular and empirical formulas and masses.

25. Discover experimentally the percentage composition of a compound.

26. Demonstrate the concept of mole and mass quantities through sample calculations.

III. Chemical Equations

Objective #3: The student will demonstrate application of the basic rules for writing chemical equations and will demonstrate application of the mole concept to solving stoichiometric problems by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

27. Identify the variety of facts associated with a chemical formula equation.

28. Identify types of equations as composition, decomposition, or replacement.

29. Observe the Law of Conservation of atoms in balancing reactants and products.

30. Analyze a balanced equation in terms of mole ratios.

31. Identify and classify chemical equations through observations of reactions.

32. Relate the mole concept to stoichiometric problems.

33. Use the facotr-label method to solve stoichiometric problems.

IV. The Physical States of Matter

Objective #4: The student will demonstrate comprehension of the physical states of matter by performing the following activitites to be evaluated by teacher observation and/or tests.

Activities:

34. Define pressure in terms of force given an illustration of pressure effects.

35. Define mathematically pressure using various units: lbs, in2, mm, cm, torrs, atm, inches, dynes, and erys.

36. Describe properties of the gaseous state using the kinetic molecular theory.

37. Contrast an ideal gas with a real gas.

38. Describe mathematically the effect of pressure on a gas from the results of observations and data compiled from apparatus used to demonstrate Boyle's Law.

39. Compare and contrast intermolecular attractions of various gases using an appropriate demonstration or experiment.

40. Explain the relationship between temperature change and pressure change to develop the concept of absolute zero.

41. Explain the difference between Celsius and absolute temperature scales.

42. Discover Graham's Law of Diffusion by observing the rates of diffusion between ammonia gas and hydrogen chloride gas.

43. Relate graphical analysis of a gas law with its mathematical formulas by doing the following:
    a. Prove Boyle's Law is the inverse relation between a gas volume and corresponding pressure.

    b. Illustrate the direct relation of change in volume to change in temperature to prove the exactness of Charle's Law.

V. Molecular Composition of Gases

Objective #5: The student will demonstrate comprehension of the molecular composition of gases and display application of the mole concept to problems involving the behavior of gases by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

44. Develop the mole concept in molecular volumes by observing mass volume data for various gases.

45. Apply the mathematical constant 22.4 liters to determinging molecular masses of gases.

46. Explain Avogadro's hypothesis in terms of combining gas volumes.

47. Define Gay-Lussar's Law of combining gas volumes.

48. Calculate gas densities at standard conditions from given data.

49. Determine the specific gravity of any gas by understanding the relationship of Molecular mass-density.

50. Develop a concept for a diatomic gas in terms of Avogadro's hypothesis.

51. Solve volume-volume problems.

52. Use and apply the ideal gas equation and ideal gas constant.

53. Solve problems involving mass and volume given an equation.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE INCREASED COMPREHENSION OF THE NATURE AND PROPERTIES OF MATTER BY INVESTIGATING THE CONDENSED PHASES, SOLUTIONS AND SUSPENSIONS, IONIZATION AND CHEMICAL KINETICS IN THE FOLLOWING SUGGESTED ACTIVITIES.

I. Liquids, Solids, Water

Objective #1: The student will demonstrate comprehension of the nature and properties of the condensed phases of matter by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Describe the kinetic molecular theory of liquids and solids after a series of observations or illustrations.

2. Describe the general properties of liquids and solids as a result of comparisons of samples: specific gravities, evaporations rates boiling relates and melting points.

3. Apply the principle of Le Chatelier to boiling phenomena by varying temperatures and pressures.

4. Develop the concept of physical equilibrium as it relates to vaporization, condensations, and equilibrium vapor pressure.

5. Explain basic crystal systems using styrofoam or wood block models.

6. Relate the six basic crystalline systems to actual compounds or elements by viewing crystals under a microscope.

7. Recognize and interpret graphically the differences in equilibrium vapor pressures of liquids.

8. Explain the role of energy in dynamic equilibrium.

9. Explain how a monometer is used to determine vapor pressures of liquids.

10. Discuss the role of hydrogen bonding in the general properties of water and related substances given an illustration and description of hydrogen bonding.

11. Describe the use of water as a standard in temperature, specific gravity, heat calculations and mass.

12. Define:

    a. reaction types

    b. efflorescence

    c. Hygroscopic materials.

1 given a set of demonstrations of reactions with water.

13. Compare and contrast the properties of water with deuterium oxide.

14. Explain the role of an isotope in altering properties of compounds.

II. Solutions and Suspensions

Objective #2: The student will demonstrate comprhension of the nature and properties of solutions and suspensions by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

15. Differentiate between a solution and suspension after observing appropriate demonstrations.

    a. Identify components of a solutions: solute and solvent

    b. Identify from formulas and experimentation solutions which are electrolytes and nonelectrolytes.

16. Explain the principles underlying solution behavior through bonding mechanisms.

17. Relate miscibility to molecular structure of solutes and solvents through experimentation.

18. Demonstrate knowledge of the following terms by constructing various experiments given a saturated solution of a common substance such a $K_2Cr_2O_7$

    a. solution equilibrium

    b. unsaturation

    c. dilute

    d. concentrated

    e. saturation temperature

19. Using a "hypo" $Na_2S_2O_3$ solution, form a supersaturated solution.

20. Illustrate by experimentation the effect of pressure on the solubility of a gas in liquid.

21. Describe effervescence applying Le Chatlier's principle.

22. Define Henry's Law.

23. Explain, after observing a demonstration, the principles underlying the working of the ammonia fountain (HCL may be used).

24. Interpret a solubility graph by performing any experiment illustrating temperature vs. solubility of a common compound.

25. Describe dissolving mechanisms in solution formation.

26. Using appropriate demonstrations show heats of solutions for various substances.

27. Relate heats of solutions values to solubility curves.

28. Calculate concentrations of solutions using: molality percent by mass.

29. Solve problems involving boiling point elevation and freezing point depression.

30. Demonstrate molal depressions and elevations.

31. Using styrofoam models, explain the solution process by reviewing the nature of hydrogen bonding.

32. Construct an experiment showing hydrogen bonding effects in liquids.

33. Select an experiment to show selectivity of solvents and effects of hydoxy groups.

III. Ionization

Objective #3: The student will demonstrate comprehension of the nature and properties of electrolytes in terms of modern theory of ionization by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

34. Prepare a series of demonstrations which illustrate colloidal suspensions in terms of subdivision of particles.

35. Demonstrate absorption of charges on colloidal aggregates.

36. Demonstrate electrical charge in colloids by means of electrophoresis.

37. Devise and execute experiments which illustrate the properties of emulsoids, gels, and bicolloids.

38. Define the modern theory of Ionization by relating the view previously formulated by Faraday and Arrehnius.

39. Construct a series of conductivity tests to study comparatively the degrees of ionization for solutions of

    a. acids

    b. bases

    c. salts

    d. organic substances

40. Differentiate betwenn compounds which dissociate and those which ionize using molecular bonding theory.

41. Distinguish between strong and concentrated and weak and dilute using conductivity data.

42. Predict whether a compound will be an electrolyte or monelectrolyte.

43. Write equations for the dissociation of ions in aqueous solution.

44. Demonstrate the effect of electrolytes on Freezing Point and Boiling Point by constructing an experiment.

45. Define the difference in terms of interionic and molecular behavior between the apparent degree of dissociation and degree of ionization.

46. Understand ion migration and electrolysis by setting up and examining the Hoffman apparatus.

    A U-tube may be used as an alternate apparatus, where by solutions may more easily be tested.

IV. Acids, Bases, and Salts

Objective #4: The student will demonstrate comprehension of the characteristic properties behavior of acids, bases, and salts by performing the following activities to be evaluated by teacher observation and/or tests.

