Chemistry Answers

Part 1/Chemical Reactions in the Marine Environment

Activity 1/Elements and Compounds in the Ocean

1. Silver, antimony, chromium, cobalt, rubidium, cesium, selenium, molybdenum
2. CuS, ZnS, HgS, Ag2S, CdS, Bi2S3, PbS
3. Aluminum, niobium, lead, cadmium, arsenic, phosphorus, manganese, cerium, beryllium, plutonium, nickel, chromium, carbon, scandium, cobalt, iodine, silver, zirconium, copper, iron
4. Pb, Zn, Fe, Cd, Co, Cu, Ni, Mn, Sr, Ce, Mg
5. Chlorine, magnesium, bromine, strontium, sulfate, iron, silicon, tungsten, manganese, sodium, zinc, calcium, copper, potassium, cobalt, nickel, lead
6. Chloride, bromide, sulfate, carbonate, bicarbonate or hydrogen carbonate, fluoride, boron acid, magnesium, calcium, strontium, potassium, sodium
7. Mn, Fe, Ni, Cu, Co
8. Carbon dioxide, nitrate ion, ammonia, ammonium ion, phosphate ion
9. Fe3S3, Cu2S, ZnS, Ag2SO4, CaSO4

Activity 2/Atomic Chemical Reactions

1. \( 106CO_3^{2-} + 16NO_3^{-} + PO_4^{3-} + 54H_2O \rightarrow \text{C}_10\text{H}_6\text{N}_{17}\text{PH}_{10}\text{O}_{46} + 136O_2 \)
   \[ \text{C.N.P} = 106.16:1 \]
2. \( \text{Cl}_2 + 2\text{NABr} \rightarrow \text{Br}_2 + 2\text{NaCl} \)
3. \( 3\text{Br}_2 + 3\text{Na}_2\text{CO}_3 \rightarrow 5\text{NaBr} + \text{NaBrO}_3 + 3\text{CO}_2 \)
4. \( 6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_12\text{O}_6 + 6\text{O}_2 \)
5. \( 6\text{CO}_2 + 12\text{H}_2\text{S} \rightarrow \text{C}_6\text{H}_12\text{O}_6 + 12\text{S} + 6\text{H}_2\text{O} \)
6. \( 6\text{CO}_2 + \text{O}_2 + 14\text{H}_2\text{S} \rightarrow \text{C}_6\text{H}_12\text{O}_6 + 14\text{S} + 8\text{H}_2\text{O} \)
7. \( \text{Cu}_2\text{H}_2\text{O}_8 + 3\text{H}_2\text{SO}_4 \rightarrow 3\text{H}_2\text{S} + 6\text{H}_2\text{O} + 6\text{CO}_2 \)
8. \( 5\text{CH}_2\text{O} + 4\text{HNO}_3 \rightarrow 2\text{N}_2 + 7\text{H}_2\text{O} + 5\text{CO}_2 \)
9. \( 2\text{NaAlSi}_3\text{O}_8 + 2\text{H}_2\text{CO}_3 + 9\text{H}_2\text{O} \rightarrow 2\text{Na}^+ + 2\text{HCO}_3^- + 4\text{H}_2\text{SiO}_4 + \text{Al}_2\text{Si}_3\text{O}_8(\text{OH})_4 \)
10. \( 3\text{KAlSi}_3\text{O}_8 + 12\text{H}_2\text{O} \rightarrow 2\text{K}^+ + 2\text{HCO}_3^- + 6\text{H}_2\text{SiO}_4 + \text{KAl}_2\text{Si}_3\text{O}_10(\text{OH})_2 \)
11. \( 2\text{KMg}_3\text{AlSi}_3\text{O}_10(\text{OH})_2 + 14\text{H}_2\text{CO}_3 + \text{H}_2\text{O} \rightarrow 2\text{K}^+ + 6\text{Mg}^{2+} + 14\text{H}_2\text{CO}_3^- + 4\text{H}_2\text{SiO}_4 + \text{Al}_2\text{Si}_3\text{O}_8(\text{OH})_4 \)
12. \( \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 5\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SiO}_4 + \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O} \)

