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ABSTRACT

This unit of instruction presents some important and interesting processes carried on daily in industry and which result in products with which the student is familiar. The student will be responsible for learning some reactions involving these chemical processes and the quantitative calculations of these reactions. Fractional distillation, metallurgy, plastics, and the chemistry involved in food processing are a few areas that are studied. It is a course set primarily for the student who is not college-bound. The booklet lists the relevant state-adopted texts and states the performance objectives for the course. It provides a course outline and suggests experiments, films available from the Dade County Audiovisual Center, sample problems, and discussion questions. Sources of free materials are listed as well as reference books and project work. A master sheet is provided relating each suggested activity to the specific performance objectives. (EB)

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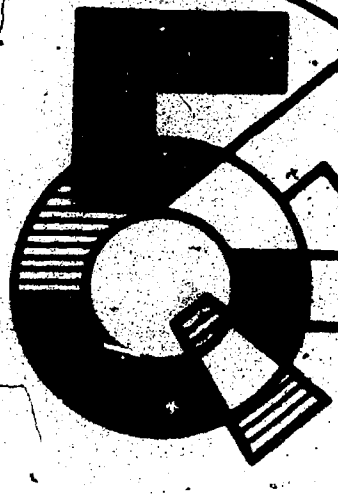
AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM



INDUSTRIAL CHEMISTRY

5316.07

SCIENCE

(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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Written by Robert Scholz
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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TABLE OF CONTENTS

INDUSTRIAL CHEMISTRY

COURSE DESCRIPTION

In this course the student will study some important and interesting processes carried on daily in industry; concentrating on the processes which result in products with which the student is familiar. The student will be responsible for learning some reactions involving these chemical processes and the quantitative calculations of these reactions. Laboratory investigations performed by the student and many teacher-demonstrations should be essential parts of this course. The teacher will have to be resourceful in developing laboratory exercises, but many can be done safely and with equipment available in most schools. Emphasis on mathematics should be kept minimal.

ENROLLMENT GUIDELINES

While this course is primarily for the student who is not college-bound; it certainly should be of interest to a large number of students. It should serve the very important function of vocational familiarization. Students should have successfully completed the courses "Introduction to Chemistry" and "Reactions of Atoms and Molecules". A good knowledge of "reaction types" will be of great help to the student.

STATE ADOPTED TEXTS

1. O'Connor, Paul; Davis, Joseph, Jr.; Haenisch, Edward; MacNab, W. Keith; McClellan, A. L. Chemistry: Experiments and Principles. Atlanta: Raytheon Education Company, 1968.

2. Choppin, Gregory; Jaffe, Bernard; Ferguson, Harold; Schmuckler, Joseph; and Siegelman, Irwin. Chemistry: Science of Matter, Energy and Change. Morristown, New Jersey: Silver Burdett Company, 1965.

3. Greenstone, Arthur; Sutman, Frank; Hollingworth, Leland. Concepts In Chemistry. New York: Harcourt, Brace and World, Inc., 1966.

STATE ADOPTED TEXTS (Continued)

4. Metcalfe, H. Clark; Williams, John; Castka, Joseph. Modern Chemistry. New York: Holt, Rinehart and Winston, Inc., 1966.

5. Brown, Theodore. General Chemistry. Columbus, Ohio: Charles E. Merrill Publishing Company, 1968.

PERFORMANCE OBJECTIVES

1. Given a list of metals, the student will describe the refining process for extracting each from its ore.

2. Given a list of metals, the student will write the practical uses of each.

3. Given a list of alloys, the student will list the metallic content and the economic use of each.

4. The student will describe the fractional distillation process.

5. The student will list the substances, in order of boiling temperatures, obtained from petroleum.

6. The student will explain the processes of cracking, polymerization, hydroforming and alkylation.

7. The student will define the term "octane rating".

8. The student will identify the uses of petroleum products.

9. The student will write the processing methods and economic uses for natural and synthetic rubber.

10. The student will list the compounds derived from coal tar.

11. The student will list the commercial products made from coal tar derivatives.

12. After studying the types of bleaches used in foods and fabric processing, the student will perform laboratory experiments in which wheat flour and cotton cloth are bleached.

