

**CENTRAL TEXAS COLLEGE
SYLLABUS FOR FPRT 1333
FIRE SERVICES CHEMISTRY I**

Semester Hours Credit: 3

INSTRUCTOR:_____

OFFICE HOURS:_____

I. INTRODUCTION

A. This study of chemistry can make a worthwhile contribution to the education of any student. Chemistry is a legitimate part of a cultural education, since it is concerned with fundamental concepts about our environment and with the applications of these concepts in controlling our environment.

B. One must know something of science to read modern newspapers and magazines with full understanding. The extent to which chemistry has a bearing upon our daily lives has become so great that technical topics are items of ordinary conversation. Chemistry is constantly providing us with a supply of new things for better living, for a longer and healthier life, and for an increased leisure in which to enjoy life. Chemistry is also playing an important role in the exploration of space. Thus, it becomes evident that a knowledge of chemistry is a useful possession of any intelligent, well-informed member of society.

C. Fire, of any sort, is simply a violent chemical reaction. In order to control fires, it is necessary to control these reactions; this requires a knowledge of chemistry. A knowledge of chemistry is also necessary in order to understand the possible physiological dangers of smoke and burning chemicals.

D. Either this course or CHEM 1411 is a required course for an Associate in Applied Science degree in Fire Protection Technology.

II. LEARNING OUTCOMES

Upon successful completion of this course, Fire Service Chemistry I, the student will be able to:

- A. Explain the basic concepts of matter.
- B. Describe the basic principles of atomic structure.
- C. Discuss the formation of chemical bonds and the formation of compounds.
- D. Demonstrate the ability to write and read chemical formulas.
- E. Explain the laws governing gases, liquids, and solids.
- F. Discuss the kinetic theory of the chemical reaction.
- G. Describe the basic concepts of acids, bases, and salts.
- H. Discuss the processes of ionization and oxidation.
- I. Identify some of the common groups of chemicals.
- J. Discuss organic chemistry.
- K. Discuss nucleonics/nuclear chemistry.

III. INSTRUCTIONAL MATERIALS

A. The instructional materials identified for this course are viewable through www.ctcd.edu/books

B. Currently (10/15): Eugene Meyers, *Chemistry of Hazardous Materials w/MyFireKit*, 6th edition 2014, Brady Books (Pearson), 0133314688X/9780133146882

C. Other materials as assigned by the instructor.

IV. COURSE REQUIREMENTS

A. Your first responsibility is scholarship. The grade you receive for this course will not be the grade of the instructor, but the grade you and you alone earn.

B. This course is designed to require a steady, continuous effort from the student. A crash-cram policy will not result in the best grade possible. In addition to exams, factors such as class participation, initiative, attendance, and individual work will be considered in grade computation.

C. You are encouraged to give your best effort throughout the semester. From the beginning, you should plan for a steady, organized, and continuous effort, which in the long run will prove more effective for your final grade than a last minute crash-cram policy. Your course grade is not determined solely by exam grade. Such factors as class participation, initiative, attendance, and individual research papers or projects will be considered in grade computation.

D. From time to time, special library and other assignments may be made to members of the class, individually and in groups. You are expected to read all assignments and fulfill your responsibilities to any group assignments.

E. You are expected to read all assigned material and bring your textbook to class. Keep up to date and informed on assignments, especially after a period of absence.

F. Good class notes are indispensable for earning a good grade since both the material assigned and discussed will be the basis for examination material. Regular attendance is essential for the same reason.

G. Scholastic Honesty: All students are required and expected to maintain the highest standards of scholastic honesty in the preparation of all coursework and during examinations. The following are considered examples of scholastic dishonesty:

Plagiarism: The taking of passages from the writing of others without giving proper credit to the sources.

Collusion: Using another's work as one's own, or working together with another person in the preparation of work, unless such joint preparation is specifically approved in advance by the instructor.

Cheating: Giving or receiving information on examinations.

H. Special Work: Special assignments may be made during the semester, both for regular work or supplemental work.

V. EXAMINATIONS

A. There will be a minimum of three (3) major examinations as follows:

1. Three-week exam
2. Mid-term exam
3. Twelve-week exam (optional)
4. Final exam

B. Unannounced short quizzes may be given covering any material that has been assigned from the beginning of the course.

C. Occasionally a student will find it unavoidable to be absent from an exam. Only students with excused absences will be permitted to take make-up exams. Unexcused absences will result in a zero for the exam missed. The policy of the college is clearly stated in the catalog. A doctor's excuse is required in case of illness.

D. The exams may be structured to include subjective, objective, or a combination of both types of questions.

VI. SEMESTER GRADE COMPUTATION

<u>EXAM</u>	<u>POINTS</u>	<u>POINTS</u>	<u>GRADES</u>
Three Week Exam	150	900-1000	A=4pts/sem hr.
Mid-Term Exam	200	800-899	B=3pts/sem hr.
Twelve Week Exam(opt)	200	700-799	C=2pts/sem hr.
Final Exam	250	600-699	D=1pt/sem hr.
Homework/Quizzes	<u>200</u>	0-599	F=0pts/sem hr.
Total	1,000		

The Twelve Week Exam is optional: if it is not given, then those points will default to Homework/Quizzes and to Incentive points. Incentive points may be earned for factors such as attendance, initiative, participation in class discussions, and timely completion of assignments. Three points will be deducted for each unexcused absence. Military assignments or unavoidable circumstances will be evaluated upon notification to class instructor.

VIII. NOTES AND ADDITIONAL INSTRUCTIONS FROM COURSE INSTRUCTOR

- A. Withdrawal from course: It is the student's responsibility to officially drop a class if circumstances prevent attendance. Any student who desires to, or must, officially withdraw from a course after the first scheduled class meeting must file a Central Texas College application for Withdrawal (CTC Form 59). The withdrawal form must be signed by the student.

CTC Form 59 will be accepted at any time prior to Friday of the 12th. Week of classes during the 16 week fall and spring semesters. The deadline for sessions of other lengths is as follows:

10 week session	Friday of the 8 th . Week.
8 week session	Friday of the 6 th . Week.
5 week session	Friday of the 4 th . Week.

The equivalent date (75% of the semester) will be used for sessions of other lengths. The specific last day to withdraw is published each semester in the Schedule Bulletin.

Students who officially withdraw will be awarded the grade of "W", provided the student's attendance and academic performance are satisfactory at the time of official withdrawal. Students must file a withdrawal application with the college before they may be considered for withdrawal.

At student may not withdraw from a class for which the instructor has previously issued the student a grade of "F" or "FN" for nonattendance.

- B. An Administrative Withdrawal: An administrative withdrawal may be initiated when the student fails to meet College attendance requirements. The instructor will assign the appropriate grade on the Administrative Withdrawal Form for submission to the Registrar.
- C. An Incomplete Grade: The College catalog states, "An incomplete grade may be given in cases where the student has completed the majority of the course work but, because of personal illness, death in the immediate family, or military orders, the student is unable to complete the requirements for a course...." Prior approval from the instructor is required before the grade of "I" is recorded. A students who merely fails to show for the final examination will receive a zero for the final and an "F" for the course.
- D. Cellular phones and Pagers: Cellular phones and pagers will be turned off while the student is in the classroom or laboratory.

- E. Americans with Disabilities Act (ADA): Disability Support Services provides services to students who have appropriate documentation of a disability. Students requiring accommodations for class are responsible for contacting the Office of Disability Support Services (DSS) located on the central campus. This service is available to all students, regardless of location. Explore the website at www.ctcd.edu/disability-support for further information. Reasonable accommodations will be given in accordance with the federal and state laws through the DSS office.