47. Give a conceptual definition of an acid.

48. Discuss the importance of acids in industry and at home.

49. Identify acids by recognizing physical and chemical properties.

50. Use of simple indicators (litmus) to identify acids.

51. Tes for acids in various foods.

52. State the Arrehnius and Bronsted definitions of acids.

53. Perform an experiment in which the oxide formed from the burning of phosphorus or sulfur is dissolved in water. Based on this experiment write appropriate equations for the reaction, test for an acid product, and define an acid anhydride.

54. Name and write formulas.

55. Define a base in operational terms.

56. Recognize simple reactions involving bases.

57. Describe the differences in systems of nomenclature for all salts and apply them through practice.

58. Describe a salt through reactions and solubilites by experimentation with salts.

V. Chemical Reactions-Kinetic

Objective #5: The student will demonstrate application of basic principles of chemical kinetics by performing th following activities to be evaluated by teacher observation and/or tests.

Activities:

59. Devise an experiment to observe heats of reactions.

60. Relate stability of compounds to heat of formation.

61. Write and interpret thermochemical equations.

62. Use thermochemical data, charts, and symbols.

63. Solve thermochemical problems.

64. Describe activation energy and reaction mechanisms using analysis of charts, graphs, and reactions.

65. Describe the driving force of a reaction by listing factors which affect reaction rates.

66. Relate bond energies to reaction heat.

67. Calculate heats of formation using the Born-Haber cycle.

68. Discuss entropy change and free energy using a demonstration.

69. Use the Law of Mass Action to describe the common ion effect.

LEVEL OBJECTIVE:

THE STUDENT WILL INCREASE HIS COMPREHENSION OF THE NATURE OF MATTER BY INVESTIGATING CHEMICAL EQUILIBRIUM, OXIDATION-REDUCTION REACTIONS, FAMILIES OF ELEMENTS, ORGANIC CHEMISTRY, AND NUCLEAR CHEMISTRY BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Equilibrium in Chemical in Chemical Reactions

Objective #1: The student will demonstrate application of equilibrium to chemical reactions by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Apply the law of mass action to simples cases of ke, ksp, and kw.
2. Illustrate the fundamental nature of equilibrium by showing it is established when forward and reverse reaction rates are equal.
3. Demonstrate that controlled conditions can regulate concentration of products and reactants.
4. Explain Le Chatelier's Principle using examples of reactions reacting usder stress.
5. Develop the equilibrium expression whose value is a constant for a given temperature.
6. Use the Law of Mass Action to define the equilibrium expression.
7. Devise an experiment to illustrate reversibility of reactions

II. Oxidation-Reduction Reactions.

Electric Energy in Chemical Reactions

Objective #2: The student will demonstrate application of the principles of oxidation-reduction reactions to the explanation of electrochemcial cells by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

8. Define and recognize oxidation-reduction equations.
9. Differentiate between the terms oxidation and reduction

10. Devise and experiment to indicate how electrochemical data is related to equilibrium values.

11. Obtain an overall redox equation by examining cell reactions for half reactions.

12. Explain the role of potential energy change during a redox reaction is electrical energy.

13. Assemble and expalin a variety of electrochemcial cells in terms of the oxidation-reduction reactions of these cells.

14. Explain the use of oxidation-reduction potentials and relate hydrogen half cell standard as a reference to reduction potentials.

15. Define the use of E values in predicting spontaneity of chemical reactions.

16. Perform claculations involving G .

17. Use half cell reduction potentials to calcualte equilibrium constants.

18. Solve problem types using Faraday's Laws.

19. Understand the principles of ion-electron method in balancing redox equations.

20. Calculate electrochemical equvalents from electrochemical calculations.

III. Descriptive Chemistry

Objective #3: The student will demonstrate knowledge of the properties of selected families of elements and the behavior of coordination compounds by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

21. Demonstrate simple reactions involving nonmetals.

22. Discuss formation of inert gas compounds.

23. Compare and contrast chemical-physical properties by relating periodicity of elements.

24. Classify chemical formulas according to their similarities in Icinitus, bonding, and oxidation reduction reactions.

25. List the properties of Group IA, II A Elements.

26. Use atomic structure and thermodynamic data to interpret behavior of metals.

27. Explain the irregularity of the first element in family to its high charge density.

28. Describe popular industrial processes involving these metals.

29. Construct the three basic cubic systems using compounds of these elements to illustrate closest packing.

30. Describe processes of metallurgy.

31. Use atomic structure models to explain colors and paramagnetism of transition metals.

32. Explain high melting points, hardness, and multiple oxidation states using principles of a orbital bonding.

33. Explain and illustrate the behavior of coordination compounds.

34. Illustrate shapes, properties, and isometric structures of complex ions using hybrid orbital concept.

35. Devise a method to explain chilation.

36. Use the Lewis Theory to explain complex ion formation.

37. Explain the Valence bond theory using styrofoam models to illustrate formation of ligands.

IV. Organic Chemistry

Objective #4: The student will demonstrate comprehension of some of the basic properties and behavior of carbon compounds by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

38. Explain covalent bonding in the compounds of carbon.

39. Identify organic compounds according to generalized formula and nomenclature.

40. Correlate reaction types of organic with inorganic chemistry.

41. Review hybridization concepts to emphasize bonding mechanisms.

42. Define resonance using orbital bonding theory.

43. Categorize organic reactions according to type.

44. Prepare organic compounds using various reactions.

45. Use ball and stick models to show members of homologous series.

46. Construct models to devise a resonance hybrid structure for benzene.

47. Devise experiments to show reactions of aromatic compounds and their substitution products.

V. Nuclear Chemistry

Objective #5: The student will demonstrate comprehension of the relationship between nuclear structure and radioactivity by performing the following activities to be evaluated by teacher observation and/ or tests.

Activities:

48. Define common terms associated with radioactivity.

49. Explain radioactive decay as a property of the nucleus.

50. Describe the role of energy release in decay processes.

51. Explain binding energy.

52. Use a variety of devices to detect products of radioactive decay.

53. Write equations to describe nuclear reactions.

54. Read charts describing decay rates and products.

55. Understand the use of radioactivity to determine age to perform calculations.

56. Describe artificial radioactivity and production of radioisotopes.

57. Demonstrate ionizing effect of radiation using an electroscope.

58. Explain the uses of radioisotopes in current industry as tracers.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE KNOWLEDGE OF THE NATURE AND METHOD OF SCIENCE OR CHEMISTRY AND WILL BEGIN TO DEVELOP A BASIC COMPREHENSION OF THE COMPOSITION AND PROPERTIES OF MATTER BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES:

I. Atoms, Molecules and Gases

A. The observational basis of chemistry

Objective #1: The student will demonstrate comprehension of the observational basis of chemistry by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

1. List four of the basic activities of Science.

2. Demonstrate his ability to sort and arrange collected data and make qualitative predictions based on this data given a set of data.

3. Differentiate between characteristic and non-characteristic properties of substances.

4. Define phase change, state conditions necessary for a phase change to occur and relate phases to energy.

5. Construct a model which will predict and/or define and/or account for gas pressure.

6. Solve simple problems using uncertainty measurements.

II. The Atomic Theory

Objective #2: The student will display comprehension of the properties of gases in terms of the development of a molecular model by completing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

7. Define law, model, theory, pressure, and volume.

8. Demonstrate his ability to construct a graph (given appropriate data) and predict quantitative realtionships between the variables to be evaluated by teacher observation and/or tests.

9. State and apply Boyle's law in the solution of pressure/volume problems.

10. Predict relative weights or atoms and molecules of gases given density or other appropriate data.

B.

11. Define a mole as an Avogadro number of particles or the number of particles in 32 grams of oxygen and predict these gases which are diatomic.

12. Change grams to moles, liters of gas to moles, moles to grams and moles to liters of gas, given necessary data.

13. Determine the molecular weight of any common substance given the formula for that substance and a table of atomic weights.