13. The student will make aniline (eosin or malachite green) in the laboratory.

PERFORMANCE OBJECTIVES (Continued)

14. The student will dye and fix a piece of cotton cloth and a piece of wool cloth with his dye from #13 above.

15. The student will construct an electrochemical cell.

16. Given a list of foods, the student will identify the ways in which each food is processed to prevent decomposition and decoloration.

17. The student will describe the industrial processes of extrusion, and of stamping the thermoplastic and the thermosetting plastics.

18. The student will diagram (using equations) the "contact process" of making sulfuric acid.

19. The student will diagram the "Haber Process" of making ammonia.

20. The student will list the commercial products which contain sulfuric acid or ammonia as an essential raw material.

COURSE OUTLINE (Order is not relatively important)

I. Petroleum

   A. Theoretical origin

   B. Fractional distillation

      1. Cracking
      2. Hydrogenation
      3. Polymerization

   C. Products

      1. Solvents
      2. Gasolines

         a. Length of carbon chains
         b. Octane rating

      3. Paraffins
      4. Lubricants
      5. Pitch (asphalt)

COURSE OUTLINE (Continued)

II. Metals (metallurgy)

A. Mining processes

B. Recovery of metals from their ores

C. Iron

1. Steel production

a. Open-hearth process
b. Electric furnace process
c. Basic oxygen process

2. Purity of iron
3. Three oxides of iron
4. Reactions of the ferrous ion
5. Reactions of the ferric ions
6. Tests for the ferrous and the ferric ions

D. Other alloys

1. Nickel
2. Zinc
3. Tin
4. Aluminum
5. Coins

III. Plastics

A. Chemical composition

B. Methods of fabrication

1. Extrusion (injection)
2. Stamping (compression)

C. Synthetic fibers

1. Chemical composition
2. Characteristics and uses of each kind

IV. Coal Tar

A. Its origin

B. Chemical derivatives

COURSE OUTLINE (Continued)

C. Laboratory and commercial products in daily use

1. Drugs
2. Dyes
3. Cosmetics

V. Food Processing

A. Canning (sterilization)

B. Dry packaging (dehydration)

C. Freezing

D. Color additives and removers (bleaches)

E. Adulteration

VI. Chemistry of Refrigeration

VII. Rubber

A. Natural

1. Origin
2. Vulcanization

B. Synthetic

1. Chemical composition
2. Products and uses

VIII. Power In Chemistry

A. The electrochemical cell

B. Combustion (fuels)

IX. Sulfuric Acid and Ammonia

A. Sulfuric acid

1. Commercial preparation (contact process)
2. Industrial importance

B. Ammonia

1. Commercial preparation (Haber process)
2. Industrial importance

EXPERIMENTS

Anderson and Bachmann. Laboratory Manual of Organic Chemistry. 4th ed. Ann Arbor, Michigan: Edward Brothers Inc., 1953.

1. Fractional Distillation (p. 4a)
2. Cellulose Acetate (p. 26a)
3. Dyeing (p. 604)
4. Aniline (p. 33a)

Bagby, Henry. Modern Road to Chemistry. New York: College Entrance Book Company, 1965.

5. Some Properties of Dry Ice (p. 303)
6. Some Compounds of the Alkali Metals (p. 247)
7. Some Important Calcium Compounds (p. 253)
8. Hard Water (p. 255)
9. Identification of Ferrous and Ferric Ions (p. 269)
10. Copper and Its Compounds (p. 273)
11. The Protective Metals (p. 281)
12. Lead, Tin and Some of Their Compounds (p. 283)
13. Aluminum (p. 289)

Baisch and Gladieux. Directed Activities in Chemistry. New York: Oxford Book Company, 1956.

