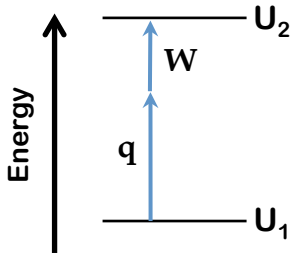
**#1. (10 points) Short Answer Questions**

**a) The energy change shown in the diagram at right corresponds to a(n):**

- ☐ EXOTHERMIC CONTRACTION
- ■ ENDOTHERMIC CONTRACTION
- ☐ EXOTHERMIC EXPANSION
- ☐ ENDOTHERMIC EXPANSION




**b) Name the following compounds:**

$CuClO_3$ ___copper (I) chlorate_____

$CaSO_4 \cdot 7\ H_2O$ __calcium sulphate heptahydrate_____

**c) Starting with an atom of copper-63, we remove three protons, add one neutron, and remove 6 electrons from the atom. Fill in the blanks for our new species:**

| Number of protons | Number of neutrons | Number of electrons | Chemical Symbol |
|---|---|---|---|
| 26 | 34 | 23 | $^{60}_{26}Fe^{3+}$ |

**d) Four balloons are filled to the same volume with the following gases and a small hole is made in each balloon. Circle the one which will deflate the fastest and underline the one that will deflate the slowest.** $SO_3$ Kr $O_2$ $CO_2$

**e) When the power was turned off to a 125 L water heater, the temperature of the water dropped from 75.0°C to 22.5°C. The amount of heat, in kilojoules, transferred to/from the surroundings was:** ___$q = mc\Delta T = -2.75 \times 10^4$ kJ_____.

**f) A solution of $CH_3Cl$ and $H_2O$ is 45% $H_2O$ *by mass*; $H_2O$ is the solvent.** TRUE FALSE

**g) Toothpaste contains 0.21% m/v sodium fluoride. This concentration expressed in mol/L is:** _____0.050 mol/L_____

**BONUS: The standard heat of formation of solid ammonium chloride is –314.4 kJ. Write the chemical equation for the reaction to which this value applies (include phases).**

$$\tfrac{1}{2}\ N_2\ (g) + 2\ H_2\ (g) + \tfrac{1}{2}\ Cl_2\ (g) \rightarrow NH_4Cl\ (s)$$

**#2. Elemental lead can be isolated from basic solutions using the following half reactions:**

$$Pb(OH)_3^- (aq) \rightarrow Pb (s)$$

$$Fe(OH)_2 (s) \rightarrow Fe(OH)_3 (s)$$

**a) (4 pts) Determine the balanced chemical equation for the overall redox reaction.**

**THIS IS SILBERBERG SUGGESTED PROBLEM 19.16c**

$$Pb(OH)_3^- (aq) \rightarrow Pb (s)$$

$$3OH^- (aq) + 3H^+ (aq) + Pb(OH)_3^- (aq) \rightarrow Pb (s) + 3 H_2O (l) + 3 OH^- (aq)$$

$$2e^- (aq) + Pb(OH)_3^- (aq) \rightarrow Pb (s) + 3 OH^- (aq)$$

$$Fe(OH)_2 (s) \rightarrow Fe(OH)_3 (s)$$

$$Fe(OH)_2 (s) + OH^- (aq) \rightarrow Fe(OH)_3 (s) + e^-$$

$$2 Fe(OH)_2 (s) + 2 OH^- (aq) \rightarrow 2 Fe(OH)_3 (s) + 2 e^-$$

$$2 Fe(OH)_2 (s) + Pb(OH)_3^- (aq) \rightarrow Pb (s) + 2 Fe(OH)_3 (s) + OH^- (aq)$$

reducing agent oxidizing agent

**b) (1 pt) Identify the oxidizing agent and the reducing agent in your reaction above.**

**c) (5 pts) 2.045 g of $Fe(OH)_2$ is added to 127.0 mL of a 0.0671 M aqueous basic solution of $Pb(OH)_3^-$ and 0.813 g of solid lead is obtained. What was the yield of the redox reaction?**