14. Name Binary compounds from formulas and write formulas from names.

15. Balance chemical expressions given the reactants and products.

16. Predict the number of moles of all substance produced or consumed in a chemical reaction given the expression and the mass of one of the substances in the expression.

17. Determine the molecular weight of a gas given the weight of a fixed volume of the gas and the weight of an equal volume of oxygen (or other standard).

III. Conservation Laws

Objective #3: The student will demonstrate comprehension of the laws of Conservation of Mass and Conservation of Energy by performing the following activites to be evaluated by teacher observation and/or tests.

Activities:

18. Convert absolute number of molecules, grams of molecules, and volumes of gases to number of moles using method of unit analysis.

19. State the Law of Conservation of mass.

20. State the Law of Conservation of energy.

21. Balance chemical expressions from a knowledge of reactants and preducts and show conservation of matter or atoms.

22. Write chemical equations which define a) the heat of combustion and b) the heat of formation given the substance burned or the substance formed and the accompanying energy change.

23. Apply mole concepts in balanceing expressions, describing mass balance and in solving chemical problems.

24. Predict the amount of energy change which accompanies a chemical reaction given the chemical expression and the energy change for one mole of reactant consumed.

25. Use acceptable nonenclature (or symbols) to show direction of energy change.

26. State Charles' Law in qualitative terms.

27. Predict the volume or temperature of a gas in the final state given the volume and temperature of the gas in the initial state and either the volume or temperature in the final state.

IV. Kinetic Theory

Objective #4: The student will display application of the kinetic molecular theory as it applies to the behavior of gases by completing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

28. Apply the rules for calculating either the volume, pressure, or temperature of any fixed mass of gan, given values of each property in the initial state and the values of two of the three properties in the final state.

29. Apply the rules that relate Kelvin and Celsius temperature scale units to convert a temperature reading on one scale to the corresponding temperature on the other.

30. Define STP.

31. State Dalton's Law of partial pressures.

32. Illustrate and apply the rules in Dalton's Law of partial pressures.

33. Construct and demonstrate a procedure for obtaining data to indicate the relationship between the number of moles of gas produced at STP and the number of moles of either reactant given a system initially composed of magnesium metal and hydrochloric acid.

34. Apply the rule for calculating the volume of a gas in the initial or final state of a system given the quantity of one of the other components in the system, the equation for the reaction, and the pressure and temperature of the gas.

35. Describe or identify a property of matter which is explained by or supports a given assumption of the kinetic molecular theory; and/or name an assumption of this theory which explains a given property.

36. State the ideal gas law and solve representative problems using this law.

V. Condensed Phases

Objective #5: The student will demonstrate comprehension of the condensed phases of matter by examining properties of solids, liquids, and solutions in performing the following suggested activities to be measured by teacher observation and/or tests.

Activities:

37. Justify the existence of interatomic (or intermolecular forces).

38. Revise of modify the kinetic molecular theory to include liquids and solids.

39. Comapre and/or predict boiling points of various liquids given the molar volumes of the gaseous phase of these liquids.

40. Comapre and/or predict the strength of the intermolecular forces of various substances given either the boiling point or the vapor pressure of these substances.

41. Predict changes in boiling points due to changes in pressure.

42. Calculate the energy required to melt or vaporize a substance given the formula or name of the substnace, the mass of the substnace, and its molar heat of fusion or molar heat of vaporization.

43. Explain and compare the processes of evaporation and boiling on the molecular level.

44. Comapre and/or predict the relative boiling points of various substance given the vapor pressure at a common temperature and/or predict the boiling point of a substance given the ambient temperature, the ambient pressure, and the vapor pressure of the substance at various temperatures.

45. Define in operational terms; solvent, solute, solution composition or concentration of a solution in units of molarity, saturated or unsatruated solution, and soluble or insoluble.

46. Prepare and/or given directions for the preparation of a solution of a given concentration given the formula for the solute and sufficient solvent.

47. Compute the mass of solute present in any specified volume of a solution given the formula for the solute and the concentration of the solution.

48. Compute the volume of a solution needed to contain a specified mass of solute given the formula of the solute and the concentration of the solution.

49. Predict in qualitative terms the effect of a solute on the vapor pressure, the melting point and the boiling point of a substance.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE INCREASED COMPREHENSION OF THE NATURE OF MATTER BY CONSIDERING THE EVIDENCE WHICH SUPPORTS THE ATOMIC THEORY, THE STRUCTURE OF THE ATOM, AND THE PERIODIC TABLE BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES:

I. Belief in Atoms

Objective #1: The student will demonstrate comprehension of the experimental evidence which supports the atomic theory by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. State the law of definite composition and/or generate the law of definite composition from percent by mass analysis of some common laboratory substances.

2. Predict empirical formulas for substances given the percent by mass and the atomic mass of each component of the substance.

3. Predict molecular formulas for substances given the percent by mass, the atomic mass of each component of the substance, and the molecular mass of the substance.

4. State the law of simple multiple proportions and/or generate the law of simples multiple proportions by the analysis of two or more different compounds formed from the same elements brought together under different conditions.

5. Determine the formula for a compound or series of compounds of the same two elements given the mass of one of the elements per gram of the other element and the atomic mass of each element.

6. Rejustify the existence of atoms as components of molecules using the law of combining volumes.

7. Demonstrate and/or describe procedures to determine the type of charge, if any, on an object, an electroscope, and the terminals of a battery.

8. Construct or describe a hypothesis which explains the behavior of charged bodies given observations of the interaction of two charged bodies.

9. State and apply the rule for determining whether or not the force between two charged bodies is increased or decreased and by what amount when either the magnituden of the charges, distance between the charges, or the medium (given the diglectric constant) between the charges is changed.

10. State and apply the rule for determining whether or not the potential energy of a system of two like or unlike charges is the same, greater than or less than that of another system with similar charges, given the values for the magnitude of the charges, distance between the charges and the de-electric constant for the media.

11. Identify the polarity of the electrodes of an electrochemical cell, direction and magnitude of current in a circuit, quantity of a charge which passes a point in a circuit in a given time, and solutions which contain ions, given either the necessary equipment or a description of a procedure and the observations recorded.

12. Select compounds from a list whose aqueous states conduct charge and write equations to indicate ionization and/or dissociation.

13. Differentiate atoms from ions using electrons, protons and appropriate symbols.

14. Write equations to show the conversion of atoms into ions and/or the conversion of ions into atoms.

15. Construct a procedure for obtaining data to determine the relationship, if any, between the quantity of charge passing through the external circuit and the quantity of products produced at the electrodes of an electrolytic cell during electrolysis, given the components of the system in the initial state and the equation for the reaction.

16. Apply the rule for deteriming the quantity of charge, the mass, and the charge to mass or the charge to mole ratio of an element produced during electrolysis, given values for the other two.

17. Generate a hypothesis as to the number of electrons (elementary charges) transferred per atom or ion of either of two elements in a system which has undergone electrolysis, given the electrons transferred per atom or ion of one of the elements, the mass of each element produced or ionized at each of the electrodes and the hypothesis that charge is conserved.

18. Compute the concentration of all ions formed in a conducting solution given the mass of the undissolved solute, the volume of the solution after mixing and dilution, and the identity of the ions formed.

II. The Structure of the Atom

Objective #2: The student will demonstrate comprehension of atomic structure by analyzing the development of a model for atoms which accounts for the electrical nature of matter. The following suggested activities are directed toward this objective and will be measured by teacher observation and or tests.

Activities:

19. Construct a hypothesis as to the type of charge and its direction of flow in high vacum discharge, thermionic, or photoelectric tube given either the necessary equipment or a description of an experiment and the recorded observations.

20. Construct hypothesis as to the nature of an electron, the mass of an electron, the nature of positive ions, the mass of a proton, the nature of the nucleus and the architecuture of an atom given a discription of experiments performed by Thomson, Millikan, Goldstein, Rutherford, Chadwick, and others.