14. Destructive Distillation (p. 147)
15. Soap Making (p. 177)
16. Ore Concentration and Special Properties (p. 191)
17. Metallurgy (p. 193)
18. Qualitative Analysis of Metals (p. 97)

Bassow, Herbert. Observation and Intrepretation in Chemistry. New York: College Entrance Book Company, 1971.

19. Preparing a Condensation Polymer (p. 357)

Chemical Education Materials Study. An Experimental Science, Laboratory Manual. San Francisco: Freeman and Company, 1963.

20. Some Investigations Into the Corrosion of Iron (p. 95)
21. The Preparation of Some Polymers (p. 32)

EXPERIMENTS (Continued)

Brownlee, Fuller, Hancock, Sohon, Whitsit. Laboratory Experiments in Chemistry. Boston: Allyn and Bacon, 1945.

22. Flame Text (p. 43)
23. Ammonia (p. 104)
24. Fusible Alloys (p. 126)
25. Destructive Distillation (p. 143)
26. Colloids (P. 151)
27. Metals By Reduction (p. 172)
28. Hardening and Tempering of Steel (p. 176)
29. Physical Properties of Metals (p. 177)
30. Chemical Properties of Metals (p. 179)
31. Qualitative Separation of Lead, Silver and Mercury (p. 213)

Ferguson, Harold; Schmuchler, Joseph S. and Siegelman, Irvin. Investigating Matter, Energy and Change. Morristown, New Jersey: Silver Burdett Company, 1966.

32. Some Chemistry of Copper (p. 202)
33. Giant Molecules (Making rayon and orlon) (p. 205)
34. Giant Molecules II (Making glyptal resins and synthetic rubber) (p. 206)

Greenstone, Arthur; Sutman, Frank X.; Hollingworth, Leland. Concepts in Chemistry. New York: Harcourt, Brace and World, Inc., 1966.

35. Oxidation-Reduction in Iron Compounds (p. 516)
36. Testing for Positive Ions (p. 540)
37. Preparation and Testing of Acetylene (p. 619)

Students can fractionally distill various brands of gasolines to determine the relative range of volatile (flash point) substances contained. Students find this very interesting and this activity can be reasonably safe. Students bring in 100 to 200 ml samples of various grades and brands of gasolines. Set-up the conventional distilling apparatus being sure to heat the distilling flask in a sand bath. Keep the flame of burner low. Preferably, a filtering flask is used as a collecting vessel with a piece of rubber tubing connected to the side-arm and extending to the floor. This virtually eliminates any danger of fire. Use some even amount of gasoline (100 or 200 ml) of gasoline in the distilling flask which has a one-hole stopper with thermometer. Students are to collect distillant in ten degree centigrade units; recording data and plotting graph. Tars and gums will remain in the distilling flask so student will be able to determine per cent of combustible material. Lab is preceded with an explanation of flash-point and its relationship to economy, efficiency and pollution.

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER

1. Better Tomorrow, A.
   1-30340, 30', B/W

2. Chemical Changes All About Us
   1-10914, 14', B.W

3. Chemistry of Aluminum
   1-10942, 14', C

4. Chemistry and A Changing World
   1-04055, 11', B/W

5. Copper Mining
   1-11598, 14', C

6. Copper: Mining and Smelting
   1-04074, 11', C

7. Drilling For Oil
   1-11412, 22', C

8. Gift of Green, The
   1-11090, 20', C

9. Glass
   1-11591, 20', B/W

10. Iron Ore Mining
    1-11594, 15', C

11. Meet Monsanto
    1-40026, 35', C

12. Miracle Materials
    1-11614, 23', B/W

13. Oil: The Invisible Traveler
    1-13225, 19', C

14. Silicon and Its Compounds
    1-10948, 14', B/W

15. Silver and Gold Mining
    1-11415, 17', C

16. Steel
    1-04071, 11', B/W

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER (Continued)

17. Sulfur and Its Compounds
I-10937, 14', C

18. Sulfuric Acid
I-10944, 16', C

19. Synthetic Fibers
I-11615, 14', B/W

20. What Comes Out Of a Blast Furnace
I-04073, 8', B/W

21. What Goes Into a Blast Furnace
I-11597, 15', B/W

22. Yesterday, Today and Tomorrow
I-31185, 30', B/W

An excellent source for films in this area is:

Modern Talking Picture Service, Inc.
714 Spring Street, N.W.
Atlanta, Georgia 30308

SAMPLE PROBLEMS

While the arithmetic requirements of the course should be kept to a minimum, the content would be of little value to the student if he were unable to quantitatively determine the amounts of various substances required to produce a given quantity of commercial product. Obviously, the chemical reaction involved should be an intregal part of the problem.