Activity 3/Identification of Halide Ions

1. a. \( \text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl}^+ + \text{NaNO}_3 \)
   b. \( \text{NaBr} + \text{AgNO}_3 \rightarrow \text{AgBr}^+ + \text{NaNO}_3 \)
   c. \( \text{NaI} + \text{AgNO}_3 \rightarrow \text{AgI}^+ + \text{NaNO}_3 \)
   d. \( \text{NaF} + \text{AgNO}_3 \rightarrow \text{No reaction} \)
2. \( \text{AgCl}, \text{silver chloride}; \text{AgBr}, \text{silver bromide}; \text{AgI}, \text{silver iodide} \)
3. \( \text{AgF}, \text{silver fluorde} \)
4. yes
5. yes
6. soluble
7. nitrate
8. sodium
9. negative
10. a) white
    b) off-white
    c) yellowish
11. Improper cleaning of equipment. Poor observation/data recording techniques. Not carefully reading labels on solution bottles.
12. Hydrochloric
13. Because chloride ions in the presence of silver ions form a white precipitate, silver chloride, and fluoride ions in the presence of silver ions form no precipitate.
14. chloride
15. chloride and sodium

Activity 4/Magnesium and its Compounds
1. metal, solid, silvery, etc.
2. white powder
3. $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$
4. solution becomes pink
5. basic
6. $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2$
7. bubbling—a gas is formed
8. $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\uparrow$
9. white powder
10. magnesium chloride, $\text{MgCl}_2$
11. yes
12. solution becomes pink
C / 64

13. basic
14. $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2 + \text{H}_2\uparrow$
15. a precipitate forms
16. $\text{MgSO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{Mg(OH)}_2\downarrow$

Activity 5/Magnesium from the Sea
1. clear, colorless solution
2. A cloudy, white, gelatinous precipitate formed. The solution above the white precipitate was clear and colorless.
4. $\text{MgSO}_4 + 2\text{NaCl} \rightarrow \text{Na}_2\text{SO}_4 + \text{Mg(OH)}_2\downarrow$
5. magnesium hydroxide
6. Use an electric current (electrolysis).

Activity 6/Biogeochemical Zonation

Transparency 1
1. (a) atmosphere: air drafts, wind, diffusion, gravity, rain/precipitation, attachment to flying objects.
   (b) water: currents, waves, diffusion, gravity, attachment to other moving things (sinking particles, swimmers).
   (c) sediments: gravity, sedimentation (burial), diffusion, digging.
2. Gravity makes objects move toward the earth, whether these objects are in the atmosphere, water or sediments. However, gravity acting upon a stone in water is not the same as gravity acting upon a stone in the air or sediments.
3. The rock is eroded by wind and rain. Then it is swept into a river and eventually carried to the ocean where silicon may be leached to form dissolved ions. Leaching also may occur during runoff or in the river, with the resultant ion carried to the sea.
4. The wind carries sand across the Sahara until it reaches the Mediterranean where it drops into the sea. The sand floats to the bottom where the silicon is leached. The resultant ions are carried by current through the Straits of Gibraltar to the eastern Atlantic.
Transparency 2

1. They need light and CO₂ to make food.
2. The zooplankton feed on the phytoplankton.

Transparency 3

1. Zooplankton satisfy their need by eating phytoplankton, other zooplankton or decaying organic matter. Fish eat phytoplankton, zooplankton and other fish.
2. The decomposition process starts with the ingestion of the zooplankton. Through the digestive process, the zooplankton's cellular material is broken down into molecules the fish can use in their physiological functions. Excess and indigestible material collects in the digestive tract and is expelled as fecal material. Once the feces is released into the marine environment, it is consumed by other marine organisms and decomposed further. This decomposition process reduces the zooplankton's cellular structure to the less complex chemical elements and molecules.