VIII. COURSE OUTLINE

A. Unit One: Introduction

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Describe the general nature of the information that the Consumer Product Safety Commission (CPSC) requires on the labels affixed to containers of consumer products.
 - b. Name the 16 categories of information about a hazardous chemical that OSHA requires employers to evaluate and provide to their employees on a safety data sheet.
 - c. Identify the physical or health hazard associated with each GHS pictogram.
 - d. Provide the meanings of the numbers entered in the top three quadrants of hazard diamonds.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter I, Introduction, pp. 1-33
3. Unit Outline:
 - a. Comments
 - b. Why must Emergency Responders study chemistry?
 - c. Federal Hazardous Substances Act
 - d. Hazardous Substances in the Environment
 1. Clean Air Act
 2. Clean Water Act
 3. Resource Conservation and Recovery Act
 4. Comprehensive Environmental Response, Compensation, and Liability Act
 - e. Hazardous Chemical Products
 1. Toxic Substances Control Act
 2. Federal Insecticide, Fungicide, and Rodenticide Act
 - f. Hazardous Components of Products Used in the Workplace
 1. Warning Labels
 2. Safety Data Sheets
 3. Emergency Action Plans
 - g. Hazardous Substances stored and used in Commodities
 - h. Hazardous Materials in Transit

1. Marine Activities Regulated by DOT
2. National Transportation Safety Board
- i. Integrated Contingency Plans
- j. Global Harmonization concerning the Classification and Labeling of Hazardous Chemicals
- k. Canada's Workplace Hazardous Materials Information System
- l. NFPA System of Identifying Potential Hazards
- m. CHEMTREC
- n. National Response Center

B. Units Two: Features of Matter and Energy.

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Identify the common properties that characterize solids, liquids, and gases.
 - b. Use the factor-unit method to convert measurements expressed in customary units into their equivalents in appropriate metric units and vice versa.
 - c. Describe the concepts of density, specific gravity, vapor density, and vapor pressure and cite examples of their usefulness to emergency responders.
 - d. Convert temperature readings on one temperature scale into their equivalents on the other temperature scales noted in this chapter.
 - e. Describe the mechanisms that contribute to the spread of fire from one location to another.
 - f. Convert heat measurements expressed in BTUs to measurements expressed in calories and vice versa.
 - g. Use the gas laws to calculate the volume of gases subjected to different temperature and pressure calculations.
 - h. Describe the potential danger associated with the expansion of a heated gas or vapor that is confined in a storage vessel.
 - i. Identify the general hazards that emergency responders encounter when exposed to cryogenics
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework/study
 - c. Text assignment: Chapter 2, Features of Matter and Energy, pp. 23-69
3. Unit Outline:
 - a. Matter Defined
 1. Solids
 2. Liquids
 3. Gases
 - b. Units of Measurement
 1. Length
 2. Mass
 3. Volume

- 4. General Use of the Metric System in the United States
- c. Converting between Units of the Same Kind
- d. Concentration
- e. Density of Matter
 - 1. Specific Gravity
 - 2. Vapor Density
- f. Energy
- g. Temperature and its Measurement
 - 1. The Fahrenheit and Celsius Temperature Scales
 - 2. The Kelvin and Rankine Temperature Scales
- h. Pressure and its Measurement
- i. Heat and its Transmission'
 - 1. Conduction
 - 2. Convection
 - 3. Radiation
 - 4. Spread of Fire
- j. Calculation of Heat
- k. Volumetric Expansion of Liquids resulting from a Change in Temperature
- l. General Properties of the Gaseous State of Matter
 - 1. Boyle's Law
 - 2. Charles's Law
 - 3. Combined Gas Law
- m. Cryogenics
 - 1. Expansion of Cryogenics during Vaporization
 - 2. Impact of cryogenics on Other Matter
 - 3. Ill Effects caused by Exposure to Cryogenics

C. Unit Three: Flammable Gases and Flammable Liquids.

- 1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Determine the OSHA category and NFPA class of flammable liquids from knowledge of their flashpoints and boiling points.
 - b. Identify the information that DOT requires manufacturers to mark on gas cylinders and rail tankcars used to transport gases.
 - c. Describe the general safety practices that are recommended with handling, storing, and transporting compressed gases.
 - d. Identify the practices for safely storing flammable liquids in containers, portable tanks, and stationary tanks in the workplace.
 - e. Describe the general features of pressure and nonpressure rail tankcars.
 - f. Identify the conditions that trigger BLEVEs, and identify the actions emergency responders should implement to prevent the occurrence of BLEVEs.

2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework/study
 - c. Text assignment: Chapter 3, Flammable Gases and Liquids, pp. 70-105
3. Unit Outline:
 - a. Flammability Criteria
 1. OSHA's Definition of a Flammable Liquid
 2. NFPA's Definition of Flammable and Combustible Liquids
 3. Assigning Numbers to the Red Quadrant of the Hazard Diagram
 4. CPSC's Definition of a Flammable Liquid
 5. DOT's Definition of a Flammable Liquid
 6. Fire and Toxicity Hazards of "emptied" Containers and Tanks
 7. Accelerants and their use by arsonists
 - b. RCRA Characteristic of Ignitability
 - c. Compressed Gases
 1. Storage and Use of Nonbulk Volumes of Compressed Gases
 2. Transportation of Nonbulk Volumes of Compressed Gases
 - d. Encountering Compressed Gases during Emergency Response Actions
 - e. Responding to Incidents involving the Release of Flammable Gases
 - f. Storing Flammable Liquids
 1. Storage in Containers
 2. Storage in Portable Tanks
 3. Storage in Stationary Tanks
 - g. Transportation of Flammable Gases and Flammable Liquids
 1. Transportation by Railway
 2. Transportation by Public Highway
 - h. Responding to Incidents involving the Release of Flammable Liquids
 1. Boiling-Liquid Expanding-Vapor Explosions
 2. General Emergency Response Procedures

D. Unit Four: Chemical Forms of Matter

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Distinguish between elements and compounds.
 - b. Memorize the symbols of the elements listed in Table 4.2.
 - c. Identify representative physical and chemical changes of a substance.
 - d. Identify the names and common properties of the major particles of which all atoms are composed.
 - e. Distinguish between the nature of ionic and covalent bonding.
 - f. Use Lewis symbols of the elements to describe the covalent bonding of molecules.
 - g. Memorize the symbols of the ions listed in Table 4.7.
 - h. Write the chemical formulas of ionic compounds when their names are provided and vice versa.
 - i. Memorize the chemical formulas of the covalent compounds named in Tables 4.8 and 4.10.

2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter 4, Chemical Forms of Matter, pp. 106-134
3. Unit Outline:
 - a. Elements and Compounds
 - b. Metals, nonmetals, and Metalloids
 - c. Chemical and Physical Changes
 - d. Some Basic Features of Atoms
 - e. The Periodic Classification of the Elements
 - f. Molecules and Ions
 - g. The Nature of Chemical Bonding
 - h. Lewis Symbols
 - i. Ionic Bonding
 - j. Covalent Bonding
 - k. Ionic and Covalent Compounds and their Solutions
 - l. The Chemical Formula
 - m. Writing Chemical Formulas and Naming Ionic Compounds
 1. Positive Ions
 2. Negative Ions
 - n. Some Chemical Formulas and Names of Covalent Compounds
 - o. Naming Acids
 1. Binary Acids
 2. Oxyacids
 - p. Molecular Weights, Formula weights, and the Mole

E. Unit Five: Principles of Chemical Reactions.

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Describe the nature of a balanced chemical equation.
 - b. Identify the types of simple chemical reactions.
 - c. Identify the factors that influence the rate at which a chemical reaction occurs.
 - d. Describe the ordinary combustion of a substance in air.
 - e. Identify the manner in which global warming influences the workload of emergency responders.