1. Iron (Fe) burns in air to form a black, solid oxide (Fe_3O_4).

   a. Write the equation for the reaction.

   b. How many moles of oxygen gas are needed to burn one mole of iron?

   c. How many grams of oxygen is that?

   d. Can a piece of iron weighing 5.6 grams burn completely to Fe_3O_4 in a vessel containing 0.05 mole of O_2?

SAMPLE PROBLEMS (Continued)

2. Suppose that one gallon of gasoline is about 25 moles of octane (C_8H_{18}).

   a. How many moles of oxygen must be used to burn this gasoline assuming the only products are CO_2 and H_2O?

   b. How many moles of carbon dioxide are formed?

   c. How much does the carbon dioxide weigh in kg?

   d. How many pounds of carbon dioxide are released into the atmosphere when your automobile consumes 10 gallons of gasoline? (the density of gasoline = 0.85 g/ml.; one liter = 1.058 qt.; one kilogram = 2.2 pounds)

3. A reaction involved in the production of iron from iron ore is:

   $$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2 + 4.3 \text{ kcal of heat}$$

   a. How many grams of CO must react to release 13 kcal?

   b. How many liters of CO(STP) are needed to produce 1.0 Kg of Fe?

4. How many pounds of iron could be extracted from one ton of magnetite iron ore with the formula Fe_3O_4?

5. What volume of air would be necessary to completely burn 114 grams of octane?

6. A sample of hematite ore contains Fe_2O_3, 87%; silica, 8%; moisture, 4%; other impurities, 1%. What is the percentage of iron in the ore?

7. A sample of cinnabar ore contains 75% mercuric sulfide and 25% silica. How much mercury will it yield per ton of ore?

8. To make benzene soluble cement, melt 59 g. of rosin in an iron pan and add 28 g. each of shellac and beeswax. How many pounds of each component should be taken to make 75 lbs. of cement?

9. A furnace contains 10 tons of steel containing 5% manganese. What weight of steel, 50% manganese, should be added so that the final mixture will contain 14 percent manganese?

SAMPLE PROBLEMS (Continued)

10. What weight of copper is needed to make 200 twelve carat gold class rings, weighing 5 grams each?

There is no limit to the problems one can find similar to those above. The older textbooks in chemistry provide a large variety of these problems. One must remember that industrial technology has been virtually left out of all texts since 1960. Physical Science texts often provide problems and project ideas.

DEMONSTRATIONS

Greenstone, Arthur; Sutman, Frank; and Hollingworth, Leland. Concepts in Chemistry. New York: Harcourt, Brace and World, 1966.

1. Rusting of Iron (p. 512)
2. Electrolysis in Corrosion (p. 513)
3. Tempering of Steel (p. 511)
4. Iron Compounds and Blue Prints (p. 518)
5. Destructive Distillation of Soft Coal (p. 615)
6. Properties of Rubber (p. 632

Chapters 30, 31, 32, 36, 37, and 38 are excellent sources for ideas regarding student project work.

Brownlee, Raymond; Fuller, Robert; Hancock, William; Sohon, Michael; Whitsit, Jesse. Laboratory Experiments in Chemistry. Boston: Allyn and Bacon, 1945.