21. Apply the rules for determining the atomic number and mass number of an isotope of an element given the number of electrons, protons and neutrons in an atom of the isotope and/or given the atomic number and mass number, determine the number of electrons, protons, and neutrons.

22. Identify isotopes of an element given a set of elements described only by their atomic number and mass number.

23. Describe the structure and composition of atoms of an isotope of an element in terms of the hypothesis of the atom devised by Rutherford, Chadwick and others given the atomic number and mass number of the isotope.

24. Predict atomic radii given appropriate inter nuclear distances and/or predict inter nuclear distances given appropriate atomic radii.

25. Reconstruct the method of ion formation and justify the hypothesis based on the atomic architecture proposed by Rutherford, Chadwick and others.

26. Write equations to show the formation of positive and negative ions from their respective parent atoms and show the energy requirement associated with the ion formation

27. Identify an alpha particle, a beta particle, a neutron and a positron and write appropriate symbolism for each particle.

28. Complete and balance equations to demonstrate beta decay, alpha particle emission and/or positron loss, given the isotopic symbolism for the unstable nucleus and a table of atomic numbers.

29. Propose a hypothesis to explain the stability of atomic nuclei given the componenets of a nucleus.

III. The Periodic Table

Objective #3: The student will demonstrate application of the periodic table by completing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

30. Construct and/or identify a pattern, if any, for the possible arrangement of elements numbered one through twenty given the description of a procedure for the removal of electrons from a neutral atom and the first ionization energy for elements on through twenty.

31. Construct a graph of first ionization energy against atomic number for the first twenty elements and identify stable electronic patterns given the first ionization energy for the first twenty elements.

32. Formulate a hypothesis to explain or support the formation of ions of predictable charge given the first through eleventh ionization energies for the first eleven elements.

33. Predict all possible stabel electron arrangements given a graph of ionization energy against atomic number for all known elements if the ionization energy is available.

34. Construct and/or propose a model for electron arrangement in levels for elements one through twenty given all necessary ionization energies, and explain why the first ionization energy is lower than the second ionization energy and the second is lower than the third.

35. Describe the trends in first ionization energies of two or more sequential elements within a group or period and account for these trends in terms of electronic configuaration of the elements.

36. Describe the trends in the boiling points, the ionization energies and atomic weights for the noble gases, the halogens and the alicali metals and account for these trends in terms of electronic configuration of these elements.

37. Identify and/or predict the type of bonding between designated atoms given the position or location of these atoms in the periodic table and/or respective atomic numbers.

38. Classify elements as metals or non-metals and predict relative reactivity of metals and/or non-metals given the periodic table or a procedure for determining relative reactivity or the observations from such a procedure.

39. Construct equations for the reaction of any element in groups IA, IIA, or IIIA with any element of groups VI or VII of the Periodic Table.

40. Predict formulas for possible compounds formed from pairs of elements given the atomic number and/or the location of the elements by group in the Periodic Table.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE NATURE OF CHEMICAL CHANGES BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Energy Changes in Chemical and Nuclear Reactions

Objective #1: The student will demonstrate ability to analyze quantitatively the energy changes involved in chemical and nuclear reactions by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Classify a given chemical change as an exothermic or endothermic reaction given a description of the system in the initial state and a description of the system in the final state and/or a statement of the thermal energy of the reactants compared to the termal energy of the products.

2. Apply the rule for calculating either the mass, heat capacity, temperature change or the termal energy transferred to or from a substance, given values for the other three.

3. Construct and/or demonstrate a procedure for obtaining data to determine whether or not there is a unique thermal energy change per mole of reactant, given either the procedure and/or either a) a finely divided metallic element and an aqueous solution of a substance of known molarity with which it reacts or b) two reacting solutions and their molarities.

4. Construct and/or demonstrate a procedure for obtaining data and calculating the enthalpy of reaction of a system composed of an acid and a base in its initial state given either the procedure and/or an acid of known molarity, a solution of a base of known molarity, an undissolved sample of the base and sufficient solvent to make the required solution and a statement of Hess' Law of Additivity.

5. Apply the rules for calculating emthalpies of reaction and writing thermochemical equations for chemical changes given the formulas of each component of a system in its initial and final state and the quantity of heat transferred for a given quantity of one of the components.

6. Construct a thermochemical equation for a reaction, given a description of an experiment performed, the equation for the reaction and the data collected.

7. Apply the rule for calculating the quantity of heat transferred for a given reactant or product of a chemical change, given the thermochemical equation for the reaction.

8. Apply the rule known as Hess' Law to calcualte the enthalpy of reaction for a change, given the equation for the reaction, and tables of thermochemical equations from which to select those required for the calculation.

9. Identify and distinguish between or among enthalpies of reaction, variazation, fusion, sublimation, cumbustion, formation, dissociation, solution and bond energies given thermochemical equations for the change and/or construct thermochemical equations for each of these enthalpies given necessary formula and lists of elements.

10. Calculate the energy released during a nuclear fission or fusion process given the mass of each of the reactive species, the mass of each of the product species, the overall thermonuclear reaction and Einstein's equation relating mass and energy.

11. Compare and discuss the reasons for the differences between the temperature and energy changes associated with chemical processes with the temperature and energy changes associated with the changes, and with the temperature and energy changes associated with nuclear changes.

II. The Rates of Reaction

Objective #2: The student will demonstrate comprehension of chemical kinetics by analysis of the factors which determine, regulate, and predict reaction rates. This objective will be accomplished by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

12. Describe how the rate of a reaction might be changes, given the equation and the enthalpy change.

13. Identify the rate determining step and the proposed mechanism for the reaction and write the equation for the overall reaction.

14. State and apply the rules which determine whether a reaction is fast or slow at room temperature given the reaction and the nature of the reactants.

15. Construct and/or demonstrate a procedure for determining the effect of changes in the temperature, concentration of a reactant or particle size of a solid reactant on the reaction rate of a

chemical system given the overall equation for the reaction.

16. Name a variable and describe its effect on the reaction rate of a specific change given a description of the rate experiment and data collected.

17. Identify the activation energy, enthalpy change, the reactants and the products of a chemical system given the potential energy diagram for the reaction.

18. Construct a potential energy diagram for the change in a chemical system given the reaction mechanism, the aviation energy for each step and the enthalpy change for the net reaction.

19. Discuss and construct a model to explain how the rate of a reaction can be affected by (1) changes in concentration of one or two other of the reactants and (2) changes in the temperature of the reacting system.

20. Reconstruct and/ or modify potential energy diagrams and/or reaction mechanisms to account for the effect of either/or both positive and inhibiting catalysts.

21. State three methods by which the pressure of a gaseous system can be increased and discuss how each method will influence the reaction rate given the formulas for the components in the initial state and the rate determining step.

22. Apply the rule for calculating either the activation energy for the forward reaction, the activation energy for the reverse reaction or the net heat of reaction given a potential energy diagram or values for the ohter two.

III. Equilibrium in Phase Changes and in Chemical Reactions

Objective #3: The student will demonstrate application of the qualitative and quantitative aspects of equilibrium to phas changes and chemical reactions by performing the following activities to be measured by teacher observation and/or tests.

Activities:

23. Apply the rules for determining whether or not an equilibrium condition exists, given a description of the system over a period of time, in terms of either the molecular activity or the microscope properties of the system.

24. Describe the vapor-liquid equilibrium situation on the molecular level and discuss the rule of temperature as a variable in controlling the equilibrium condition.

25. Differentiate between a system in a steady state and a system in an equilibrium state.

26. Apply the rule known as Lechatlier's Principle to predict the effect if any, on a given chemical system in the equilibrium state of (a) increasing or decreasing the concentration of one or more of the components, (b) increasing or decreasing the temperature of the system (transferring thermal energy into or out of the reacting system of either exothermic or endothermic.