- f. Identify the classes of fire that are effectively extinguished by the use of water, aqueous-film-forming foam, alcohol-resistant aqueous-film-forming foam, carbon dioxide, alkali metal bicarbonates, and dry-powder.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework/study
 - c. Text assignment: Chapter 5, Principles of Chemical Reactions, pp. 135-172
 3. Unit Outline:
 - a. The Chemical Reaction
 - b. Balancing Simple Equations
 - c. Types of Chemical Reactions
 1. Combination (or Synthesis) Reactions
 2. Decomposition Reactions
 3. Single Replacement (or Single Displacement) Reactions
 4. Double Replacement (or Double Displacement) Reactions
 - d. Oxidation-Reduction Reactions
 1. Oxidation
 2. Reduction
 - e. Factors affecting the Rate of Reaction
 1. Nature of the Material
 2. Subdivision of the Reactants
 3. State of Aggregation
 4. Concentration of Reactants
 5. Activation Energy
 6. Temperature
 7. Catalysts
 - f. The Combustion Reaction
 1. Relationship between Combustion and Fire
 2. Early Attempts to Control Fire
 3. Types of Chemical Energy
 - g. Spontaneous Combustion
 - h. Global Warming
 - i. The RCRA Reactivity Characteristic
 - j. Classification of Fires
 - k. The Fire Triangle and Fire Tetrahedron
 1. Initiation
 2. Propagation
 3. Termination
 - l. Water as a Fire Extinguishing Agent
 1. Discharging Water as a Fire Extinguishing Agent
 2. Aqueous-Film-Forming Foam
 3. Alcohol-Resistant Aqueous-Film-Forming Foam
 4. Protein Foam
 5. Pyrocool Fire Extinguishing Foam
 - m. Carbon Dioxide as a Fire Extinguishing Agent

1. The Pressure-Temperature Relationship for Carbon Dioxide
 2. General Features of Carbon Dioxide as a Fire Extinguishing Agent
 3. Carbon Dioxide in Total-Flooding Systems
 4. Carbon Dioxide Production by Chemical Action
- n. Halons as Fire Extinguishing Agents
- o. Dry-Chemical Fire Extinguishing Agents
1. Alkali Metal Bicarbonates
 2. ABC Fire Extinguishing Agent
- p. Fire Extinguishing Agents for Class D Fires
- q. Fire Extinguishing Agents for Class K Fires

F. Unit Six: Use of the DOT Hazardous Materials Regulations by Emergency Responders.

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Illustrate how shippers of hazardous materials use the Hazardous Materials Table at 49 C.F.R section 172.101 to prepare a shipping description.
 - b. Identify the specific information emergency responders obtain from hazardous materials shipping descriptions.
 - c. Memorize the colors and inscriptions on the DOT labels and placards corresponding to all hazard classes and divisions.
 - d. Identify the information that DOT requires shippers to mark on the packaging used to transport hazardous materials.
 - e. Memorize the hazard classes and divisions of the hazardous materials whose transport vehicles always require placarding; and those that require placarding only when the amount of the materials equals or exceeds 1001 pounds (454 kg).
 - f. Demonstrate how first-on-the-scene responders use UN/NA identification numbers and DOT's Emergency Response Guidebook to mitigate the impact of a transport mishap involving hazardous materials.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter 6, Use of the DOT Hazardous Materials Regulations by Emergency Responders, pp. 173-220
3. Unit Outline:
 - a. DOT Hazardous Materials and their Proper Shipping Names
 1. Proper Shipping Names
 2. Hazard Classes and Divisions
 3. UN/NA Identification Numbers
 4. Packing Groups
 5. Packaging
 6. Special Provisions

- b. The Shipping Paper
 - 1. Shipping Descriptions of Hazardous Materials
 - 2. Reportable Quantities
 - 3. Marine Pollutants and Severe Marine Pollutants
- c. Location of the Shipping Paper during Transit
- d. DOT Labeling Requirements
- e. DOT Marking Requirements
 - 1. Marking nonbulk packaging to denote performance test features
 - 2. Marking Cylinders containing Compressed Gases and Liquefied Compressed Gases
 - 3. Marking nonbulk packaging containing Hazardous Substances
 - 4. Marking nonbulk packaging containing Hazardous Materials that pose an Inhalation Hazard
 - 5. Marking nonbulk packaging containing Class 6 Hazardous Materials
 - 6. Marking nonbulk packaging containing Liquid Hazardous Materials other than Liquefied Compressed Gases
 - 7. Marking nonbulk packaging containing a limited quantity of a Hazardous Material for shipment by Rail or Air
 - 8. Marking nonbulk packaging requiring a Special Permit
 - 9. Marking nonbulk packaging containing Hazardous Wastes
 - 10. Marking nonbulk packaging of Marine Pollutants or Severe Marine Pollutants
 - 11. Marking overpacked nonbulk packaging
 - 12. Marking nonbulk packaging containing an Excepted Quantity
 - 13. Marking nonbulk packaging containing ORM-DS
 - 14. Marking all forms of bulk packaging containing Hazardous Materials
 - 15. Marking Transport Vehicles and Freight Containers loaded with Hazardous Materials in nonbulk packaging
 - 16. Marking Freight Containers containing Fueled Items
 - 17. Marking bulk packaging containing Hazardous Materials that pose an Inhalation Hazard
 - 18. Marking bulk packaging containing Elevated-Temperature Materials
 - 19. Marking bulk packaging containing Marine Pollutants or Severe Marine Pollutants
 - 20. Marking Emptied bulk packaging that contained Hazardous Materials
 - 21. Marking Portable Tanks containing Hazardous Materials
 - 22. Marking bulk packaging containing certain Hazardous Materials for shipment by Highway or Rail
 - 23. Marking bulk packaging during or following their Fumigation
- f. DOT Placarding Requirements
 - 1. Placarding Requirements when shipping Multiple Packages of Materials whose Hazard Classes are limited solely to Table 6.9

2. Placarding for Subsidiary Hazards
3. Special Placarding Requirements when Hazardous Materials are transported in Separate Compartmented Portable Tanks, Cargo Tanks, or Tank Cars
4. Special Placarding Requirements when Hazardous Materials in certain divisions are transported by Rail
- g. Responding to Incidents involving the Release of Hazardous Materials
- h. Reporting the Release of a Hazardous Substance
- i. Transportation Security Plans
- j. Hazardous Materials Safety Permits

G. Unit Seven: Chemistry of Some Common Elements.

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of the elements noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Identify the primary industries that use the elements noted in this chapter.
 - c. Describe how exposure to ground-level ozone may diminish the quality of life.
 - d. Describe how the depletion of ozone in the stratosphere negatively affects life on Earth.
 - e. Identify the common metals that react with acids and/or water to produce hydrogen.
 - f. Identify the principal health hazards associated with exposure to chlorine and phosphorus vapor.
 - g. Illustrate the sulfur and carbon act as reducing agents in chemical reactions.
 - h. Identify the labels, markings, and placards that DOT requires on packaging of the elements noted in this chapter and the transport vehicles used for their shipment.
 - i. Identify the response actions to be executed when the elements noted in this chapter are released from their packaging into the environment.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter 7, Chemistry of Some Common Elements, pp. 221-269
3. Unit Outline
 - a. Oxygen
 1. Liquid Oxygen
 2. Commercial Uses of Oxygen
 3. Respiration
 4. Chemical Oxygen Generators

