9.1. Name five pneumoconioses and identify their causes.

ANS: The text lists six: siderosis--iron oxide dust; stannosis--tin dust; byssinosis--cotton dust; aluminosis--aluminum dust; asbestosis--asbestos fibers; silicosis--silica

ref. p. 173

9.2. Name five chemical irritants.

ANS: The text lists at least seven: ammonia gas, chromic acid, chlorine gas, fluorine, bromine, oxides of nitrogen, phosgene

ref. p. 173-174

9.3. What distinguishing effect do irritants have upon the body?

ANS: inflame the surfaces of the parts of the body by their corrosive action

ref. p. 173

9.4. What extremely dangerous gas can be produced when chlorinated hydrocarbons are exposed to welding radiation?

ANS: phosgene

ref. p. 174

9.5. What extremely dangerous gas can be produced when solvents and degreasers are exposed to welding radiation?

ANS: phosgene

ref. p. 174

9.6. Which of the following is a dangerous gas associated with the exposure of chlorinated hydrocarbons to welding radiation?

a. hydrogen cyanide
b. hydrogen sulfide
c. chlorine
d. phosgene

ref. p. 174

9.7. Which of the following is a dangerous gas associated with the exposure of solvents and degreasers to welding radiation?

a. hydrogen cyanide
b. hydrogen sulfide
c. chlorine
d. phosgene

ref. p. 174

9.8. Corrosive action on the nasal septum is most associated with which of the following air contaminants?

a. ammonia
b. chromic acid
c. phosgene
d. oxides of nitrogen

ref. p. 174

9.9. The toxic effects of halogens are primarily

a. as systemic poisons
b. as depressants
c. as irritants
d. as carcinogens

ref. p. 174

9.10. The toxic effects of bromine are primarily

a. as a systemic poison
b. as a depressant
c. as an irritant
d. as a carcinogen

ref. p. 174
9.11. The toxic effects of chlorine are primarily
   a. as a systemic poison
   b. as a depressant
   c. as an irritant
   d. as a carcinogen
   ref. p. 174

9.12. The toxic effects of fluorine are primarily
   a. as a systemic poison
   b. as a depressant
   c. as an irritant
   d. as a carcinogen
   ref. p. 174

9.13. Carbon disulfide is a systemic poison.
   a. true
   b. false
   ref. p. 174

9.14. Which of the following useful chemicals is a solvent, disinfectant, and insecticide, but unfortunately is also a systemic poison?
   a. carbon disulfide
   b. chlorine
   c. sodium hydroxide
   d. hydrogen sulfide
   ref. p. 174

9.15. The toxic effects of acetylene are primarily as
   a. an irritant
   b. a systemic poison
   c. a carcinogen
   d. a depressant
   ref. p. 174

9.16. Name at least three modes of toxicity for benzene.
   ANS: The text lists four: depressant, irritant, systemic poison, carcinogen (leukemia)
   ref. p. 175

9.17. Benzene has which of the following effects upon the body?
   a. irritant
   b. systemic poison
   c. depressant
   d. all of the above
   ref. p. 175

9.18. The primary effect of hydrogen cyanide upon the body is as
   a. an asphyxiant
   b. a systemic poison
   c. a carcinogen
   d. a depressant
   ref. p. 176

9.19. Which of the following substances is known as a teratogen?
   a. hydrogen sulfide
   b. vinyl chloride
   c. acetylene
   d. MAPP gas
   ref. p. 177

9.20. Which of the following classifications of toxic substances primarily attacks the species, rather than the individual?
   a. teratogens
   b. mutagens
   c. systemic poisons
   d. endemic agents
   ref. p. 177
9.21. A well-known agent is extremely hazardous as a monomer but is virtually harmless as a polymer. What is this agent?

ANS: vinyl chloride

9.22. Describe a way in which a toxic substance can be indirectly ingested into the body.

ANS: Substances become embedded beneath fingernails and on hands which later come into contact with food.

9.23. What term describes gases that are normally liquids or solids?

ANS: vapors

9.24. Which of the following is not a particulate?

a. fumes
b. vapors
b. dusts
d. mists

9.25. A coal dust particle is determined in the laboratory to have diameter 17 micrometers.

a. What is the diameter in centimeters?
ANS: .0017 cm

b. What is the diameter in inches?
ANS: .0017/2.54 = .00067 in.