Transparency 4

1. Carbon-containing molecules are the building blocks for living tissue. Through photosynthesis, carbon is changed from the atmospheric carbon dioxide molecule to a variety of saccharide (sugar) and protein forms that are used in the cellular construction and maintenance of living organisms.
2. (a) Carbon dioxide gas in the atmosphere diffuses into the water and is dissolved in the surface layers of the ocean. (b) The carbon dioxide gas dissolved in the ocean water is used by plants during photosynthesis to become carbon in living plant tissue at the ocean's surface. (c) The plant tissue containing carbon is eaten by an animal and is excreted as an ocean fecal pellet that sinks to the bottom. The plant tissue itself can be on the bottom if the depth is less than 200 meters.

Transparency 5

1. The matter is consumed by organisms that assimilate the nutrients into their own body or release them as new particles. Fewer particles are produced with depth because of continuous decomposition.
2. NO₃⁻ reduction would occur if NO₃⁻ is available; Fe reduction, if O₂ and NO₃⁻ are absent and iron (III) is available; SO₄²⁻ reduction, if O₂, NO₃⁻ and Fe (III) are absent and SO₄²⁻ is available.

3. The dead matter would not be broken down (decomposed) by organisms. It would probably sink and be buried over time. The absence of such oxidizers in our geologic past is believed to be what is responsible for large oil deposits.

Part 2/Density Dynamics and Estuaries

Activity 1/Salinity Stratification
1. Because of the different densities of the solutions and the care taken not to mix the solutions.
2. The solutions may have mixed depending on what order was chosen.
3. They will mix.
4. Waves, tides and rainfall.

Activity 2/Salinity Predications
1. salt
2. Denser salt water flows to the bottom.
3. Surface is river water, bottom is ocean water.
4. Closest to the bottom.

Activity 3/Density and Buoyancy of the Ocean
1. The sugar makes the regular soda denser.
2. salt water

Activity 4/Estuarine Stratifications and Animal Adaptations

Problem 1

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SITE 1</th>
<th>SITE 2</th>
<th>SITE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ft</td>
<td>1.015 g/ml</td>
<td>1.006 g/ml</td>
<td>1.006 g/ml</td>
</tr>
<tr>
<td>2.5 ft</td>
<td>1.016 g/ml</td>
<td>1.006 g/ml</td>
<td>1.006 g/ml</td>
</tr>
<tr>
<td>50 ft</td>
<td>1.016 g/ml</td>
<td>1.006 g/ml</td>
<td>1.006 g/ml</td>
</tr>
<tr>
<td>75 ft</td>
<td>1.016 g/ml</td>
<td>1.006 g/ml</td>
<td>1.006 g/ml</td>
</tr>
</tbody>
</table>

This is a vertically mixed estuary.

Problem 2

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SITE 2</th>
<th>SITE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ft</td>
<td>1.002 g/ml</td>
<td>1.001 g/ml</td>
</tr>
<tr>
<td>2.5 ft</td>
<td>1.004 g/ml</td>
<td>1.002 g/ml</td>
</tr>
<tr>
<td>5.0 ft</td>
<td>1.015 g/ml</td>
<td>1.004 g/ml</td>
</tr>
<tr>
<td>75 ft</td>
<td>1.022 g/ml</td>
<td>1.006 g/ml</td>
</tr>
</tbody>
</table>

This is a salt wedge estuary.
Problem 3

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>DENSITY</th>
<th>SITE 1</th>
<th>DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ft.</td>
<td>1.010 g/ml</td>
<td>1.003 g/ml</td>
<td></td>
</tr>
<tr>
<td>2.5 ft.</td>
<td>1.013 g/ml</td>
<td>1.008 g/ml</td>
<td></td>
</tr>
<tr>
<td>5.0 ft.</td>
<td>1.022 g/ml</td>
<td>1.022 g/ml</td>
<td></td>
</tr>
<tr>
<td>7.5 ft.</td>
<td>1.024 g/ml</td>
<td>1.024 g/ml</td>
<td></td>
</tr>
</tbody>
</table>

This is a highly stratified estuary.