5. Workplace Regulations involving Bulk Oxygen Systems
 6. Transporting Oxygen
 7. Responding to Incidents involving a Release of Oxygen
 8. Ozone, the Allotrope of Oxygen
 9. Commercial Uses of Ozone
 10. Ground-Level Ozone
 11. Workplace Regulations involving Ozone
 12. Environmental Regulations involving Ground-Level Ozone
 13. Stratospheric Ozone
 14. Environmental Regulations involving Stratospheric Ozone
- b. Hydrogen
1. Commercial Uses of Hydrogen
 2. Hydrogen as an Alternative Motor Fuel
 3. Production of Hydrogen
 4. Properties of Hydrogen
 5. Hydrogen and the Risk of Fire and Explosion
 6. Chemical Reactions that generate Hydrogen
 7. Hydrogen Generation when Charging Lead-Acid Storage Batteries
 8. The *Hindenburg*
 9. Workplace Regulations involving Hydrogen
 10. Transporting Hydrogen
 11. Responding to Incidents involving a Release of Hydrogen
- c. Chlorine
1. Production and Commercial Uses of Elemental Chlorine
 2. Ill Effects caused by Inhaling Chlorine
 3. Chlorine as a Chemical Warfare Agent
 4. Chemical Reactivity of Chlorine
 5. Workplace Regulations involving Chlorine
 6. Transporting Chlorine
 7. Responding to Incidents involving a Release of Chlorine
- d. Phosphorus
1. Production and Properties of Phosphorus
 2. Transporting White Phosphorus
 3. Responding to Incidents involving a Release of White Phosphorus
 4. Red Phosphorus
 5. Transporting Red Phosphorus
 6. Responding to Incidents involving a Release of Red Phosphorus
- e. Sulfur
1. Production and Properties of Sulfur
 2. Commercial Uses of Sulfur
 3. Transporting Sulfur
 4. Responding to Incidents involving a Release of Sulfur
- f. Carbon
1. Common Allotropes of Carbon

2. Commercial Uses of Diamond and Graphite
3. Coal
4. Ranks of Coal
5. Chemical Products obtained from Coal
6. Charcoal and Carbon Black
7. Consumer Product Regulations involving Charcoal
8. Transporting Carbon-Based Products
9. Responding to Incidents involving a Release of Coal
10. Uncontrolled Coal Fires

H. Unit Eight: Chemistry of Some Corrosive Materials.

1. Unit Objectives: Upon successful completion of this unit, the student will be able to:

- a. Associate the physical and health hazards of the corrosive materials noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
- b. Identify the primary industries that use the corrosive materials noted in this chapter.
- c. Identify the concentrated acids that vaporize at room temperature and cause ill effects when inhaled.
- d. Identify the labels, markings, and placards that DOT requires on packaging of corrosive materials and the transport vehicles used for their shipment.
- e. Identify the response actions to be executed when corrosive materials are released from packaging into the environment.

2. Learning Activities:

- a. Classroom lecture/discussion
- b. Student homework study
- c. Text assignment: Chapter 8, Chemistry of Some Corrosive Materials, pp. 270-307

3. Unit Outline:

- a. The Nature of Corrosivity
- b. The Nature of Acids and Bases
 1. Strong and Weak Acids and Bases
 2. Mineral Acids and Bases
 3. Oxidizing and nonoxidizing Acids
 4. Concentrated and Diluted Acids
- c. The pH Scale
- d. Properties of Acids and Bases
- e. The Anhydrides of Acids and Bases
- f. Acids and Bases as Corrosive Materials
 1. Reactions of Acids and Metals
 2. Reactions of Acids and Metallic Oxides
 3. Reactions of Acids and Metallic Carbonates
 4. Reactions of Acids with Skin Tissue
 5. Reactions of Bases and Metals

6. Reaction of Bases with Skin Tissue
- g. Sulfuric Acid
 1. Production of Sulfuric Acid
 2. The Hazard associated with diluting Sulfuric Acid with Water
 3. Dehydrating Action of Concentrated Sulfuric Acid
 4. Oxidizing Potential of Concentrated Sulfuric Acid
 5. Ill Effects caused by Inhaling the Vapors, Mists, and Fumes of Sulfuric Acid
 6. Workplace Regulations involving Sulfuric Acid
 7. Oleum (Fuming Sulfuric Acid)
 8. Transporting Sulfuric Acid
- h. Nitric Acid
 1. Production of Nitric Acid
 2. Oxidation of Metals by Nitric Acid
 3. Oxidation of nonmetals by Nitric Acid
 4. Oxidation of Organic Compounds by Nitric Acid
 5. Reactions of Nitric Acid with Cellulosic Materials
 6. Ill Effects caused by Exposure to Nitric Acid
 7. Fuming Nitric Acid
 8. Workplace Regulations involving Nitric Acid
 9. Transporting Nitric Acid
- i. Hydrochloric Acid
 1. Production of Hydrochloric Acid
 2. Ill Effects caused by Inhaling Hydrogen Chloride
 3. Reactions of Hydrochloric Acid with Oxidizing Agents
 4. Anhydrous Hydrogen Chloride
 5. Workplace Regulations involving Hydrogen Chloride
 6. Transporting Hydrochloric Acid and Anhydrous Hydrogen Chloride
- j. Perchloric Acid
 1. Production of Perchloric Acid
 2. Thermal Decomposition of Perchloric Acid
 3. Oxidizing Potential of Perchloric Acid
 4. Transporting Perchloric Acid
- k. Hydrofluoric Acid
 1. Production of Hydrofluoric Acid
 2. Ill Effects caused by Exposure to Hydrofluoric Acid
 3. Reactions of Hydrofluoric Acid with Silicon Compounds
 4. Anhydrous Hydrogen Fluoride
 5. Workplace Regulations involving Hydrogen Fluoride
 6. Transporting Hydrofluoric Acid and Anhydrous Hydrogen Fluoride
- l. Phosphoric Acid
 1. Production of Phosphoric Acid
 2. Phosphoric Anhydride
 3. Transporting Phosphoric Acid and Phosphoric Anhydride

- m. Acetic Acid
 - 1. Production of Acetic Acid
 - 2. Vaporization of Acetic Acid
 - 3. Combustible Nature of Acetic Acid
 - 4. Workplace Regulations involving Acetic Acid
 - 5. Transporting Acetic Acid
- n. Sodium Hydroxide, Potassium Hydroxide, and Calcium Hydroxide
 - 1. Production of Sodium Hydroxide and Potassium Hydroxide
 - 2. Production of Calcium Hydroxide
 - 3. Transporting Sodium Hydroxide, Potassium Hydroxide, and Calcium Hydroxide
- o. RCRA Corrosivity Characteristics
- p. Workplace Regulations involving Corrosive Materials
- q. Responding to Incidents involving a Release of a Corrosive Material
- r. Responding to Incidents involving Acid and Alkali Poisoning

I. Unit Nine: Chemistry of Some Water- and Air-Reactive Substances.

1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of water- and air-reactive materials noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Identify the industries that use the water- and air-reactive materials noted in this chapter..
 - c. Identify the labels, markings, and placards that DOT requires on packaging of water- and air-reactive materials and the transport vehicles used for their shipment.
 - d. Identify the response actions to be executed when water- and air-reactive materials are released from their packaging into the environment.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study.
 - c. Text assignment: Chapter Nine, Chemistry of Some Water- and Air-Reactive Substances, pp. 308- 344
3. Unit Outline:
 - a. Water- and Air-Reactive Substances
 1. Identifying Air-Reactive (Pyrophoric) Substances
 2. Transporting Water-Reactive Substances
 - b. Alkali Metals
 1. Metallic Lithium
 2. Metallic Sodium
 3. Metallic Potassium
 4. Transporting Alkali Metals and Primary Lithium Batteries
 - c. Combustible Metals
 1. Metallic Magnesium
 2. Metallic Titanium