27. Construct or demonstrate a procedure for obtaining data and calculating the equilibrium constant, Keql for a system composed of (a) a partially soluble solid water system in equilibrium or (b) simple ions which can associate and be in equilibrium with a complex ion.

28. Apply the rule, known as the law of mass action, to write the expression indicating the equilibrium law relations, given the equation for the reaction.

29. Apply the rule, known as Guldberg and Waage's Law, for determining the equilibrium constant, given the equation and the concentration of each of the components of the system in the equilibrium state.

30. Apply the rule for determining the concentration of a component of a system in the equilibrium state, given the equation for the reaction, the value of the equilibrium constant and the concentration of at least one of the other components of the system in the initial or equilibrium state.

31. Construct and/or defend a model to show how the equilibrium state is achieved as the result of a compromise between the tendency for a system to achieve a state of minimum enthalpy and maximum entropy.

32. Predict (a) whether the tendency toward minimum enthalpy favors reactant or product and/or (b) whether the tendency toward maximum enthalpy favors reactant or product given the thermochemical equation for the reaction equilibrium.

IV. Solubility Equilibrium

Objective #4: The student will demonstrate application of the principles of equilibrium to solubility problems by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

33. Construct a procedure for obtaining data to determine the solubility of a given solid substance in water

34. Construct a procedure for obtaining data to determine the effect if any, of (a) temperature on the solubility and rate of solubility of a substance in water and (b) surface area of the solubility and rate of solubility of a substance in water.

35. Propose a model to support the dynamic nature of solubility equilibria given the factors which determine the rate of solution and the factors which determine the rate of precipitation.

36. Identify incomplete reactions in aqueous chemical systems, given the volume and concentration of one or more of the reactants and either the concentration or the mass of one of the products.

37. Compare the solubility of a solid in various solvents at the same temperature given the heat of solution of the solid in each of the solvents and/or the entropy of solution of the solid in each of the solvents.

38. Compare the solubility of a solid in various solvents at different temperature given the heat of solution and the entropy of solution of each solid-solvent system.

39. Apply the rules which determine the solubility of a solid in a liquid to a system composed of a gas in a liquid.

40. Describe the effect, if any, of the tendency toward maximum randomness and the tendency toward minimum energy on the solubility of either a solid and/or a gas in a liquid.

41. (Review) write equations to show the formation of ions when an ionic solid dissolves in water.

42. Apply solubility rules to determine whether or not an ionic compound will dissolve in water.

43. Write the formula for a compound given either the classical or stock name for the compound and/or name the compound using either the classical or stock name for the compound given the formula for the compound.

44. Apply the rule for determining the solubility product constant of a substance given its solubility.

45. Given the solubility product constant for a solid-liquid system and the formula of the solid, determine the concentration of the ions formed.

46. Apply the rules for determining whether or not a precipitate will form in a chemical system given the identity and concentrations of the components of the system in the initial state, the solubility product constant and the solubility rules.

47. Construct net ionic equations for reactions in which precipitates are formed when aqueous solutions are mixed given systems in the initial states composed of pairs of aqueous solutions selected from ammonium, alkali metal, nitrate, halide, sulfate, sulfide, hydroxide, carbonate or phosphate compounds.

48. Construct and demonstrate a procedure for identifying each solution in a set of six to ten unlabeled aqueous solutions given the names of the solutions in the set but no other reagents.

V. Acids and Bases

Objective #5: The student will demonstrate comprehension of the characteristic properties and behavior of acids and bases by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

49. Identify substances which are acids or bases given either substances, solutions of substances and/or descriptions of the properties of substances of their solutions and describe the criteria used to make the identification.

50. Identify Arrhenius, Bronsted-Lowry and/or Lewis acid-base reactions in a given set of reactions written with either empirical structural formulas.

51. Name the conjugate acid-base pairs, given equations representing Bronsted-Lowry acid base reaction.

52. Construct and/or demonstrate a procedure for a ordering acids of bases in decreasing strength, given aqueous solutions of three acids or bases or given the procedure and aqueous solutions of three acids or bases.

53. Classify an electrolyte as either strong or weak given an aqueous solution of the electroyte, an equation for the dissociation, and the value of the equilibrium constant for the dissociation.

54. Apply the rule for calculating the pH, (H_3O^+) or the (OH^-) in an aqueous solution, given the concentration of one of the others.

55. Apply the rule for calculating the (H_3O^+) and/ or the (OH^-) in an acid-water or base-water system at equilibrium, given the concentration of the acid in the initial state and its ionization constant.

56. Construct and/or demonstrate a procedure for obtaining data to determine the concentration of acidic and/or basic aqueous solutions, given an acidic solution, a basic solution and the concentration of one of the solutions or given the procedure, an acidic solution, a basic solution and the concentration of one of the solutions.

57. Apply the rule for calculating either the volume or the concentration of either the acid or the base given data obtained from the titration of the acid with the base.

58. Order substances which are acids or bases in aqueous solutions in either increasing or decreasing acid or base strength, given either equations for the spontaneous reactions which occur when each of the substances is mixed with each of the other substances in the set or given the dissociation reaction and the value of the ionization constant (Ka or Kb) for each of the substances in the set.

59. Calculate the (H_3O^+) and the (OH^-) in an aqueous solution of an acid and a base given the volume and the concentration of both the acid and the base in the aqueous solution

60. Calculate Ka for an acidic solution given either the mass of acid dissolved, the volume of the solution, the equation for the dissociation and the (H^+) or the concentration of the acidic solution, the equation for the dissociation and the (H^+).

VI. Oxidation-Reduction Reactions

Objective #6: The student will demonstrate application of the principles of oxidation-reduction reactions to the explanation of electrochemical cells by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

61. Assemble an electrochemical cell given aqueous solutions of electrocytes, electrodes made of suitable substances, an ammeter, wire, and either a salt bridge and beakers or a porous cup and beakers and show direction charge flow using an appropriate diagram.

62. Generate the equations for the half-cell reactions and the overall chemical reaction for an electrochemical cell given the name and the magnitude of the charge of the cation in each half-cell, and the direction of charge flow.

63. Name or identify the half reactions, electrodes, ions involved, and chemical reaction at each electrode as either electron acceptor or electron producer, either anode or cathode, either anion or cation, either oxidation or reduction.

64. Construct and demonstrate a procedure for obtaining data to order in decreasing strength a set of reducing agents given aqueous solutions of each substance, and the magnitude of the charge on each cation but no other reagents.

65. Construct and demonstrate a procedure for obtaining data on the value and sign of the maximum electrode potential of each of four unlabeled metal-metal ion half-cell, one of which is designated the standard electrode.

66. Order a set of reducting agents on the basis of increasing or decreasing strength given a table of half-cell reactions and their standard electrode potentials.

67. Construct net equations for spontaneous reactions, if any, given descriptions of systems composed of a metal in a solution of a salt of another metal and a table of half-cell reactions and their standard electrode potentials.

68. Apply the rule for calculating the maximum potential difference of an electrochemcial cell given a description for the standard half-cells and a table of half-cell reactions and their standard electrode potentials.

69. Apply the rule for calculating the free energy change produced by an electrochemical cell (assuming constant electrode potential) given a description of the standard half-cells, their standard electrode potnetials and either the current and time of operation or the changes in the quantity of a component of the system.

70. Construct net equations for spontaneous reactions, if any, given descriptions of systems composed of a metal in a solution of a salt of another metal, a table of half-cell reactions and their standard free energy changes.

71. Identify oxidation-reduction reactions, given equations for reactions.

72. Identify the oxidizing and reducing agents and the elements oxidized and reduced, if any, in a system in which a change occurs, given the equation for the changes.

73. Apply the rules for calculating the oxidation number of each constituent element of a substance or ion givne its formula.

74. Construct equations for oxidation-reduction reactions given formulas of reactants and products and net ionic equations for oxidation-reduction reactions in acidic, basic or neutral aqueous solutions and given formulas for all reactants and products except H_2O, H+ and OH- using either a method based

on half-cell reactions or a method based on oxidation numbers.