Problem 4

1. Between the 1.013 and 1.020 lines near the bottom; the same place.

2. Similar density

3. Yes. The water is of lower density.

Problem 5

1. SITE | DENSITY
A      | 1.026 g/ml
B      | 1.009 g/ml

2. As the density decreases, the Metridium decreases in size. As the density increases, the Metridium returns to its original shape. The Metridium expels water from its body cavity reducing the tissue contact with the external medium when it encounters lower density seawater. This is a gradual change over the time period indicated.

Problem 6

1. High density

2. Low density

3. If density decreases, fewer larvae are released.

Test Question Answers

1. It will decrease. It will decrease

2. No. Seawater in the Northern Hemisphere will be of a lower density.

3. A. As density decreases, the hermit crab hides in his shell (is not exposed).

   B. As density increases, it moves around.

4. Density
   1.003 g/ml
   1.026 g/ml
   1.020 g/ml
   1.009 g/ml

5. Depth
   0 m
   bottom
   4 m
   2 m

   Highly stratified.

Part 3/PH and Ocean Buffering

Activity 1/Acids and Bases

1. 2b and 3

2. Equation  BL Acid  BL Base
   2b  H₂CO₃⁻  H₂O
   3  HCO₃⁻  H₂O

3. (a) HCO₃⁻

4. Because HCO₃⁻ can donate a hydrogen ion.

5. Equation  Conjugate Base  Conjugate Acid
   2b  HCO₃⁻  H₂O⁺
   3  CO₂⁻  H₃O⁺

6. (b) HCO₃⁻ and CO₂⁻

7. The water is in the liquid state.

8. (g) means gaseous state
   (aq) means dissolved in water

9. It is maintaining an equilibrium between the gaseous state in the earth's atmosphere and an aqueous state in the ocean.

   (For example, carbon dioxide gas is traveling from the atmosphere to the water where it is dissolved. This reaction is lending toward equilibrium with respect to CO₂ gas and dissolved CO₂, which is coming out of solution [like bubbles in soda pop] and entering the atmosphere.)

10. They are also moving to equilibrium concentrations, which are based on the amount of the compounds and the buffering ability of the ocean.
11. Hydronium ion

12. Both, because it can function as a proton donor and a proton acceptor. A Bronsted-Lowry acid is a proton donor. A Bronsted-Lowry base is a proton acceptor.

13. Reactants: HCO₃⁻, H₂O
   Products: CO₃²⁻, H₃O⁺

Activity 2/Inorganic Carbon Compound Reactions and their Equilibrium Constants

1. 

<table>
<thead>
<tr>
<th>Equilibrium Constant Expression</th>
<th>K₁ = CO₂(aq)</th>
<th>CO₂(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂, H₂O</td>
<td>HCO₃⁻, H₂O⁺</td>
<td>K₂ = [HCO₃⁻][H₂O⁺] / [CO₂]</td>
</tr>
<tr>
<td></td>
<td>HCO₃⁻, H₂O</td>
<td>K₃ = [H₃O⁺][CO₃²⁻] / [HCO₃⁻]</td>
</tr>
</tbody>
</table>

2. 

<table>
<thead>
<tr>
<th>K₂</th>
<th>K₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.41 x 10⁻⁷</td>
<td>4.17 x 10⁻¹⁰</td>
</tr>
<tr>
<td>1.70 x 10⁻⁷</td>
<td>3.72 x 10⁻¹⁰</td>
</tr>
<tr>
<td>1.00 x 10⁻⁷</td>
<td>7.41 x 10⁻¹⁰</td>
</tr>
</tbody>
</table>