3. Metallic Zirconium
4. Metallic Aluminum
5. Metallic Zinc
6. Transporting Combustible Metals
- d. Aluminum Alkyl Compounds and their Derivatives
 1. Commercial Uses of the Aluminum Alkyl Compounds and their Derivatives
 2. Properties of the Aluminum Alkyl Compounds and their Derivatives
 3. Transporting Aluminum Alkyl Compounds and their Derivatives
- e. Ionic Hydrides
 1. Simple Ionic Hydrides
 2. Ionic Borohydrides
 3. Ionic Aluminum Hydrides
 4. Water Reactivity of the Ionic Hydrides
 5. Transporting Ionic Hydrides
- f. Metallic Phosphides
 1. Transporting Metallic Phosphides
 2. Phosphine
 3. Workplace Regulations involving Phosphine
 4. Transporting Phosphine
- g. Metallic Carbides
 1. Aluminum Carbide
 2. Calcium Carbide
 3. Transporting Metallic Carbides
- h. Water-Reactive Substances that produce Hydrogen Chloride
 1. Aluminum Chloride, Anhydrous
 2. Phosphorus Oxychloride
 3. Phosphorus Pentachloride
 4. Phosphorus Trichloride
 5. Silicon Tetrachloride
 6. Sulfuryl Chloride
 7. Thionyl Chloride
 8. Tin(IV) Chloride, Anhydrous
 9. Titanium(IV) Chloride, Anhydrous
 10. Chlorosilanes
 11. Transporting Substances that React with Water to Produce Hydrogen Chloride Vapor
- i. Water-Reactive Compounds that Produce Acetic Acid Vapor
 1. Acetic Anhydride
 2. Workplace Regulations involving Acetic Anhydride
 3. Acetyl Chloride
 4. Transporting Acetic Anhydride and Acetyl Chloride
- j. Responding to Incidents involving the Release of a Material in Hazard Classes 4.1, 4.2, and 4.3

1. Alkali Metals
2. Combustible Metals
3. Aluminum Alkyl Compounds and Metallic Hydrides, Phosphides, and Carbides
4. Water-Reactive Substances that Generate Hydrogen Chloride
5. Acetic Anhydride and Acetyl Chloride

J. Unit Ten: Chemistry of Some Toxic Substances.

1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of the toxic substance noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Identify the common means by which toxic substances may enter the body and adversely impact human health.
 - c. Describe generally the ways in which a toxic substance may adversely affect one's health.
 - d. Identify the factors that affect the degree of toxicity resulting from chemical exposure.
 - e. Identify the mechanisms by which carbon monoxide and hydrogen cyanide interfere with the proper transfer of oxygen to the cells of the body.
 - f. Identify how on-duty firefighters may determine whether they have been overexposed to carbon
 - g. Identify the chemical features of commercial products that produce sulfur dioxide, hydrogen sulfide, and nitrogen oxides when the products smolder or burn.
 - h. Identify the primary industries that are likely to use anhydrous ammonia.
 - i. Identify the labels, markings, and placards that DOT requires on the packaging of toxic substances and the transport vehicles used for their shipment.
 - j. Identify the response actions to be executed when toxic substances are released from their packaging into the environment.
 - k. Describe how emergency responders use DOT ***Emergency Response Guidebook*** to establish the initial isolation and protective-action zones associated with large and small spills of a toxic substance.
2. Learning Activities:
 - a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter 10, Chemistry of Some Toxic Substances, pp. 345-420
3. Unit Outline:
 - a. Toxic Substances and Government Regulations
 1. Workplace Regulations involving Toxic Substances
 2. RCRA Toxicity Characteristics

- 3. Transporting Toxic Substances
- b. How Toxic Substances enter the Body
 - 1. Oral Ingestion
 - 2. Skin Absorption
 - 3. Inhalation
- c. Some Common Ways Toxic Substances Adversely Affect Health
 - 1. Asphyxiates
 - 2. Irritants
- d. Types of Toxicological Effects
 - 1. Acute Health Effect
 - 2. Chronic Health Effect
 - 3. Short-Term Health Effect
 - 4. Latent Health Effect
- e. Factors Affecting the Degree of Toxicity
 - 1. Quantity of Substance
 - 2. Duration of Exposure
 - 3. Rate at which a Substance Absorbs into the Bloodstream
 - 4. Age, Sex, Ethnicity, and the General Health of Individuals
 - 5. Individual Sensitivities
 - 6. Adverse Health Impacts on a Developing Fetus
- f. Measuring Toxicity
 - 1. Lethal Dose, 50% Kill
 - 2. Lethal Concentration, 50% Kill
 - 3. Threshold Limit Value
 - 4. Permissible and Ceiling Exposure Limits
 - 5. Short-Term Exposure Limit
 - 6. Immediately-Dangerous-to-Life-and-Health Limit
 - 7. Recommended Exposure Limit
- g. CPSC Criteria of a Toxic Substance
- h. The Hazard Zone
- i. Toxicity of the Fire Scene
 - 1. The Impact of Smoke on Vision
 - 2. Ill Effects caused by Inhaling Smoke
 - 3. The Adsorption of Gases on the Surfaces of Carbon Particulates
 - 4. Environmental Regulations involving Particulate Matter
- j. Carbon Monoxide
 - 1. Production of Carbon Monoxide
 - 2. Ill Effects Caused by Inhaling Carbon Monoxide
 - 3. Carbon Monoxide at Fire Scenes and Other Locations
 - 4. Workplace Regulations involving Carbon Monoxide
 - 5. Environmental Regulations involving Carbon Monoxide
 - 6. Consumer Product Regulations involving Carbon Monoxide
 - 7. Transporting Carbon Monoxide
 - 8. Responding to Incidents Associated with Exposure to Carbon Monoxide
- k. Hydrogen Cyanide

1. Production of Hydrogen Cyanide
 2. Ill Effects Caused by Inhaling Hydrogen Cyanide
 3. Use of Hydrogen Cyanide for Legal Executions
 4. Hydrogen Cyanide as a Chemical Warfare Agent
 5. Hydrogen Cyanide at Fire Scenes
 6. Workplace Regulations involving Hydrogen Cyanide
 7. Transporting Hydrogen Cyanide
 8. Hydrocyanic Acid
 9. Transporting Hydrocyanic Acid
 10. Metallic Cyanides
 11. Transporting Metallic Cyanides
- l. Sulfur Dioxide
1. Ill Effects Caused by Inhaling Sulfur Dioxide
 2. Environmental Events Associated with the Generation of Sulfur Dioxide
 3. Sulfur Dioxide at Fire Scenes
 4. Workplace Regulations involving Sulfur Dioxide
 5. Environmental Regulations involving Sulfur Dioxide
 6. Transporting Sulfur Dioxide
- m. Hydrogen Sulfide
1. Ill Effects Caused by Inhaling Hydrogen Sulfide
 2. Hydrogen Sulfide at Fire Scenes
 3. Workplace Regulations involving Hydrogen Sulfide
 4. Transporting Hydrogen Sulfide
 5. Responding to Incidents involving a Release of Hydrogen Sulfide
- n. Nitrogen Oxides
1. Production of NO_x
 2. Environmental Issues Associated with Nitrogen Oxide
 3. Ill Effects Caused by Inhaling NO_x
 4. Nitrogen Oxides at Fire Scenes
 5. Workplace Regulations involving the Nitrogen Oxides
 6. Transporting the Nitrogen Oxides
- o. Ammonia
1. Production of Ammonia
 2. Ammonia at Fire Scenes
 3. Ill Effects Caused by Inhaling Ammonia
 4. Workplace Regulations involving Anhydrous Ammonia
 5. Transporting Anhydrous Ammonia
 6. Responding to Incidents involving a Release of Anhydrous Ammonia
 7. Ammonia Solutions
 8. Transporting Ammonia Solutions
- p. Response Actions at Scenes involving a Release of Toxic Substances
- q. Carcinogenesis
1. Classification of Chemical Carcinogens