7. Flame Text (p. 43)
8. Ammonia (p. 104)
9. Fusible Alloy (p. 126)
10. Destructive Distillation (p. 143)
11. Colloids (p. 151)
12. Metals by Reduction (p. 172)
13. Hardening and Tempering of Steel (p. 176)
14. Physical Properties of Metals (p. 177)
15. Chemical Properties of Metals (p. 179)
16. Qualitative Separation of Lead, Silver and Mercury (p. 213)

This is just a sampling of teacher-performed demonstrations from just two sources. The number and variety of demonstrations is only limited by the resourcefulness, material acquisition ability and time of the instructor.

SOURCES OF FREE MATERIALS

1. The International Nickel Company, Inc.
   67 Wall Street
   New York, New York 10005

   (Monthly paper, posters, and films)

2. Pan American Petroleum Corporation
   Ocala, Florida

   (Posters, career pamphlets, films and geological samples)

3. American Oil Company
   171 Lenore Street, N. W.
   Chicago, Illinois

   (Posters, project booklet, films - you pay postage)

4. Aluminum Corporation of America
   510 Fifth Avenue
   New York, New York

   (Quarterly magazine; production and careers pamphlets;
   "new products" bulletin; film rental - inexpensive)

5. Bethlehem Steel Corporation
   Potstown, Pennsylvania

   (Films, career booklets, products usage paper - monthly)

This is just a beginning on the list that could be developed for acquisition of free materials.

FIELD TRIPS

Miami-Dade County area does not have "manufacturing industry" in the true sense of the term. Field trips, which should be an integral part of this course, will therefore be few. The following are just a few which the author has investigated.

1. Plastic Graphix Corporation
   2520 S. W. 28th Lane

   (Fabricators - both by stamping (150 tons) and injection. Will conduct tours of small groups.)

2. Airco Plating Company, Inc.
   3636 N. W. 46th Street

   (Capable of plating a wide variety of metals - may have to wait some time to get good selection of plating methods.)

3. Eastern Air Lines

   (Will conduct seminars for small groups in aeronautical alloys at over-haul center.)

4. Cape Kennedy

   (Will conduct seminars for small groups in alloys related to space travel.)

DISCUSSION QUESTIONS

1. What causes some oil wells to be "gushers"?
2. A sample of gasoline has an octane rating of 82. Describe in detail just what that means.
3. What is lead tetraethyl and for what is it used?
4. What is the chemist's definition of the term "plastic"?

DISCUSSION QUESTIONS (Continued)

5. What is the difference between thermoplastic and thermosetting plastics? Give examples of each and uses of each.

6. List the raw materials of each of the following plastics:

   a. urea-formaldehyde
   b. phenolic plastics
   c. polystyrene
   d. methacrylate resins
   e. vinylite plastics.

7. Explain how the polymer structure of rubber accounts for the elasticity of rubber.

8. Mention a use for which each of the following is particularly suitable:

   a. permalloy
   b. Invar
   c. silicon steel
   d. stainless steel
   e. manganese steel
   f. chrome-nickel steel
   g. tungsten steel.

9. What chemical change occurs when blueprint paper is exposed to the light? What is the chemical name for the blue compound that is formed on the blueprint paper?

10. What is an amalgam?

11. Suppose you had a powdered mixture that contained 90% gold and 10% silver. How could you obtain pure gold from such a mixture?

12. In the contact process for making sulfuric acid, what comes in contact with what?

13. List the most effective way to remove the metal from its ore for each of the following metals:

   a. zinc
   b. copper
   c. iron
   d. aluminum
   e. gold.

DISCUSSION QUESTIONS (Continued)

14. List the "starting reactants" for many organic reactions obtained from coal tar.

15. List the color remover and/or the color preservative for each of the following foods:

    a. wheat flour
    b. peaches (canned)
    c. hot dogs
    d. pickles.

16. Define the following as they pertain to the electrochemical cell:

    a. electrolyte
    b. anode
    c. cathode
    d. electromotive potential
    e. zinc casing of the dry cell.

PROJECT WORK

1. Obtain a blowout repair kit from an automobile supply store. The sheet rubber in the repair kit is unvulcanized stock. Note how sticky it is. Get an old inner tube and apply a patch, following the directions that come with the repair kit. Note how vulcanization of the sheet rubber is accomplished. Is the patch still sticky?

