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ABSTRACT

Performance objectives are stated for this secondary school instructional unit concerned with aspects of physical chemistry, involving the physical properties of matter, and laws and theories regarding chemical interaction. Lists of films and state-adopted and other texts are presented. Included are enrollment guidelines; an outline summarizing the unit content; a list of discussion questions; and numerous suggestions for experiments, demonstrations, field trips, and reading assignments. A master sheet showing the relationship of each suggested activity to the objectives of the unit is appended in this booklet. (CC)

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

PHYSICAL CHEMISTRY

5318.60

SCIENCE

(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION•1971

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Written by Charlotta B. Mary and Jerold Feuer

for the

DIVISION OF INSTRUCTION
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TABLE OF CONTENTS

PHYSICAL CHEMISTRY

COURSE DESCRIPTION

Physical chemistry is that branch of chemistry which deals with the study of the physical properties of matter, the structure of matter and the laws and theories regarding chemical interaction. Physical chemists seek to codify the data and formulate the basic principles of descriptive chemistry as usually taught in the introductory courses.

ENROLLMENT GUIDELINES

The student should have finished four quinmester courses of chemistry before electing physical chemistry. Progress in physical chemistry is tested largely by the student's ability to solve specific problems. It is recommended that he have a good grasp of the algebraic processes, and that he be able to relate the symbols of a mathematical expression to chemical realities.

STATE ADOPTED TEXT

1. Physical Sciences Study Committee, *Physics*, 2d ed. Boston: D. C. Heath and Co., 1965.

PERFORMANCE OBJECTIVES

The student will:

1. Given problems involving the pressure, volume and temperature of an ideal gas, show his comprehension of Charles' Law, Boyle's Law and the ideal gas equation by using the correct relationship to solve problems.

2. Plot a graph of pressure versus volume of an ideal gas.

3. Given the above graph, identify the various isotherms, isobars and isometric curves.

4. Synthesize from experimental data a cycle utilizing the pressure versus volume graph (Carnot cycle).

5. Distinguish between C_v (heat capacity at constant volume) and Cp (heat capacity at constant pressure).

6. Differentiate between enthalpy (ΔH), energy (ΔE), entropy (ΔS), and Gibbs' free energy (ΔG).

7. Specify how these state functions are related to C_p and C_v.

8. Discover the relationships between ΔE, ΔG, ΔH, ΔS, and the equations for chemical equilibriums.

9. Derive the rate law and the molecularity for a given equation.

10. Identify the variables in the Boltzmann expression, the Arrhenius equation and the absolute reaction rate.

PERFORMANCE OBJECTIVES (CONT'D)

11. Examine the deviations from solution ideality involved in Raoult's Law and Henry's Law.

12. Cite evidence for the failure of Newtonian Mechanics to explain atomic spectra, black body radiation, and the behavior of elementary particles.

13. Discuss critically the conclusions of De Broglie, Heisenberg, Planck and Schroedinger, relative to the quantum theory.

14. Describe an electron cloud conception of both covalent and ionic chemical bonds.

15. Propose reasons for dipole moments, bond strengths, bond angles, bond lengths in terms of electron cloud model and overlap.

16. Describe the bonding in F_2 and LiF in terms of simple molecular orbital theory.

COURSE OUTLINE

I. Gases

 A. Charles' Law

 B. Boyle's Law

 C. Ideal Gas Law

 D. pv = nRT (Pressure- Volume Relationships)

 E. Carnot Cycle

II. Thermodynamics

 A. Heat Capacity

COURSE OUTLINE (CONT'D)

1. C_v (Constant Volume)
2. C_p (Constant Pressure)

B. State Functions
1. Enthalpy
2. Energy
3. Entropy
4. Gibbs Free Energy

C. Chemical Equilibrium
1. Mass Action Law
2. Solubility Expressions

III. Kinetics

A. Rate Laws and Molecularity

B. Kinetic Theories
1. Boltzmann Expression
2. Arrhenius Equation
3. Absolute Rate Theory

IV. Solutions

A. Ideal Solutions
1. Raoult's Law
2. Henry's Law

B. Nonideal Solutions

V. Quantum Theory

A. History
1. Failure of Newtonian Mechanics to Explain Observed Phenomena.
2. De Broglie
3. Heisenberg
4. Planck
5. Schroedinger

B. Wave Mechanics

COURSE OUTLINE (CONT'D)

C. Orbital Overlap and Bonding
   1. Dipole Moments
   2. Bond Angles
   3. Bond Lengths
   4. Bond Strengths

D. Molecular Orbital Theory
   1. Linear Combination of Atomic Orbitals
   2. Resonance

EXPERIMENTS

Curriculum Bulletin, 8-D. Chemistry 2. Miami, Florida: Dade County Public Schools, 1966.
1. Boyle's Law (Ex. 18, p. 105)
2. Charles' Law (Ex. 19, p. 107)
3. Molecular Weight of a Gas (Ex. 20, p. 109)
4. Solubility (Ex. 21, p. 113)
5. Solubility Product Constants (Ex. 22, p. 116)
6. Reaction Principles (Ex. 27, p. 132)

Salzberg, Morrow, Cohen, Laboratory Course in Physical Chemistry. New York: Academic Press, 1966.
7. C_v/C_p Ratio of a Gas (Ex. 2, p. 179)
8. Standard Free Energy, Enthalpy, and Entropy of Reaction, (Ex. 20, p. 221)
9. Energies and Heats of Combustion and Formation (Ex. 13, p. 217)
10. Rate of the Acid-Catalyzed Inversion of Sucrose (Ex. 30, p. 250)
11. Effect of Ion Strength on Rate of Reaction (Ex. 31, p. 252)
12. Vapor Pressure Versus Temperature (Ex. 6, p. 188)
13. Bond Moments, Bond Angles and Dipole Moments (Ex. 37, p. 272)
14. Dipole Moment of a Polar Liquid (Ex. 36, p. 268)

DEMONSTRATIONS

Shoemaker and Garland. Experiments in Physical Chemistry. New York: McGraw Hill Book Co., 1962.