2. Workplace Regulations involving Carcinogens
- r. Compounds of Toxic Metals
 1. Lead and its Compounds
 2. Consumer Product Regulations involving Lead
 3. Workplace Regulations involving Lead
 4. Environmental Regulations involving Lead
 5. Transporting Lead
- s. Asbestos
 1. Ill Effects Caused by Exposure to Asbestos
 2. Consumer Product Regulations involving Asbestos
 3. Workplace Regulations involving Asbestos
 4. Environmental Regulations involving Asbestos
 5. Transporting Asbestos
 6. Responding to Incidents involving a Release of Asbestos
- t. Pesticides
 1. Environmental Regulation Pertaining to Pesticides
 2. Transporting Pesticides
 3. Pesticides and Firefighting
- u. Biological Warfare Agents
 1. Select Agents
 2. Dissemination of Infectious Pathogens and Toxins
 3. Responding to Incidents involving a Release of Infectious Pathogens and Toxins
 4. Transporting Infectious Substances
 5. Anthrax
 6. Ricin

K. Unit Eleven: Chemistry of Some Oxidizers.

1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of the oxidizers noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Describe how NFPA distinguishes the degree of hazard potentially posed by different oxidizers.
 - c. Identify the primary industries that use the oxidizers noted in this chapter.
 - d. Identify commercial products that contain oxidizers.
 - e. Describe the OSHA and DHS regulations that pertain to the handling, storage, stowing, loading, unloading, or discharge of bulk quantities of ammonium nitrate.
 - f. Identify the labels, markings, and placards that DOT requires on the packaging of oxidizers and the transport vehicles used for their shipment.
 - g. Identify the response actions to be executed when oxidizers are released from their packaging into the environment.
2. Learning Activities:

- a. Classroom lecture/discussion
 - b. Student homework study
 - c. Text assignment: Chapter 11, Chemistry of Some Oxidizers, pp. 421-465
3. Unit Outline:
- a. What is an Oxidizer?
 - 1. DOT Classification of Oxidizers
 - 2. OSHA/GHS Identification of Oxidizers
 - b. Oxidation Numbers
 - c. Oxidation-Reduction Reactions
 - d. Common Features of Oxidizers
 - e. Hydrogen Peroxide
 - 1. The *KURSK*
 - 2. Workplace Regulations involving Hydrogen Peroxide
 - 3. Transporting Hydrogen Peroxide
 - 4. Responding to Incidents involving a Release of Hydrogen Peroxide
 - 5. Nonchlorine Bleaches
 - f. Metallic Hypochlorites
 - 1. Sodium Hypochlorite
 - 2. Calcium Hypochlorite
 - 3. Transporting Metallic Hypochlorites
 - g. Di- and Trichloroisocyanuric Acids and their Salts
 - 1. Commercial Uses of Di- and Trichloroisocyanuric Acids and their Salts
 - 2. Transporting Di- and Trichloroisocyanuric Acids and their Salts
 - h. Chlorine Dioxide
 - 1. Commercial Uses of Chlorine Dioxide
 - 2. Transporting Chlorine Dioxide
 - i. Oxidizers in Fireworks and Other Pyrotechnics
 - 1. Transporting Fireworks
 - 2. Displaying Fireworks
 - 3. Transporting Metallic Chlorites, Chlorates, and Perchlorates
 - 4. Ill Effects cause by Exposure to Metallic Perchlorates
 - j. Oxidizers in Flares, Signaling Smokes, and Smoke Bombs
 - 1. Chemical Actuation of Flares, Signaling Smokes, and Smoke Bombs
 - 2. Transporting Flares, Signaling Smokes, and Smoke Bombs
 - k. The Thermal Stability of Ammonium Compounds
 - 1. Commercial Uses of Ammonium Compounds
 - 2. Transporting Ammonium Compounds
 - l. Ammonium Nitrate
 - 1. Ammonium Nitrate at Fire Scenes
 - 2. Workplace Regulations involving the Bulk Storage of Ammonium Nitrate
 - 3. Homeland Security Measures involving Ammonium Nitrate

- m. Oxidizing Chromium Compounds
 - 1. Potassium Dichromate
 - 2. Chromium Trioxide
 - 3. Ammonium Oxochloride
 - 4. Ammonium Dichromate
 - 5. Workplace Regulations involving the Oxidizing Chromium Compounds
 - 6. Transporting the Oxidizing Chromium Compounds
- n. Sodium Permanganate and the Potassium Permanganate
 - 1. Production and Commercial Use
 - 2. Transporting Metallic Permanganates
- o. Metallic Nitrites and Metallic Nitrates
 - 1. Some Properties of Metallic Nitrites
 - 2. Some Properties of Metallic Nitrates
 - 3. FDA Regulations involving Sodium Nitrite and Sodium Nitrate
 - 4. Transporting Metallic Nitrites and Nitrates
- p. Metallic Peroxides and Superoxides
 - 1. Properties of Metallic Peroxides
 - 2. Properties of Metallic Superoxides
 - 3. Transporting Metallic Peroxides and Superoxides
- q. Potassium Persulfate and Sodium Persulfate
 - 1. Properties and Commercial Use
 - 2. Transporting Metallic Persulfates
- r. Matches
 - 1. Strike-Anywhere Matches
 - 2. Safety Matches
 - 3. Transporting Matches
- s. Responding to Incidents involving a Release of a Metallic Oxidizer

L. Units Twelve and Thirteen: Chemistry of Some Hazardous Organic Compounds, Parts 1 and 2

- 1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of the organic compounds noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Discuss the manner in which a carbon atom covalently bonds to non-metallic atoms including other carbon atoms.
 - c. Describe the nature of carbon-carbon single bonds, carbon-carbon double bonds, and carbon-carbon triple bonds.
 - d. Describe the chemical bonds that exist in molecules of the hydrocarbons.
 - e. Illustrate that most hydrocarbons have structural isomers but only those with carbon-carbon double bonds have geometrical isomers.

- f. Memorize and apply the rules for naming simple alkanes, cycloalkanes, alkenes, dienes, trienes, cycloalkenes, cyclodienes, cyclotrienes, and alkynes.
- g. Describe the nature of the line markers required by DOT to identify the approximate locations of natural gas and petroleum transmission pipelines.
- h. Identify the types of liquefied petroleum gas that are available for commercial use as bottled gas.
- i. Identify the general nature of the labels required by the U. S. Federal Trade Commission on compressed natural gas and liquefied petroleum gas dispensers when these substances are provided to customers for potential use as alternative motor fuels.
- j. Describe generally the manner in which acetylene is containerized in steel cylinders for storage and transportation.
- k. Name the simple aromatic hydrocarbons and their derivatives when provided with the molecular structures and vice versa.
- l. Identify the most common ways by which emergency responders are likely to be exposed to polynuclear aromatic hydrocarbons (PAHs).
- m. Identify the petroleum products that are produced by the fractionation of crude petroleum.
- n. Provide the molecular structures of the halogenated hydrocarbons having one and two carbon atoms per molecule and provide acceptable names for them.
- o. Identify the primary risks associated with exposure to the halogenated hydrocarbons having one and two carbon atoms per molecule.
- p. Describe the molecular nature of the most common chlorofluorocarbons.
- q. Identify the principal ways in which chlorofluorocarbons and related substances were formerly used.
- r. Describe the nature of the markings that EPA requires on containers and tanks of ozone-depleting substances.
- s. Describe the molecular structures of the polychlorinated biphenyls (PCBs).
- t. Identify the primary reason that PCBs are no longer manufactured in the United States.
- u. Identify the locations in a typical community where emergency responders are likely to encounter PCB transformers.
- v. Describe the nature of the markings that EPA requires on PCB-containing electrical equipment.
- w. Identify the labels, markings, and placards that DOT requires on packaging of the organic compounds noted in this chapter and transport vehicles used for their shipment.
- X. Associate the physical and health hazards of the organic compounds in this chapter with the information provided by their hazard diamonds and GHS pictograms.
- Y. Memorize the functional group by their hazard diamonds and GHS pictograms.