Table 5

<table>
<thead>
<tr>
<th>K₂</th>
<th>K₃</th>
<th>HCO₃⁻</th>
<th>CO₃²⁻</th>
<th>H₃O⁺</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0</td>
<td>10.5</td>
<td>10.0</td>
<td>9.33</td>
<td>9.12</td>
<td>7.76</td>
</tr>
<tr>
<td>10.2</td>
<td>8.32</td>
<td>5.65</td>
<td>3.87</td>
<td>9.33</td>
<td>7.76</td>
</tr>
<tr>
<td>9.33</td>
<td>6.46</td>
<td></td>
<td>9.33</td>
<td></td>
<td>7.76</td>
</tr>
<tr>
<td>9.12</td>
<td>6.17</td>
<td>4.47</td>
<td>4.67</td>
<td>12.4</td>
<td>7.76</td>
</tr>
<tr>
<td>7.76</td>
<td>4.47</td>
<td>4.64</td>
<td>12.8</td>
<td></td>
<td>7.76</td>
</tr>
<tr>
<td>7.76</td>
<td>3.98</td>
<td>22.7</td>
<td>99.4</td>
<td></td>
<td>7.24</td>
</tr>
</tbody>
</table>

Activity 3/What is pH?

1. a. 4.0
   b. 14
   c. 7.1
   d. 1.6
   e. 4.45
   f. 7.54

2. a. 1 x 10⁻⁵
   b. 1 x 10⁻¹

Questions

1. CO₂
2. CO₂
3. From the atmosphere
4. CO₂ + H₂O → H₂CO₃
5. Increasing dissolved CO₂ makes a solution more acidic.
6. (student answer)
7. (student answer)
8. salt, neutralization
9. HNO₃, Pb(OH)₂
10. H₂CO₃, NaOH
11. 7
12. The reaction of a salt with water to produce a slightly acidic or slightly basic solution.
13. (It will be acidic.) yes
14. (It will be basic.) yes
15. weak
16. strong
17. (student answer)
18. (student answer)
19. Hydrochloric acid furnishes more hydrogen (hydronium) ions in solution. pH is a measure of hydrogen ions in solution.
20. basic
21. To neutralize an "acid" stomach to combat acidosis in heart attack victims

22. (student answer)

23. vinegar, lemon juice

24. acidity

25. (student answer)

26. Acids and bases neutralize each other.

27. A solution that resists a change in pH.

**Part 4/The Behavior of Gases in the Marine Environment**

**Activity 1/Seawater and Pressure**

1. Because of pressure differences, pressure is greatest on the bottom hole.

2. Water would stream out even farther because the pressure would be greater.

3. No difference

4. The distance is less because the pressure is decreasing.

**Activity 2/The Cartesian Diver**

1. fresh

2. salty

3. Pressure on the air in the dropper is increased. More water comes in. The dropper gets heavier and it sinks.

4. Releasing the pressure on the air in the dropper reverses the process described in #3.

5. Greater salinity makes the water denser and it will support a greater mass. Thus the dropper must be denser to submerge in salt water than in fresh. That means greater pressure must be put on the air inside the dropper. This is why more pressure is required to cause the dropper to dive in salt water.

**Activity 3/Scuba Diving and the Gas Laws**

**Boyle's Law**

1. 66 feet = 3.0 atm pressure
   \[ P_1V_1 = P_2V_2 \]
   \[ (1.0 \text{ atm})(4.0 \text{ liters}) = (3.0 \text{ atm})V_2 \]
   \[ V_2 = 1.31 \text{ liters} \]

2. Depth | Pressure | Volume | Density
   ------- | -------- | ------ | ------
   surface | 1.0 atm  | 4.0 liters | 1.0 kg/liter |
   33 ft.  | 2.0 atm  | 2.0 liters | 2.0 kg/liter |
   99 ft.  | 4.0 atm  | 1.0 liter  | 4.0 kg/liter |
   132 ft. | 5.0 atm  | 0.80 liter  | 5.0 kg/liter |

3. \[ P_1V_1 = P_2V_2 \]
   surface: \( (2.0 \text{ atm})(1.0 \text{ liter}) = (1.0 \text{ atm})V_2 \)
   \[ V_2 = 2.0 \text{ liters} \]