75. Compare and contrast an electrochemical cell with an electrolytic cell given a list of the physical features of each cell, a list of the nomenclature appropriate to each cell, a list of half-cell reactions and electrode potentials appropriate to each cell and/or a labeled diagram of each type of cell.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE AN INCREASED COMPREHENSION OF THE NATURE OF MATTER BY INVESTIGATING THE ELECTRONIC STRUCTURE OF ATOMS, CHEMICAL BONDING, AND MOLECUALR ARCHITECTURE BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Electromagnetic Radiation & Atomic Structure

Objective #1: The student will demonstrate comprehension of the nature of electromagnetic radiation as it applies to explaining the arrangment of electrons in atoms by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

1. (Review) Prepare a chart of the isotopes elements number one through twenty which will show the arrangement of electrons by levels outside the nucleus given the anem of the isotope of the element, the atomic number of the isotope, and the first ionization energy of the isotope of the element.

2. Identify and describe the nature of the source and/or the spectrum produced by a source, given either the necessary equipment or a description of a procedure and the observations recorded.

3. Identify and describe the nature of diffraction of interference patterns given either the necessary equipment or a description of a procedure and the observations recorded.

4. Identify and describe the characteristics of a wave in technical language given a diagram of a wave.

5. Apply the role for determining either the frequency of light or the wavelength of light given the value of one of these properties and the velocity of light.

6. Order photons of light as to increasing energy, given the color of the wavelength of the photons.

7. Order the spectrum of sunlight as to increasing angle of bending given either the necessary equipment of a description of a procedure and the observations recorded.

8. Correlate wavelength, frequency and angle of bending given an unlabeled diagram of a beam sunlight, a prism, and the uncolored spectrum produced.

9. Order the electromagnetic spectrum as to increasing energy or as to increasing wave length given either the name of the radiation or the frequency of the radiation.

10. Apply the rule for determining either the energy, the frequency or the wavelength of photons of radiation given the value of Plank's constant and the values of any two of the other properties of the radiation.

11. Apply the rule known as the Rydberg equation for determining the frequency of the lines in the spectrum of the hydrogen atom given the value of the Rydberg constant and the values of the levels of the electron transitions.

12. Identify and describe the energy level scheme of the hydrogen atom given values of the energy release for the various allowed electron transitions.

13. Apply the rule for determining the energy or the frequency or the wavelength of a matter wave associated with a particle, give the momentum of the particle and Plank's constant.

14. Describe or identify a property of matter which is explained by or supports a given assumption of the atomic orbital model which explains a given property of matter.

15. Apply the rule for assigning electron waves to orbitals to write the electronic configuration of atoms or ions of an element, given its atomic number.

16. Construct, identify, and/or distinguish among s,p,d, and f, electron waves as to shape and orientation.

17. Place an element in the periodic table and identify its group, family and/or series, given its electron configuration.

18. Apply the rules for determining the number of valence electrons a given atom possesses given values of the first through ionization energies of that atom.

19. Determine and/or describe the ionization energies of an atom given a description of the ground state orbital and a description of the location of the electron to be removed.

20. Compare, describe and/or relate the chemist's s,p,d,f, notation for describing electron waves with the physicist's n,m,l, and s notation for describing electron waves.

II. Mulecular architecture: Gaseous Molecules

Objective 2: The student will demonstrate comprehension of the nature of the chemical bond and the molecular

architecture of gaseous molecules by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

21. Construct diagrams of the electron waves in the outer energy level of atoms withing a molecule in terms of both the atomic orbital and electron dot (Lewis) representations given the formula of the molecule.

22. Construct, identify and/or distinguish between s,p,sp, sp^2 sp^3 electron waves as to shape and orientation.

23. Identify and/or distinguish between s-s, s-p, sp^2-s sp^2-p, sp^2-sp^2, sp^3-s, sp^3-p, sp^3-p, sp^3-sp^3 bonds in molecules given the formula of the compound or a diagram of the electron waves in the outer energy level of the atoms within the molecule.

24. Identify and/or distinguish between single, double and triple bonds in molecules given the formula of the compound or a diagram of the electron waves in the outer energy level of the atoms within the molecule.

25. Identify and/or distinguish between bond angles in molecules given the formula of the compound or a diagram of the electron waves in the outer energy level of the atoms within the molecule.

26. Identify and/or distinguish between sigma and pi bonds in molecules given the formula of the compound or a diagram of the electron waves in the outer energy level of the atoms within the molecule.

27. Identify and/or distinguish between the geometric shapes of molecules given the formula of the compound or a diagram of the electron waves in the outer energy level of the atoms within the molecules.

28. Identify and/or distinguish between covalent and ionic bonds; polar and non-polar molecules given diagrams of the electon distribution between the atoms in the molecule and/or the ionization energies or electronegativites of the atoms in the molecule.

29. Determine the molecular dipole, if any, of a molecule given a diagram of the molecule showing the individual dipoles of each bond, if any, or given the formula for the molecule, the electronegativites of each atom in the molecule and a description of the bonds formed between the atoms in the molecule.

30. Construct, identify and distinguish among structural isomers of a compound, given the formula of the compound but not the diagram of the compound.

31. Predict the formula of the compound given the identity of the atoms within the atoms within the molecule and the atomic number of these atoms.

32. Describe, explain an/or compare the modern physical methods (1) x-ray diffraction (2) electron diffraction (3) infrared spectroscopy (4) microwave spectroscopy and (5) nuclear magnetic resonance spectroscopy used in structure determination.

III. Molecular Architecture: Liquids and Solids

Objective #3: The student will demonstrate comprehension of the chemical bonds and molecular architecture of liquids and solids by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

33. Identify and describe the basis for van der Waals attraction in a given substance composed of either atoms or molecules.

34. Apply the rule of electric symmetry to predict and/or interpert differences in melting points and boiling points given atomic orbital diagrams, Lewis or Couper structures or formulas of any series of substances composed of elements with atomic number one through twenty.

35. Identify samples of substances as metallic, covalant or ionic given a sample of the substances or observations of the properties of the substance, and describe the criteria used.

36. Describe, name and identify properties of substances which are explained by or support one or more of the hypotheses that bonding electrons in metals are delocalized among nuclei.

37. Describe, name, and identify properties of substances which are explained by or support one or more of the hypotheses that bonding electrons in covalant substances are localized between nuclei.

38. Describe, name, and identify properties of substances which are explained by or support one or more of the hypotheses that bonding electrons in ionic substances are localized around individual nuclei.

39. Identify, describe, and construct diagrams and/or three dimensional representations of both aggregates and unit cells of hexagonal closest packed, face centered cubic packed and body centered cubic packed metal crystal structures.

40. Order heats of vaporization of metals from lowest to highest in a group or in a period given the name of the metals and a periodic table, or order metals from lowest to highest bond strength in a group or in a period given a table or heats of vaporization for metals.

41. Identify, describe, and construct diagrams and/or three dimensional representations of both aggregates and unit cells of sodium chloride and cesium chloride lattice ionic crystal structures.

42. Apply the rule known as Hess' law to calculate the hydration energy, crystal energy or enthalpy of solution of an ionic substance, given valves of the other two.

43. Describe, name, and identify properties of substances which are explained by or support the hypotheses of the hydrogen bond.

44. Construct and demonstrate a procedure to determine whether a solid substance was held together by ionic bonds, covalant bonds or van der Waals forces given a sample of the solid substance and access to any necessary materials or equipment.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE NATURE AND METHOD OF PHYSICS AND APPLICATION OF THE FUNDAMENTAL LAWS OF MOTION AND THE LAWS OF DYNAMICS BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. The Nature and Method of Physics

Objective #1: The student will demonstrate knowledge of the nature and method of the science of physics and will demonstrate facility with mathematical computations involved in systems of measurement by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

1. Define physics in terms of its subject content and its method of investigation.

2. Demonstrate that he can solve problems in addition, subtraction, division, and multiplication by writing all numbers in scientific notation.