- Z. Memorize and apply the rules for naming simple alcohols, ethers, aldehydes, ketones, organic acids, esters, amines, and peroxy-organic compounds.
- aa. Identify the adverse health effects that result from abusing the use of alcoholic beverages.
 - bb. Describe the most practical means of extinguishing bulk ethanol fires.
 - cc. Identify the risk associated with encountering an elevated concentration of peroxy-organic compound within the containers used to store ethers.
 - dd. Identify the hazardous properties of the halogenated ethers, including the PCDFs, and PCDDs, PBDFs, PBDDs, and PBDEs, and identify the most likely ways by which emergency responders are likely to be exposed to them.
 - ee. Identify the locations at which emergency responders are likely to encounter formaldehyde.
 - ff. Identify the general nature of the labels required by the U. S. Federal Trade Commission on biodiesel dispensers when types of this material are provided to customers for potential use as alternative motor fuels.
 - gg. Identify the labels, markings, and placards that DOT requires on packaging of the organic compounds noted in this chapter, especially organic peroxides, and the transport vehicles used for their shipment.

2. Learning Activities:

- a. Classroom lecture/discussion
- b. Student homework study
- c. Text assignment: Chapters 12 and 13, Chemistry of Some Hazardous Organic Compounds, Parts 1 and 2, pp. 466-605

3. Unit Outline:

- a. What are Organic Compounds?
- b. Alkanes and Cycloalkanes
 - 1. Formulas of the Alkanes
 - 2. Formulas of the Cycloalkanes
 - 3. The IUPAC System of Nomenclature
 - 4. Transporting Alkanes and Cycloalkanes
- c. Alkenes, Dienes, Trienes, cycloalkenes, cyclodienes, and cyclotrienes.
 - 1. Structural Isomerism in Alkenes
 - 2. Naming Alkenes, Dienes, Trienes, cycloalkenes, cyclodienes, and cyclotrienes
 - 3. Geometrical Isomerism in Alkenes
 - 4. Transporting Alkenes, Dienes, Trienes, Cycloalkenes, cyclodienes, and cyclotrienes
- d. Alkynes
- e. Natural Gas (Methane)
 - 1. Methane in the Atmosphere of Coal Mines
 - 2. Methane Production by the Decomposition of Organic Matter
 - 3. Industrial Sources of Methane
 - 4. Natural Gas Transmission by Pipeline
 - 5. Bulk Sources of Methane

- f. Liquefied Petroleum Gas
 - 1. Bottled Gas
- g. Ethylene and Propylene
- h. Butadiene
- i. Acetylene
- j. Transporting the Simple Gaseous Hydrocarbons
- k. Aromatic Hydrocarbons
 - 1. Benzene, Toluene, and Xylene(s)
 - 2. Ill Effects Caused by Inhaling BTX Vapor
 - 3. Workplace Regulations involving the BTX Hydrocarbons
 - 4. Transporting Aromatic Hydrocarbons
- l. Polynuclear Aromatic Hydrocarbons
 - 1. Naphthalene
 - 2. Sources of PAHs
 - 3. Ill Effects Caused by Inhaling PAHs
 - 4. PAHs and Firefighting
 - 5. Workplace Regulations involving the PAHs
- m. Petroleum and Petroleum Products
 - 1. The Nature and Natural Origin of Crude Oil
 - 2. Fighting Fires involving Crude Oil
 - 3. Fractionation of Crude Petroleum
 - 4. Chemical Treatment of Petroleum Fractions
 - 5. Gasoline
 - 6. Diesel Oil
 - 7. Heating Oils
 - 8. Transmission of Crude Petroleum and Petroleum Products by Pipeline
 - 9. Transporting Crude Petroleum and Petroleum-Based Commodities
 - 10. Petrochemicals
- n. Simple Halogenated Hydrocarbons
 - 1. Ill Effects Caused by Inhaling the Vapors of the Simple Halogenated Hydrocarbons
 - 2. Transporting the Halogenated Hydrocarbons
- o. Chlorofluorocarbons and their related Compounds
 - 1. How the CFCs Destroy Stratospheric Ozone
 - 2. Hydrofluorocarbons and Hydrochlorofluorocarbons
 - 3. Substitutes for the Halon Fire-Extinguishing Agents
 - 4. Storing Ozone-Depleting Substances
 - 5. Transporting CFCs, HFCs, and HCFCs
- p. Polychlorinated Biphenyls
 - 1. Use of PCBs in Electrical Equipment
 - 2. PCBs and Firefighting
 - 3. The Adverse Impact on the Environment caused by PCBs
 - 4. FDA Regulations involving PCBs
 - 5. Transporting PCBs

q. Organochlorine Pesticides

R. Function Groups

S. Alcohols

1. Methanol
2. Consumer Product Regulations involving Methanol
3. Methanol as an Alternative Motor Fuel
4. Ethanol
5. Ill Effects caused by Alcohol Abuse
6. Industrial-Grade Ethanol
7. Ethanol as a Biofuel
8. Extinguishing Ethanol Fires
9. Isopropanol
10. Glycols
11. Phenol
12. Cresols
13. Workplace Regulations involving Alcohols
14. Transporting Alcohols
15. Bisphenol A

T. Ethers

1. Reactions of Ethers with Atmospheric Oxygen
2. Diethyl Ether
3. Methyl *tert*-Butyl Ether
4. Ducalyptol
5. Ethylene Glycol Alkyl Ethers
6. Transporting Ethers

U. Halogenated Ethers

1. Epichlorohydrin
2. Polychlorinated Dibenzofurans and Dibenzo-*p*-Dioxins
3. Polybrominated Dibenzofurans and Dibenzo-*p*-Dioxins
4. Polybrominated Diphenyl Ethers

V. Aldehydes and Ketones

1. Formaldehyde
2. Workplace Regulations involving Formaldehyde
3. Acetone
4. Other Ketones
5. Transporting Aldehydes and Ketones

W. Organic Acids

1. The Formyl, Acetyl, and Benzoyl Groups
2. Perfluorooctanoic Acid
3. Transporting Organic Acids

X. Esters

1. Ethyl Acetate
2. DI(2-Ethylhexyl) Phthalate
3. Linseed Oil
4. Biodiesel Fuel, Biodiesel Blends, and Biomass-Based Diesel Fuels

5. Transporting Esters
- Y. Amines
 1. Workplace Regulations involving the Simple Amines
 2. *N*-Nitrosamines
 3. Methamphetamine
 4. Transporting Amines
- Z. Peroxo-Organic Compounds
 1. Transporting Peroxo-Organic Compounds
 2. Storing Peroxo-Organic Compounds
 3. Identifying Containerized Peroxo-Organic Compounds
 4. Responding to Incidents involving a Release of Peroxo-Organic Compounds
 5. Terrorists' Misuse of Peroxo-Compounds
- aa. Carbon Disulfide
 1. Workplace Regulations involving Carbon Disulfide
 2. Transporting Carbon Disulfide
- bb. Chemical Warfare Agents
 1. Nerve Agents
 2. Vesicants
 3. Blood Agents
 4. Choking Agents
 5. Responding to Incidents involving the Release of a Chemical Warfare Agent
- cc. Lacrimators
- dd. Napalm

M. Unit Fourteen: Chemistry of Some Polymeric Materials.

1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Associate the physical and health hazards of the monomers noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
 - b. Describe the general nature of the polymerization reaction.
 - c. Distinguish between addition and condensation polymerization reactions.
 - d. Describe how cross-linking and the use of plasticizers alters the physical features of polymers.
 - e. Discuss the general phenomena that occur when polymers burn on exposure to heat.
 - f. Identify the toxic gases produced when polymer thermally decompose or burn.
 - g. Describe and compare the macromolecular structures of the common vegetable and animal fibers.
 - h. Identify the common products made from polyethylene, polypropylene, poly(vinyl chloride), polyacrylonitrile, poly(methacrylate), polyacrylamide, phenol-formaldehyde, urea-formaldehyde, melamine-

formaldehyde polymers, and polyurethane, and identify the toxic gases produced when they burn or smolder.

i. Describe how natural rubber is vulcanized.

j. Identify the labels, markings and placards that DOT requires on packaging of the monomers noted in this chapter and the transport vehicles used for their shipment.