   99 feet: \( (2.0 \text{ atm})(1.0 \text{ liter}) = (4.0 \text{ atm})V_2 \)
   \[ V_2 = 0.50 \text{ liter} \]

4. Site | Depth | \( V_2 \) | Burst
   ------ | ----- | ------ | ----
   A      | 66 ft | 9.0 liters | yes |
   B      | 132 ft| 5.0 liters | yes |
   C      | 99 ft | 2.0 liters | no  |
   D      | 66 ft | .99 liter  | no  |

**Charles' Law**

1. As the temperature of the gas increases (at constant pressure), volume increases. This is a direct relationship.

2. a) It will increase.
   b) The gas will expand.
   c) It might explode.

3. a) \( 13^\circ \text{C} = 1.5 \text{ liters} \)
   \( 25^\circ \text{C} = 3.0 \text{ liters} \)
   b) \( 13^\circ \text{C} \). The low temperature gas occupies less volume so more gas can be added to an air tank.

**Dalton's Law**

1. a. \( P_{total} = P_{O_2} + P_{N_2} \)
   \( 810 = 150 \text{ mm } + P_{N_2} \)
   \( P_{N_2} = 660 \text{ mm } Hg \)
b. \[ \%O_2 = \left( \frac{P_{O_2}}{P_{total}} \right) \times 100 = \left( \frac{150 \text{ mm} \times 810 \text{ mm}}{810 \text{ mm}} \right) \times 100 = 19\% \]

\[ \%N_2 = \left( \frac{P_{N_2}}{P_{total}} \right) \times 100 = \left( \frac{660 \text{ mm} \times 810 \text{ mm}}{810 \text{ mm}} \right) \times 100 = 81\% \]

c. Yes, very close.

2. 132 feet = 50 atm

\[ P_{O_2} = P_{total} \times 21\% = 50 \text{ atm} \times 21 \]

\[ P_{O_2} = 1 \text{ atm} \]

\[ 50 \text{ atm} \times 760 \text{ mm Hg/atm} = 3,800 \text{ mm Hg} \]

\[ P_{O_2} = P_{total} \times 0.21 = 3,800 \times 0.21 = 800 \times 10^2 \text{ mm Hg} \]

3. 500 feet = 160 atm [1 atm at the surface plus 150 atm more (500,33 feet)]

\[ P_{total} = (160 \text{ atm} \times 760 \text{ mm}) + 1 \text{ atm} = 1,200 \text{ mm Hg} \]

\[ \%O_2 = \left( \frac{P_{O_2}}{P_{total}} \right) \times 100 = \left( \frac{210 \text{ mm}}{1,200 \text{ mm}} \right) \times 100 = 18\% \]

Henry's Law

1. Gas dissolved
   
   \[
   \text{Gas dissolved} \quad \text{pressure}
   \]

2. At 132 feet, the increase in depth and in pressure results in increases in nitrogen dissolved.

Test Question Answers

1. a) If the diver holds his breath during ascent, he risks bursting his lungs. This is possible because as the pressure decreases in his lungs the volume of the gas increases (Boyle's law).
   
   b) If the ascent is too quick because he panics, he may develop the bends. The decrease in pressure would force nitrogen from the tissues faster than it can be removed from the bloodstream. Nitrogen may have entered his bloodstream in the form of bubbles that lodged in his joints. This problem is explained by Henry's law. Using a recompression chamber should alleviate the pain. The diver will be fine if he remains calm, ascends slowly and exhales.

2. See lecture material.

3. a) Boyle's law. If a diver holds his breath during ascent, the pressure decreases while the volume in his lungs increases. If the maximum expansion is exceeded, the lungs will burst.

   b) Dalton's law. At depths greater than 100 feet the partial pressure of nitrogen increases to a level that produces nitrogen narcosis.

   c) Boyle's law. As the pressure increases during a descent, the volume of the gas in the air spaces decreases and eventually produces a squeezing feeling.

   d) Henry's law. Bubbles form in the bloodstream as nitrogen is released from tissues too quickly during a rapid ascent. As the pressure decreases on ascent, the amount of nitrogen that can remain in the tissues decreases, thus producing bubbles that bring about decompression sickness.