3. Demonstrate that he can use the "C" and "D" scale on a slide rule to multiply and divide.

4. Demonstrate that he can solve complex eractions by using a slide rule.

5. Demonstrate that he can extract squares, cubes, square roots, and cube roots by using the "A", "K", and "D" scales on a slide rule.

6. Conceptualize and demonstrate the Law of Exponents by solving arithmetic problems.

II. Motion

Objective #2: The student will demonstrate application of basic principles of kinematics by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

7. Conceptualize, explain, and demonstrate what a vector is and its relation to velocity.

8. Differentiate between velocity, average velocity, and uniform velocity by solving problems.

9. Explain the basic relationships that exist between distance, time, and velocity. This may be done by explaining and discussing problems.

10. Conceptualize and discuss the meaning of acceleration due to gravity.

11. Design an experiment that will allow one to determine the value of "G" at a given location.

12. Reproduce and explain the derivations of the following formulas:

(1) $a=\frac{v2-v}{t}$.

(2) $v2=v. \text{ tat}$

(3) $s=vt$

(4) $vav=\frac{v2+v}{2}$

(5) $s=v_1t + \frac{1}{2} at_2$

13 Solve at least five (5) different problems dealing with ballistics and trajectory of projectiles.

III. Forces and Motion

Objective #3: The student will demonstrate comprehension of the relation of force to motion through analysis of the laws of dynamics by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

14. State a functional definition for force, momentum, universal gravitation, inertial mass, gravitational mass, and conservation of momentum.

15. Demonstrate the two effects produced by force and explain Newton's reasoning.

16. State and cite examples that will indicate an understanding of Newton's three laws of motion.

17. Demonstrate in an experiment using two balls, Newton's first law.

18. Predict the second law by explaining the first law of motion.

19. Apply the units of force in the MKS-system, CGS-system, and in the British Engineering system to a series of problems utilizing these systems.

20. Describe Newton's logical development of the law of universal gravitation.

21. Logically develop the formula for universal gravitation and use this formula to solve related problems.

22. Use common data from the physical universe to arrive at the accepted value of G (6.67×10 $n.m^2/kg$) and explain the significance of this constant.

23. Calculate the acceleration of the moon and determine the "binding" force of the earth.

24. Distinguish between mass and weight in the English and Metric system.

25. Conceptualize, explain, and cite examples for the third Law of Motion.

26. Explain how momentum is conserved in collisions and solve related problems.

27. Perform a laboratory exercise, collect data, and interpret the data in light of a collision.

28. Distinguish between centrifugal and centripetal force, and solve related problems.

29. Describe the basic tenents of the heliocentric and geocentric theory.

30. Describe Kepler's work on planetary motion and state the three laws and their mathematical relationship.

31. Solve selected problems on planetary motion.

IV. Work and Energy

Objective #4: The student will demonstrate application of Newton's laws of motion by developing a concept of work in terms of these laws and he will use this concept to be evaluated by teacher observation and/or tests are directed toward this objective.

Activities:

32. Define work in physical terms identifying the units of work, and conceptualize the difference between physical and mental work.

33. Read Sines and Cosines on the S-scale of the slide rule.

34. Demonstrate the Law of Sines on the slide rule and solve related problems.

35. Explain how forces are resolved into components and show how slide rule solutions can be made.

36. Perform a laboratory exercise using a force table that allows for the collection of data. Interpret this data and determine that the system is in equilibrium.

37. Differentiate between work and power. Derive a formula and units for power. Solve a series of related problems that are concerned with power.

38. Discuss the variations of power such as thrust and watts. Solve problems involving electrical and aeronautical units.

39. Define and discuss the physical meaning of energy.

40. Predict the Law of Conservation of energy and relate this prediction to practical applications.

41. Describe in words, and demonstrate in the lab the conversion of potential energy. Based upon this data, predict the mathematical relationshp between potential and kinetic energy.

42. Solve a series of problems that will demonstrate his ability to setup and identify some facets in energy relationships.

V. Parallel and Concurrent Forces in Equlibrium

Objective #5: The student will demonstrate comprehension of the nature of concurrent and parallel forces and the conditions necessary to achieve mechanical equilibrium by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

43. Prepare force diagrams and identify the types of forces involved.

44. Define concurrent forces and show how a system acquires equilibrium.

45. Solve a series of problems involved with the Resolution of Concurrent Forces.

46. Calculate the thrust and tension in a crane problem that is setup in a laboratory.

47. Conceptualize and describe the nature of the forces acting on an airplane.

VI. Force and Machines

Objective #6: The student will demonstrate comprehension of the concept of frictional force and the uses of machines by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

48. Conceptualize about and derive the formula for coefficient of friction.

49. Solve a series of problems on simple machines, horsepower, and efficiency.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE FUNDAMENTAL CONCEPTS INVOLVED IN FLUID DYNAMICS, THE KINETIC MOLECULAR THEORY, AND THERMODYMANICS. IN ADDITION, HE WILL BEGIN TO DEVELOP A CONCEPT OF WAVE MOTION IN TERMS OF SOUND BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. The Physical Properties and Dynamics of Fluids

Objective #1: The student will demonstrate comprehension of the physical and dynamics of fluids by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

1. Define and discuss specific gravity, mass density, weight density, pressure, and bouyancy.

2. Describe the historical development of Boyles Law, Charles Law, General Gas Law, and the Principles of Archimedes and Pascal.

3. Theorize and explain the hydrostatic paradox.

4. Explain the concept of air and mercurial barometers.

5. Explain, discuss, and demonstrate Bernoulli's principle.

II. Atoms and Molecules in Motion

Objective #2: The student will demonstrate comprehension of the structure and properties of matter in terms of the kinetic molecular theory by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

6. Define and conceptualize about states of matter, properties of solids, and subatomic structures.

7. Perform a lab drill and interpret data so that Hooke's Law is formulated.

8. Demonstrate cohesion, adhesion, and surface tension.

9. Theorize and discriminate between conduction, radiation, and convection.

III. Thermodynamics

Objective #3: The student will demonstrate application of the fundamental laws of thermodynamics by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

10. Perform a lab drill that will allow for the measure of coefficient of expansion.

11. Differentiate between and explain the differences between heat and temperature.

12. Describe the historical development of temperature and cite two accepted sets of values.

13. Perform a lab drill and derive a natural temperature scale and graph same to absolute zero.

14. Describe and conceptualize about the seven facets of the Molecular Theory of Heat.

15. Solve problems on temperature convesiors, coefficient of expansion, and thermometry.

16. Describe Joule's experiment on the mechanical equivalent of heat.

17. Prove the Law of Conservation heat energy by a lab analysis.

18. Perform a lab exercise and gather data that will allow for the determination of specific heat of three different metals.

19. Perform a lab exercise and gather data that will allow for the determination of the Linear Coefficient of expansion of one specific metal.

20. Perform a lab exercise and gather data that will allow for the determination of the heat of vaporization of water.

21. Perform a lab exercise and gather data that will allow for the determination of the heat of fusion in water.

22. Predict the effect of various concentrations of minerals (salt) on the accepted values of heat of vaporization and on heat of fusion.

23. Solve a series of problems on heat transfer, heat of fusion, and heat of vaporization.

24. Develop and explain a model on the Kinetic-Molecular Theory of Heat by deriving formulas that are Newtonian in nature.

25. Define and describe the use of BTu, calorie, joule, and ft, lb as they relate to work and heat.

26. Develop a hypothesis on the effect of pressure on boiling point and freezing point.

IV. The Nature of Waves

Objective #4: The student will demonstrate comprehension of the nature and properties of waves through mathematical analysis of harmonic motion by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

27. Demonstrate and define harmonic motion and derive a formula that will show all the components.

28. Use a wheel to formulate a mathematical analysis of simple harmonic motion and graph the results.

29. Describe, diagram, and label two distinct kinds of waves.

30. Cite examples of the Doppler effect and show why it occurs from a mathematical standpoint.

31. Describe and explain diffraction, constructive interference, destructive interference, phase, and resonance. Cite an example of each which is taken from everyday applications.