2. Test the difference between thermoplastic and thermosetting plastics under the influence of heat. An old pair of eyeglass frames will serve as a thermoplastic substance. Bakelite objects that are no longer useful may be used since Bakelite is a thermosetting plastic. Immerse each in hot water in a beaker and observe which ones can be changed in shape by gentle heat. Place both objects in a pan containing clean beach sand. Heat vigorously and notice the change in each object.

3. Procure a sample of cloth that is about half wool and half cotton. Gently boil a two-inch square of the cloth for 5 minutes in 5% solution of sodium hydroxide. The wool will dissolve completely, leaving the cotton. Examine the rinsed dried residue of cotton.

PROJECT WORK (Continued)

4. Make a solution of chlorine in water. Clean a piece of unbleached cotton cloth by boiling it in washing soda for a few minutes. Rinse the cloth thoroughly and then immerse half of it in the chlorine water. Keep the other half for comparison. After a few hours, examine the cloth and see if it has been bleached. Keep the cloth immersed in the chlorine water for several days. Then remove it, and test its strength. It should tear easily, showing that too concentrated bleaching solutions, or too prolonged bleaching rots cotton cloth.

5. Procure some strips of aluminum metal that have been cut from an old aluminum pan. With tongs, hold a strip of the aluminum metal in a Bunsen flame and note that it melts rather easily. Does this show you why one must be careful to never allow an aluminum pan to boil dry on a stove? Add a strip of aluminum to a beaker that is half filled with hot sodium hydroxide solution. Note the reaction which occurs. Wash the piece of aluminum in water and then dip it into a beaker half filled with acetic acid (vinegar) and note the reaction in terms of color change. These tests show why caustic and acidic cleaning powders should not be used to clean aluminum pans.

6. Galvanize a piece of clean sheet iron. First melt some zinc in an evaporating dish or larger ceramic container if available. Dip the sheet iron that is to be galvanized in dilute hydrochloric acid to remove any coating of oxide. Then dip the sheet iron in the melted zinc. Allow the zinc to harden and cool. Try scratching the zinc coating. What could you have done to make the zinc adhere to the iron better?

7. Prepare insoluble pigments called lakes. Add 50 ml. of 2% alizarine solution to an equal volume of saturated solution of aluminum sulfate. Then add the same amount of 10% ammonium hydroxide solution. The precipitate which forms is colored and is known as a lake. Filter off the precipitate and dry it in a warm oven. Grind the residue that results to a fine powder in a mortar. Cochineal solution may be used instead of alizarine. Salts of chromium and tin yield different colored lakes from those produced by aluminum salts.

8. Prepare some iron tannate ink. To a solution of freshly reduced ferrous sulfate, add a solution of tannic acid. If the ferrous salt is not contaminated by ferric salt, the ferrous tannate that results will be nearly colorless. Separate the ferrous tannate solution into three parts. Use one portion to write a message

PROJECT WORK (Continued)

on paper. Note that the result is nearly colorless writing. Add a few drops of a blue dye solution to the second portion and write with this liquid. Note that the solution "writes blue". To the third solution add a few drops of hydrogen peroxide solution to serve as an oxidizing agent. Note that the ferrous tannate is immediately changed to ferric tannate, a black, insoluble substance. The writing with ferrous tannate solution will gradually turn black as the ferrous compound is oxidized by the air. The blue writing of the second portion will change to black, also, as the ferrous tannate oxidizes.

9. Make a "silver tree" from sheet zinc and silver nitrate solution. Cut a piece of sheet zinc into a more or less triangular shape like an evergreen tree. Cut horizontal slits in the zinc towards the center and bend the zinc so as to give it a three-dimensional effect. Immerse the zinc in a solution of silver nitrate solution (about 1%). Note how the replaced silver hangs from the cut edges of the zinc. Handle with care and you will be able to remove the "tree" from the solution with most of the silver still on it. (Do not get any of the silver nitrate solution on your clothing or skin).