(Note on page 179 that the conversion from micrometers to inches is approximately 0.1 to .000004 which is equivalent to 1 in = 2.5 cm. A more exact conversion factor is 1 in = 2.54 cm)

c. Is the particle classified as dust or fume?
ANS: dust

9.26. Personal protective equipment is required to be provided and used if the CAS # exceeds the PEL for an eight hour period.

a. true
b. false

9.27. Name the two types of flow process charts chemical engineers use to detect the origin of leaks of toxic contaminants to the atmosphere surrounding a process.

ANS: qualitative and quantitative

9.28. Which concentration is usually higher, AL or PEL?

ANS: PEL

9.29. Consider the following observed concentrations of air contaminants:

<table>
<thead>
<tr>
<th>TWA</th>
<th>PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isopropyl ether</td>
<td>200 ppm</td>
</tr>
<tr>
<td>Ethyl benzene</td>
<td>40 ppm</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>25 ppm</td>
</tr>
<tr>
<td>Chlorobromomethane</td>
<td>50 ppm</td>
</tr>
</tbody>
</table>

Perform calculations to determine whether this atmosphere exceeds the PEL, the AL, or both.

ANS:

<table>
<thead>
<tr>
<th>TWA</th>
<th>PEL</th>
<th>AL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isopropyl ether</td>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>Ethyl benzene</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Chlorobromomethane</td>
<td>50</td>
<td>200</td>
</tr>
</tbody>
</table>

Taken separately none of the contaminants exceed either their respective PEL's or AL's. When considered together, however, the following formula is used for mixtures:
\[
E_m = (200/500) + (40/100) + (25/75) + (50/200) \\
= .4 + .4 + .33 + .25 = 1.38
\]

Since 1.38 > 1 and 1.38 > 0.5, the concentrations exceed both the PEL and the AL, respectively.

9.30. Name two analytic tools used by the chemical engineer to determine whether air contaminant potentials are present in a process.

ANS: qualitative flow process chart, quantitative flow process chart

9.31. The proportion of health specialists in OSHA has increased since the early 1970s.

a. true
b. false

9.32. From what two perspectives is the impact of health hazards significant?

ANS: harm to employees, cost of correction of hazards

9.33. Appendix A.1 lists "Copper fumes" as having a TWA limit of .1 mg/m³. The corresponding PEL in the ppm column is blank. Explain why no ppm PEL is available for copper fumes.

ANS: Copper fume is a particulate and does not exist as a gas. Therefore ppm measurements are infeasible and irrelevant.

9.34. Explain the standards completion project.

ANS: In addition to the substances listed in the OSHA PEL table, some toxic substances have entire standards devoted to their control. The provision of these entire standards is called the "standards completion project."

9.35. What is a teratogen?

ANS: A toxic substance that affects the fetus.

9.36. An irritant whose effects upon the lung are minimal at first but whose irritant mechanical action shows up much later is called

a. scarring agent
b. teratogen
c. mutagen
d. systemic poison

9.37. In which of the following types of workers would you be most likely to find the nose septum completely destroyed?

a. cement worker
b. plating worker
c. steel worker
d. asbestos worker

9.38. Ammonia is primarily which of the following types of air contaminants?

a. irritant
b. systemic poison
c. depressant
d. asphyxiant

9.39. At first, OSHA emphasized safety more than health.

a. true
b. false
9.40. Early methods for testing contamination of the atmosphere, using a canary or a mouse, were used for testing which kind of exposure, acute or chronic?

ANS: acute

ref. p. 190

9.41. Which of the following is recognized as a leukemia hazard?

a. methane  
b. carbon disulfide  
c. benzene  
d. hydrogen cyanide

ref. p. 175

9.42. Which of the following is not a simple asphyxiant?

a. methane  
b. argon  
c. helium  
d. carbon monoxide

ref. p. 176

9.43. Which of the molecular structures shown has been identified as a dangerous carcinogen?

ANS: a

ref. p. 177

9.44. Chronic inhalation of which of the following molecular structures has been identified with angiosarcoma?

ANS: a

ref. p. 177

9.45. Air contaminant tests reveal the following concentrations over an 8-hr shift. (All values in ppm):

<table>
<thead>
<tr>
<th>Time</th>
<th>(PEL=150) Isobutyl acetate</th>
<th>(PEL = 1000) Ethyl Chloride</th>
<th>(PEL=300) Cyclohexane</th>
<th>(PEL=25) Diethylamine</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 9:00 am</td>
<td>15</td>
<td>400</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>9:00 - 11:00 am</td>
<td>10</td>
<td>200</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>11:00 - 1:00 pm</td>
<td>10</td>
<td>300</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>1:00 - 4:00 pm</td>
<td>5</td>
<td>100</td>
<td>50</td>
<td>5</td>
</tr>
</tbody>
</table>