1. The teacher will build and demonstrate a gaseous thermometer (p. 38)
2. The teacher will demonstrate calorimetrically the measurements of heat and relate this general method to the measurements of C_p, C_v, H, etc. (p. 107)
3. Iodine Clock experiment (p. 214)
4. The teacher will demonstrate the measurement of the vapor pressure of a solution (p. 1?9)

Salzberg, Morrow and Cohen, Laboratory Course in Physical Chemistry. New York: Academic Press, 1966.

5. Constant-Volume Ideal Gas Thermometers (p. 43)
6. Kinetics of the Iodine-catalyzed Decomposition of H_2O_2. (Ex. 29, p. 246)

FIELD TRIPS

1. To the University of Miami to observe the calorimetry lab.

2. To Florida Atlantic University to observe the running of infra-red, ultra-violet and nuclear magnetic resonance spectra.

DADE COUNTY 16 mm FILMS

1. Demonstrating the Gas Laws
   AV#1-10740, 21 min. C

2. Gas Pressure and Molecular Collisions
   AV#1-10849, 21 min. BW

3. Thermodynamics
   AV#1-05588, 11 min., BW

4. Introduction to Reaction Kinetics
   AV#1-10959, 13 min., C

5. Equilibrium
   AV#1-10829, 22 min., C

6. Photoelectric Effect
   AV#1-30317, 28 min., C

7. Photons
   AV#1-10794, 25 min., BW

8. Atomic Radiation
   AV#1-01921, 11 min., BW

SUGGESTED DISCUSSION QUESTIONS

1. What observations do you think Boyle and Charles made that led them to formulate their gas laws?

2. Given that pressure times volume gives units of energy, how do you think that temperature is related to energy?

3. What types of things contribute to the values of C_v and C_p?

4. For many chemical reactions, the rate of reaction doubles for a 10^0 temperature rise. How would you explain this?

5. What would a solution's cohesive properties have to do with its observance of Raoult's Law or Henry's Law?

6. What do you think causes chemical bonds to hold together?

7. How do you feel that quantum theory fits into the evolutionary scheme of science?

8. Using the same type of arguments as given for the strength of chemical bonds, why do you think that different substances melt and boil at different temperatures?

9. DeBroglie was laughed at when he first proposed his hypothesis. Can you give examples of how the evolution of scientific discovery was marked by skeptics and closed-minded scientific communities?

REFERENCES

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3. Kittsley, Scott L. Physical Chemistry, 3d ed. New York: Barnes and Noble, Inc., 1969.

4. Lewis, Gilbert N. Chemistry. 7th ed. New York: Barnes and Nobles, Inc., 1962.

5. Mahan, Bruce. Elementary Chemical Thermodynamics. New York: W. A. Benjamin, Inc. 1964.

6. Nash, Leonard K. Elements of Chemical Thermodynamics, Reading, Mass: Addison-Wesley Publishing Co., Inc., 1962.

7. Physical Sciences Study Committee. Physics, 2d ed. Boston: D. C. Heath and Co., 1965.

8. Ryschkewitsch, George E. Chemical Bonding and the Geometry of Molecules. New York: Reinhold Publishing Corporation, 1963.

9. Salzberg, Hugh W. Morrow, Jack I. and Cohen, Stephen. Laboratory Course in Physical Chemistry. New York: Academic Press, 1966.

10. Shoemaker, David and Garland, Carl. Experiments in Physical Chemistry. New York: McGraw Hill Book Company, 1962.

MASTER SHEET - PHYSICAL CHEMISTRY

Objectives	Experiments	Required Student Readings	Other References	Speakers	Films	Field Trips	Demonstrations	Discussion Questions	Sample Problems
1	1, 2, 3	4 pp.49-52 7 Chap. 9	2 Chap. 1		1, 2		5	1	5 p.17
2	1, 2	5 Chap.1,2		1	1, 2			2	5 p.27
3		6 pp.23-25	2 Chap. 3						
4		6 p. 34							8 p.107
5	7	3 p. 45 2 Chap. 2	6 pp.17,53, 18,112 5 pp. 40-45						5 p. 60
6	8	7 Chap. 25 5 Chap. 2	3 p. 80 6 p. 75 2 Chap. 2	2	3		1	3	
7		5 Chap. 2	2 Chap. 2					3	5 p. 60
8	4, 5, 9	3 p. 41 3 Chap. 8 5 pp.7,72, 89	2 Chap.3,6 6 p. 75		5			3	8 pp.105-106
9	10, 11	3 Chap. 10	2 Chap. 10		4		2	4	5 pp.110-111
10	6	3 Chap. 10					6	4	
11	12	3 Chap. 7	6 pp.51,67, 73,66, 75	1				5	
12		7 Chap. 34	2 Chap. 12	2	6, 8			6	
13	7 Chap.33 3 pp.150-171				7			6, 9	
14		8 Chap. 2	3 pp.179-181	1		2		7	5 p.171
15	13, 14	2 p.498 4 pp.77-83 2 p.502	8 Chap. 2					8	5 p.191
16		3 pp.181-192	8 pp.68,100					8	5 p.192