2. Learning Activities:

a. Classroom lecture/discussion

b. Student homework study

c. Text assignment: Chapter 14, Chemistry of Some Polymeric Materials, pp. 606-644

3. Unit Outline:

a. What are Polymers?

b. Polymerization

1. Addition Polymerization

2. Condensation Polymerization

c.. Autopolymerization

d. Polymer Decomposition and Combustion

1. The Chemical Nature of the Gases and Vapors produced during Polymeric Fires

2. Smoke Produced during Polymeric Fires

3. Consumer Product Regulations pertaining to Textiles

e. Vegetable and Animal Fibers

1. Cellulose and its Derivatives

2. Wool and Silk

f. Vinyl Polymers

1. Polyethylene

2. Polypropylene

3. Poly(Vinyl Chloride)

4. Polyacrylonitrile

5. Poly(Methyl Methacrylate)

6. Polyacrylamide

g. Epoxy Resins

h. Formaldehyde-Derived Polymers

i. Polyurethane

1. Commercial Uses of the Polyurethanes

2. Polyurethane and Firefighting

j. Heat- and Fire-Resistant Polymers

1. Poly(Tetrafluoroethylene)

2. Nomex

3. Kevlar

k. Rubber and Rubber Products

1. Natural Rubber

2. Synthetic Rubbers

3. Consumer Products produced from Synthetic Rubbers

4. Responding to Incidents involving the burning of Rubber

N. Unit Fifteen: Chemistry of Some Explosives, and Radioactive Materials

1. Unit Objective: Upon successful completion of this unit, the student will be able to:

- a. Associate the physical and health hazards of the explosives noted in this chapter with the information provided by their hazard diamonds and GHS pictograms.
- b. Distinguish between the combustion and the detonation of explosives.
- c. Distinguish between an explosive substance and an explosive article.
- d. Describe the chemical nature of a blasting agent.
- e. Identify the function of each component of a round of artillery ammunition.
- f. Identify the general nature of ATF's regulations that apply to parties who are licensed to store commercial explosives.
- g. Identify the chemical composition of black powder and note the general nature of the oxidation-reduction reaction that occurs when they are activated.
- h. Identify the composition of the three commercial types of dynamite.
- i. Compare the detonation and deflagration of nitrocellulose.
- j. Identify why explosive articles containing either TNT or cyclonite are chosen by the military for use during warfare more frequently than other explosives.
- k. Provide the general nature of a plastic explosive.
- l. Identify the labels, markings, and placards that DOT requires on packaging of explosives and the transport vehicles used for their shipment.
- m. Identify the response actions to be executed when explosives are released from their packaging into the environment.
- N. Describe the phenomenon of radioactivity and the concept of a half-life for a given radioisotope.
- O. Describe the nature of each mode by which a radioisotope may decay.
- P. Describe the differentiating features of alpha, beta, and gamma radiation.
- R. Describe the nature of a sealed radiation source and the features of the ionizing radiation symbol used to identify its presence.
- S. Identify the units used for the measurement of activity and radiation dose.
- T. Identify the general aspects of OSHA regulations requiring employers to limit radiation exposure in the workplace, including the posting of signs in areas where radioactive materials are stored or used.
- U. Describe the phenomenon of nuclear fission, including spontaneous fission.
- V. Identify the primary health concern posed by the presence of radon within residential dwellings.

W. Identify the labels, markings, and placards that DOT requires on packaging of radioactive materials and the transport vehicles used for their shipment.

X. Identify the response actions to be executed when radioactive materials are released from their packaging into the environment.

Y. Describe the response action to be executed when a radiological dirty bomb has been activated and discharged into the environment.

2. Learning Activities:

a. Classroom lecture/discussion

b. Student homework study

c. Text assignment: Chapter 15, Chemistry of Some Explosives, and Chapter 16, Radioactive Materials, pp. 645-734

3. Unit Outline:

a. General Characteristics of Explosives

b. Classification of Explosives

1. Blasting Agents

2. Artillery Ammunition

c. Storing Explosives

d. Transporting Explosives

1. Ex-Numbers

2. Compatibility Groups

3. Shipping Descriptions

4. Labeling, Marking, and Placarding Requirements

5. Explosive Wastes

6. Other DOT Requirements

e. Black Powder

1. Responding to Incidents involving the Release of Black Powder

2. Transporting Black Powder

f. Nitroglycerin

1. Commercial use of Nitroglycerin other than as an Explosive

2. Workplace Regulations involving Nitroglycerin

3. Transporting Nitroglycerin

4. Terrorists' Misuse of Nitroglycerin

g. Dynamite

1. Forms of Dynamite

2. Transporting Dynamite

h. Nitrocellulose

1. Formulations of Smokeless Powder

2. Transportation of Nitrocellulose

i. Trinitrotoluene

1. TNT Equivalents

2. Workplace Regulations involving TNT

3. Transporting TNT

j. Cyclonite

1. Workplace Regulations involving Cyclonite

2. Transporting Cyclonite

- 3. Terrorists' misuse of Cyclonite
- k. Tetryl
 - 1. Workplace Regulations involving Tetryl
 - 2. Transporting Tetryl
- l. Petn
 - 1. Use of Petn other than as an Explosive.
 - 2. Transporting Petn
 - 3. Terrorists' misuse of Petn
- m. HMX
 - 1. Use of HMX with other Explosives
 - 2. Transporting HMX
- n. Primary Explosives
 - 1. Mercury Fulminate
 - 2. Lead Azide
 - 3. Lead Styphnate
 - 4. Transporting Primary Explosives
- o. Responding to Incidents involving a Release of Explosives
- P. Features of Atomic Nuclei
- Q. Modes of Radioisotopic Decay
 - 1. Alpha Decay
 - 2. Beta Decay
 - 3. Gamma Decay
- R. Sealed Radiation Sources
- S. Detection of Radioactivity
- T. Units of Radiation and Radiation Dose
 - 1. Units of Activity
 - 2. Units of Radiation Dose
- U. Ill Effects Caused by Radiation Exposure
 - 1. General Exposure to Ionizing Radiation
 - 2. Exposure to Specific Radioisotopes
 - 3. Impact of an Individual's Age on Radiation Exposure
- V. Workplace Regulation involving Radiation Exposure
- W. Effects of Ionizing Radiation on Matter
- X. Nuclear Fission
 - 1. Criticality
 - 2. Terrorists' Potential Misuse of Fissile Material
 - 3. Plutonium-239
 - 4. Uranium-Enrichment Processes
 - 5. Spontaneous Fission
 - 6. The Global Fear of Using Nuclear Bombs during Warfare
 - 7. Nuclear Power Plants and their Hazards
 - 8. Future Use of Nuclear Power Plants
- Y. Transporting Radioactive Materials
 - 1. Shipping Description
 - 2. Labeling Requirements
 - 3. Marking Requirements

- 4. Placarding Requirements
- 5. Packaging Types
- 6. Highway Route-Controlled Quantity
- Z. Responding to Incidents involving a Release of Radioactive Materials
 - aa. Residential Radon
 - bb. Radiological Dispersal Device

O. Unit Sixteen:

- 1. Unit Objective: Upon successful completion of this unit, the student will be able to:
 - a. Discuss the major concepts presented in this class
 - b. Take and pass the Final Exam
- 2. Learning Activities:
 - a. Classroom lecture/review of chapters
 - b. Take Final Exam