V. The Nature of Sound

Objective #5: The student will demonstrate comprehension of the nature and characteristics of sound and he will display application of basic concepts of acoustics by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

32. Demonstrate sound propagation and show how speed, frequency, and wavelength of sound can be determined.

33. Describe how vibrating molecules transmit sound and discuss the formulation of waves.

34. Perform a experiment that will demonstrate sympathetic vibration and superposition. Gather data which can be graphed into a transverse wave.

35. Predict the speed of sound in various media as the densities increase and explain the concept involved.

36. Discuss the meaning of mach numbers as sound is related to aeronautics and rocketry.

37. Solve problems that will show the conversion of sound energy to electrical energy with appropriate units.

38. Demonstrate and explain Doppler effects of sound by defining frequency, pitch, and wavelength.

39. Descriminate between amplitude, quality, harmonic, fundamental, beat, resonance, and noise.

LEVEL OBJECTIVE:

THE STUDENT WILL DISPLAY COMPREHENSION OF THE NATURE OF LIGHT BY A CONSIDERATION OF BOTH THE WAVE AND PARTICLE THEORIES. IN ADDITION HE WILL DISPLAY APPLICATION OF THE BASIC CONCEPTS OF GEOMETRICAL OPTICS, PHOTOMETRY, AND SPECTROSCOPY BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITITES.

I. The Nature of Light

Objective #1: The student will demonstrate comprehension of the wave theory of light by performing the following suggested activities to be evaluated by teacher observation and/or tests.

Activities:

1. Describe Galileo's attempts to measure the velocity of light.
2. Describe Michelson's work in determining the velocity of light and the establishment of a universal standard.
3. Explain the concept of interference and diffraction by using two different theories.
4. Describe the historical development of Newton's Corpuscular Theory and compare it to one of the modern theories.
5. Define the parts of a shadow by describing rectilinear propagation of light.
6. Demonstrate and explain the polarization of light by using the Transverse Wave Theory.
7. Explain the following light concepts: Newton's Rings, Color, Interference Patterns, Diffraction Gratings, Monochromatic Colors, and 1st and 2nd order images.
8. Diagram and discuss the variations in the electro-magnetic spectrum.

II. Geometrical Optics

Objective #2: The student will demonstrate application of the fundamental principles of geometrical optics and photometry by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

9. Perform a laboratory exercise that will demonstrate and explain refraction, reflection, incidence, and reverse images.

10. Conceptualize the reasons for differences between real and virtual images.

11. Prepare ray diagrams to show light reflection from various curved surfaces that are both concave and convex in nature.

12. Prepare a series of ray diagrams to show several variations of images formed by spherical mirrors.

13. Perform a series of demonstrations that will show magnification, image sizes, and distance relationships.

14. Prepare a brief demonstration to show the concepts of light intensity, the accepted units, and the law of illumination,

15. Derive a unique formula that will allow for the prediction of intensity in terms of distances.

16. Peform a lab. exercise that will allow data to be developed into Snell's Law.

17. Predict the relationship between light velocities and indices of Refraction of various substances.

18. Describe an experiment that will demonstrate total internal refection, Critical Angle, and total absorption.

19. Demonstrate by diagrams the reflection of light from Convex and Concave Surfaces.

20. Measure and compare the variations in light intensity by using a photometer.

21. Calculate the efficiency of various light sources by using a standard formula.

22. Define and demonstrate the phenomenon of light refraction.

23. Demonstrate image formation by using double-concex lenses.

24. Draw ray diagrams of concave and convex lenses.

25. Derive the lens formula by performing a lab. exercise designed for that purpose.

26. Describe the workings of (A) the human eye (B) a camera and (C) a pair of binoculars.

27. Define and demonstrate the principles of magnification.

III. Color

Objective #3: The student will demonstrate comprehension of the nature of color by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

28. Perform and explain Newton's "experimentum crucis."

29. Explain how prisms cause dispersion of light.

30. Demonstrate the conditions of chromatic aberration.

31. Demonstrate and explain the use of a spectrometer.

32. Explain the bright-line spectra.

33. Show some practical applications of fraunhefer lines and trace the Historical development.

IV. Light: Wave or Particle?

Objective #4: The student will demonstrate comprehension of quantum theory in terms of its histroical development and application (quantum mechanics) by performing the following activities to be evaluated by teacher observation and/or tests.

Activities:

34. Represent energy curves by graphs of various colors.

35. Explain the tenets of Planck's quantum theory.

36. Derive Planck's constant by inductive reasoning.

37. Describe the work of Hertz and Maxwell in predicting electron ellission.

38. Describe Einstein's application of the quantum theory to the Photoelectric effect.

39. Determine by formula derivation the kinetic energy of an electron.

40. Relate the quantum theory to Bohr's hydrogen spectrum.

41. Explain light in terms of the photon concept.

42. Calculate the energy of a photon by mathematical derivation.

43. Calculate the mass of a photon by knowing its energy.

44. Differientiate between the wave theory and the particle theory.

45. Explain the development and function of the Heiseubers Uncertainty Principle.

46. Explain the nature and significance of DeBroglie Waves.

LEVEL OBJECTIVE:

THE STUDENT WILL DEMONSTRATE COMPREHENSION OF THE FUNDAMENTAL CONCEPTS OF MAGNETISM AND ELECTRICITY AND WILL DISPLAY APPLICATION OF THESE CONCEPTS TO ELECTRONICS BY COMPLETING THE FOLLOWING SUGGESTED ACTIVITIES.

I. Magnetism and Electricity

Objective #1: The student will demonstrate comprehension of the nature of magnetic phenomena and its relationship to electricity by performing the following suggested activities to be evaluated by teacher observations and/or tests.

Activities:

1. Explain magnetic behavior in metals.
2. Demonstrate the magnetic flux by performing a lab. exercise.
3. Explain the concept of Magnetic Domain.
4. Demonstrate and measure magnetic fields around an electric current.

II. Fundamentals of Current Electricity

Objective #2: The student will demonstrate comprehension of the fundamental principles of current electricity by performing the following suggested activities to be evaluated by teacher observations and/or tests.

Activities:

5. Calculate the velocity of electrons through an electric circuit in the lab.
6. Derive definitions for (A) Ampere (B) Coulombs and primary unit of charge.
7. Calculate electric field intensity by analysis of lab. data.
8. Calculate and explain the mass-to-charge ratio of an electron.
9. Differentiate between DC and AC electricity.
10. Derive a formula for determining the effective value of Alternating Current.
11. Demonstrate the meaning of phase angle on an excilloscope.

12. Demonstrate and explain Capacitive Reactance.

13. Explain Lenz's Law as applied to a loop of wire.

14. Demonstrate that an induced EMF is proportional to the rate of charge of Flux.

15. Prove that self-inductance is measurable in henries.

16. Derive a formula for inductive reactance.

17. Explain and demonstrate the meaning of a resonant circuit.

III. Electronics

Objective #3: The student will demonstrate comprehension of the fundamentals of electronics by performing the following suggested activities to be evaluated by teacher observations and/or tests.

Activities:

18. Diagram and explain the circuitry of a fluorescent lamp.

19. Explain the Concept of Thermonic Emissions.

20. Diagram and explain the Cathode-Ray tube.

21. Diagram and explain the electron gun.

22. Design a photon gun.

23. Demonstrate electron ejection by performing a Heb. experiment.

24. Calculate and graph the threshold frequencies of various Resistant Characteristics.

25. Describe and explain the oil drop experiment of Milliken. Review his data and verify same by analysis.