Show all calculations to justify your answers to the following:

a. Is the PEL for any individual substance exceeded?  
b. Is the AL for any individual substance exceeded?  
c. Is the PEL for the mixture exceeded?  
d. Is the AL for the mixture exceeded?
ANS:

\[ C_{(\text{isobutyl acetate})} = \frac{15x1 + 10x2 + 10x2 + 5x3}{8} = \frac{80}{8} = 8.75 \]

\[ C_{(\text{ethyl chloride})} = \frac{400x1 + 200x2 + 300x2 + 100x3}{8} = \frac{1700}{8} = 212.5 \]

\[ C_{(\text{cyclohexane})} = \frac{200x1 + 100x2 + 150x2 + 50x3}{8} = \frac{850}{8} = 106.25 \]

\[ C_{(\text{diethylamine})} = \frac{20x1 + 10x2 + 10x2 + 5x3}{8} = \frac{75}{8} = 9.375 \]

Isobutyl acetate: $8.75 < 1/2(150) < 150$  \(\therefore\) Neither PEL nor AL exceeded

Ethyl chloride: $212.5 < 1/2(1000) < 1000$  \(\therefore\) Neither PEL nor AL exceeded

Cyclohexane: $106.25 < 1/2(300) < 300$  \(\therefore\) Neither PEL nor AL exceeded

Diethylamine: $9.375 < 1/2(25) < 25$  \(\therefore\) Neither PEL nor AL exceeded

Mixture: \( E_m = \frac{8.75}{150} + \frac{212.5}{1000} + \frac{106.25}{300} + \frac{9.375}{25} = 1.000 \)

Since \( E_m = 1.0 \), the mixture is right at the PEL. Therefore, PEL not exceeded.

Since \( E_m = 1.0 > 0.5 \), the mixture does exceed the AL.

ref. pp. 183-184

9.46. A plant's atmosphere has the following concentrations of contaminants for the times shown:

<table>
<thead>
<tr>
<th>Time</th>
<th>Diethylamine (PEL 25 ppm)</th>
<th>Phenol (PEL 5 ppm)</th>
<th>Methyl alcohol (PEL 200 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM - 10:00 AM</td>
<td>4 ppm</td>
<td>none</td>
<td>10 ppm</td>
</tr>
<tr>
<td>10:00 AM - 11:00 AM</td>
<td>6 ppm</td>
<td>none</td>
<td>30 ppm</td>
</tr>
<tr>
<td>11:00 AM - noon</td>
<td>9 ppm</td>
<td>1 ppm</td>
<td>50 ppm</td>
</tr>
<tr>
<td>noon - 4:00 PM</td>
<td>12 ppm</td>
<td>3 ppm</td>
<td>80 ppm</td>
</tr>
</tbody>
</table>

Perform all calculations to determine whether action levels and PELs for the contaminants and their mixture are exceeded. SHOW YOUR CALCULATIONS.

ANS:

\[ \text{TWA(diethylamine)} = (4x2 + 6x1 + 9x1 + 12x4)/8 = 71/8 = 8.875 \text{ ppm} \]

\[ \text{TWA (phenol)} = (0 + 0 + 1x1 + 3x4) = 13/8 = 1.625 \]

\[ \text{TWA(methyl alcohol)}=(10x2+30x1+50x1+80x4) / 8 = 410/8 = 52.5 \text{ ppm} \]

For contaminants taken separately:

\[ \text{AL(DIETHYLAMINE)} = 1/2 \text{ PEL} = (1/2)x(25) = 12.5 \text{ PPM} \]
TWA(DIETHYLAMINE) = 8.875 ppm < 12.5 ppm, so neither AL nor PEL are exceeded.

AL (PHENOL) = 1/2 PEL = (1/2)x(5) = 2.5 PPM
TWA (PHENOL) = 1.625 < 2.5 PPM, so neither AL nor PEL are exceeded.

AL (METHYL ALCOHOL) = 1/2 PEL = (1/2)x(200) = 100 PPM
TWA (METHYL ALCOHOL) = 52.5 PPM < 100 PPM, so neither AL nor PEL are exceeded.