4. a) Boyle's Law

   b) Charles' Law

   c) Henry's Law

5. 160mm Hg of O_2 and 600mm Hg of N_2 (based on 21% oxygen and 79% nitrogen). Yes. The pressures change. But the percent of each gas in the air remains the same.

6. true

7. false
8. 40 atm at 99 feet
    79% of air is N₂
    \[ P_{N₂} = P_{Es} \times \%N₂ \]
    \[ = 4.0 \text{ atm} \times 0.79 \]
    \[ = 3.2 \text{ atm} \]

    \[ 40 \text{ atm} = 3.040 \text{ mm Hg} \]
    \[ P_{N₂} = 3.040 \text{ mm Hg} \times 0.79 \]
    \[ = 2.400 \text{ mm Hg} \]

9. lower

10. Water is denser than air.

11. 1.

12. lungs, middle ear and sinus cavities

13. Air tanks deliver air at the same pressure as the diver's surroundings.

14. loss of consciousness, brain damage, heart attacks.

15. greater

16. pain in the joints, nerve damage, paralysis

17. the bends, decompression sickness or caisson disease

18. Hold points allow dissolved nitrogen to escape.

19. less

**Activity 4/Underwater Research Facilities: Hydrolab**

1. Henry's, Dalton's and Boyle's laws

2. He may develop the bends during his ascent due to the nitrogen remaining in his tissues and fat.

3. A surface interval is the time required at the surface for a diver to gradually lose nitrogen.

4. 50 feet = 2.5 atm

5. depth and time

6. No. At Hydrolab, divers live and usually work at depths less than 100 feet. This means that partial pressure does not reach the level necessary to induce nitrogen narcosis.

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7. It takes approximately 8 to 12 hours to become saturated at a new depth. It takes approximately the same time to return to surface pressure saturation.

**Activity 5/Dramatic Pressure Change**

1. water/moisture

2. student calculations

3. student calculations

4. student calculations

5. water/moisture in the normal kernel.

6. normal

7. Pike's Peak
   The atmospheric/external pressure is less

8. student graph

9. student data table

10. 264 ft. or 80 meters. The air above the ocean exerts one atmosphere of pressure.

**Activity 6/Sea Squeeze**

1. Pressure is inversely related to volume.

2. \( PV_1 = PV_2 \) or \( PV = k \)

3. As divers descend, the pressure increases and their lungs feel a "squeeze." As divers ascend, the pressure decreases and their lungs expand.

**Activity 7/Diver's Lung**

1. same as Activity 6

2. same as Activity 6

3. same as Activity 6

**Activity 8/Pressure Versus Volume**

1. Fill the buret with water and pour the water into a graduated cylinder through the top, not the tip, to avoid losing the water that fills the tip.

2. student answer

3. student answer
4. The volume of a gas is inversely related to the pressure exerted on the gas.

5. \( P_1V_1 = P_2V_2 \)

6. student answer

7. student answer

8. inversely

9. student graph

10. student answer

11. \[
\begin{array}{c}
1.00 \text{ atm} \\
34 \text{ ft.}
\end{array} \quad \begin{array}{c}
1 \text{ ft.} \\
12 \text{ in.}
\end{array} \quad \begin{array}{c}
1 \text{ in.} \\
2.54 \text{ cm}
\end{array} = 9.6 \times 10^{-4} \text{ atm cm}
\]

12. student answer

13. water vapor

14. Not considering the pressure due to water vapor in the buret. Not reading the buret or metric ruler properly.

15. It is less dense because it did not contain any salt.

16. more—Salty water is more dense than fresh water.

17. It will decrease. Pressure is increasing as a diver descends.

18. They will expand and could burst.

19. self-contained underwater breathing apparatus