10. Try to dye some wool and cotton with dyes you have extracted from various plant sources. Beets, red cabbage, and blueberries are good for this purpose. Experiment with various barks and leaves also. Croton leaves make interesting dyes.

REFERENCES

1. Ahrens, Bush and Easley. Living Chemistry. Boston: Ginn and Company, 1946.

2. Brauer, Oscar. Chemistry and Its Wonders. New York: American Book Company, 1965.

3. Brooks, Tracy and Tropp. Modern Physical Science. New York: Holt Rinehart and Winston, 1962.

4. Brownlee, Fuller, Hancock, Sohon and Whitsit. Laboratory Experiments in Chemistry. Chicago: Allyn and Bacon, 1948.

5. Cotton and Lynch. Chemistry: An Investigative Approach. Boston: Houghton and Mifflin, 1968.

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6. Dull, Metcalfe and Williams. Modern Chemistry. New York: Henry Holt and Company, 1962.

7. Hopkins, Smith, Davis, McGill and Bradbury. Chemistry and You. Chicago: Lyons and Carnahan, 1957.

8. Jaffe, Bernard. New World of Chemistry. New York: Silver-Burdett Company, 1958.

9. Lemkin, William. Chemistry in Modern Practice. New York: Oxford Book Company, 1963.

10. Price and Bruce. Chemistry and Human Affairs. New York: World Book Company, 1965.

11. Weaver and Foster. Chemistry For Our Times. New York: McGraw Hill Company, Inc., 1957.

12. Williams, Embree and DeBey. Introduction to Chemistry. Reading, Mass.: Addison-Wesley Publishing Company, 1968.

13. Wilson, Sherman. Descriptive Chemistry and Physics. New York: Holt, Rinehart and Winston, 1968.

NOTE: Many of the above references are quite old. The writer feels that this does not dilute their value for this particular course of study. Most of the processes described in these references are still the methods used in industry.

Objectives	Texts	References	Labs	Field Trips	Problems	Demonstrations	Projects	Films
1	4. ch. 26 3. ch. 30 2. ch. 25 1. pp. 405-407	1,3,4,9,12	16,18,27		3,4,6,7,10	5		5,10,21,6,10,15
2	2. ch. 24 3. ch. 29-33 4. ch. 24-27	1,2,3,6,8,11	11,17,20,22,24,28		1,2	1,4,13	5	1,22,11,3
3	2. ch. 24 3. ch. 29-33 4. ch. 24-27	1,2,3,6,10,11,13	24,31,12,6,9,10	7,1,4		3,7,16,9	6	
4	4. p. 292 3. p. 621	3,6,7,8,11,13	1					13
5	3. p. 622	2,6,7,8,11,13						
6		2,3,6,7,8,9,10,13						7
7		1,3,6,7,8,9,10,11,13			2,5			
8		3,6,10,13			7			
9	4. p. 300 3. p. 633 5. p. 580	1,3,5,6,8,11	34			6,11,12	1	
10	1. p. 355 3. p. 615 4. p. 274	5,6,12	4					
11	1. p. 355 3. p. 617 4. p. 277	5,6,12						
12	3. pp. 375 & 403 4. pp. 504-517	4	2,3,26				4,12	3,7
13	2. p. 611 3. p. 588 4. p. 491	4,10,11	3,4,8,15				7,8	
14		2,4,11	14				3,4	19
15	4. p. 387 3. p. 299 2. p. 391 1. p. 289 5. ch. 16	3,5,9,12.13	27,30	2		2	9	
16		9,10,11						8
17	3. p. 639 2. p. 634	3,6,11,13	19,21	1			2	19
18	2. p. 587 3. p. 405 4. p. 504 5. p. 455	5,6,7,9,12						18
19	4. p. 486 3. p. 429 1. p. 237 2. p. 343	6,7,9,12,13	23					
20	2. pp. 571-588 3. pp. 409-432 4. pp. 487-506	1,6,9,11,12	5					18