FOR THE MIXTURE OF CONTAMINANTS:

\[ E_m = \frac{8.875}{25} + \frac{1.625}{5} + \frac{52.5}{200} \]

\[ = 0.355 + 0.325 + 0.2625 = 0.9425 \]

SINCE \( E_m = 0.9425 > 0.5 \), the AL for the mixture is exceeded.

SINCE \( E_m = 0.9425 < 1.0 \), the PEL for the mixture is not exceeded.

ref. pp. 183-184

9.47. A hand-operated bellows pump would likely be used to

   a. gather test samples for a detector tube
   b. perform calibration of breathing apparatus
   c. find the flashpoint of unknown liquids
   d. assist in CPR

   ref. p. 191

9.48. Pneumoconiosis

   a. is "dust disease of the lungs."
   b. is a bloodborne pathogen.
   c. acts more as a mutagen than a teratogen.
   d. is expected to occur whenever air contaminants exceed the PEL.

   ref. p. 173

9.49. Give a simple definition for the term "pneumoconiosis." The text identified seven different types of pneumoconiosis. Name three of these seven "oses," and for the three you have selected, identify the cause of each.

ANS. "Pneumoconiosis" simply means "dust diseases of the lungs." The seven types of pneumoconiosis named in the text are:

   Siderosis - from exposure to iron oxide dust
   Stannosis - from exposure to tin dust
   Byssinosis - from exposure to cotton dust
   Aluminosis - from exposure to aluminum dust
   Asbestosis - from exposure to asbestos fibers
   Silicosis - from exposure to silica

   ref. p. 173

9.50. In the context of occupational safety and health standards, identify each of the following terms (write out what the letters represent) and then explain the purpose of each. Explain how each term relates to others in the list.

   AL
   C
   TWA
   PEL
   TLV

   ANSWERS:

   AL "Action Level" The purpose is to set a trigger level at one-half the legal PEL limit so that employers will respond to dangers before the employee is exposed to levels at or near the legal limit (the PEL).

   C "Ceiling Level" The purpose is to set a standard beyond which employees should not be exposed, even for a little while. The time-weighted-average (TWA) is not appropriate when the OSHA table lists the PEL as a "ceiling value."

   ref. pp. 183-184
values are indicated by the letter C adjacent to the PEL as shown in Appendix A.1.

TWA "Time-Weighted Average" Refers to a standard for average exposure during a full eight-hour shift. PELs are usually stated as TWAs, but may be stated as C for "ceiling level" exposure.

PEL "Permissible Exposure Level" A maximum exposure level as stated in a regulatory standard. PELs are usually stated as TWAs, but may be stated as C for "ceiling level" exposure. PELs are usually derived from accepted TLVs.

TLV "Threshold Limit Value" For a given contaminant, a level of exposure below which the contaminant is believed not to be harmful. Although public and scientific opinion may vary on what level of contaminant exposure is harmful, the American Conference of Governmental Industrial Hygienists (ACGIH) publishes a list of TLVs considered to be appropriate. TLVs are not legally enforceable, but PELs can be derived from published TLVs. Like PELs, TLVs are usually stated as TWAs, but they may be stated as ceiling values (C).

9.51. Which of the following is subject to periodic updating or changes as published by the American Council of Governmental Industrial Hygienists (ACGIH)?

a. TLVs
b. PELs
c. Als
d. STELs

9.52. Explain the difference between a dosimeter and a direct-reading instrument.

ANS: A dosimeter, worn on the person, collects a time-weighted average exposure and is most convenient for obtaining TWA exposures; unfortunately they are beyond the state of the art for the most toxic substances.

A direct-reading instrument provides an instantaneous readout for specific contaminants. Such direct readout is more timely and convenient than sampling and laboratory analysis and more accurate than detector tube technology. Direct-reading instruments are available for such commonly encountered problems as oxygen deficiency and natural gas leaks.

9.53. A process engineer proposes a new solvent that will reduce the quantities required by the process and significantly reduce the quantities of solvent vapors released to the air inside the plant. The new solvent is trichloroethylene and it is expected to reduce the solvent vapors absorbed into the plant air by 20% by volume as compared to the old solvent (Stoddard solvent). You are called in as a Certified Safety Professional to evaluate the proposed change to the process. Do you support the proposed process change? Explain your position.

ANS: PEL (Stoddard Solvent) = 500 ppm

PEL (trichloroethylene) = 100 ppm

No; do not support the process change. Trichloroethylene is more dangerous as shown by the ratios of the PEL's: 500/100 = 5 to 1

Even though the solvent vapors would be reduced by 20% the PEL would be reduced by 80% (5 to 1).