**THIS IS VERY SIMILAR TO A LECTURETOOLS QUESTION DONE IN CLASS**

$$\text{? g Pb from } Fe(OH)_2 = 2.045\text{g } Fe(OH)_2 \times \frac{\text{mol } Fe(OH)_2}{89.86 \text{ g } Fe(OH)_2} \times \frac{1 \text{ mol Pb}}{2 \text{ mol } Fe(OH)_2} \times \frac{207.2 \text{ g Pb}}{\text{mol Pb}}$$

$$= 2.36 \text{ g}$$

$$\text{? g Pb from } Pb(OH)_3^- = 0.1270 \text{ L solution} \times \frac{0.0671 \text{ mol } Pb(OH)_3^-}{\text{L solution}} \times \frac{1 \text{ mol Pb}}{1 \text{ mol } Pb(OH)_3^-} \times \frac{207.2 \text{ g Pb}}{\text{mol Pb}}$$

$$= 1.76 \text{ g}$$

**Therefore, $Pb(OH)_3^-$ is the limiting reagent.**

$$\% \text{ yield} = \frac{0.813 \text{ g}}{1.76 \text{ g}} \times 100\% = 46.2\%$$

**Answer:** _____

**#3. You are trying to identify an unknown gas. A 100.0 mL glass vessel weighs 45.1066 g when evacuated and 45.1267 g when filled with the gas.**

**THESE QUESTIONS ARE BASED ON THE CHAPTER 4 EXAMPLES IN THE NOTES**

**a) (5 pts) If the pressure and temperature of the gas are 49.19 mmHg and 21.05°C respectively, what is the molar mass of the gas, in g/mol?**

$$m_{gas} = 45.1267\ g - 45.1066\ g = 0.0201\ g$$

$$P = 49.10\ mmHg \times \frac{1\ atm}{760\ mmHg} = 0.06472\ atm$$

$$T = 21.05 + 273.15 = 294.2\ K$$

$$n = \frac{PV}{RT} = \frac{0.06472\ atm \times 0.1000\ L}{0.08206\ L \cdot atm \cdot mol^{-1} \cdot K^{-1} \times 294.2\ K} = 0.0002681\ mol$$

$$\therefore MM = \frac{0.0201\ g}{0.0002681\ mol} = 74.98\ g/mol$$

**Answer:** _____

**b) (2 pts) The empirical formula of the gas is found to be $CH_3$. What is the molecular formula of the gas?**

$$n = \frac{MF\ mass}{EF\ mass} = \frac{74.98}{15.03} = 5$$

$$\therefore CH_3 \times 5 = C_5H_{15}$$

**Answer:** _____

**c) (3 pts) The temperature of the vessel in part (a) is raised to 505.4K. In order to maintain a constant pressure, some of the gas is allowed to escape. What is the mass, in mg, of gas that escapes?**

$$m_2 = m_1 \times \frac{T_1}{T_2} = 0.0201\ g \times \frac{294.2\ K}{505.4\ K} = 0.0117\ g$$

$$\Delta m = m_1 - m_2 = 0.0201\ g - 0.0117\ g = 0.0084\ g \times \frac{1000\ mg}{1\ g} = 8.4\ mg$$

**Answer:** _____

**#4. Dr. Fox decides to demonstrate Boyle's law while scuba diving. She takes a syringe filled with 16.0 mL of air from the surface (which is at an atmospheric pressure of 1.033 bar and a temperature of 26.78°C) with her on a dive to an unknown depth.**

**THIS IS A NEW QUESTION**

**a) (3 pts) During the dive, the volume of the air in the syringe drops to 7.50 mL. What is the pressure at this unknown depth, in bars?**

$$P_2 = P_1 \times \frac{V_1}{V_2} = 1.033 \text{ bar} \times \frac{16.0 \text{ mL}}{7.50 \text{ mL}} = 2.204 \text{ bar}$$

**Answer =** _____

**b) (3 pts) Scuba divers are taught that pressure increases by exactly 1 bar for every 10 m of depth. What was the depth of Dr. Fox's dive, in metres?**

**The pressure is already 1.033 bar at the surface. Therefore, the *increase* in pressure is:**

**$\Delta P = 2.204 \text{ bar} - 1.033 \text{ bar} = 1.170 \text{ bar}$**

$$?\text{ m depth} = 1.170 \text{ bar} \times \frac{10 \text{ m}}{1 \text{ bar}} = 11.70 \text{ m}$$

**Answer =** _____

**c) (4 pts) If the mol fraction of oxygen in air is 0.218, calculate the number of moles of oxygen in the syringe.**

$$P_{O_2} = \chi_{O_2} \times P_T = 0.218 \times 1.033 \text{ bar} = 0.225 \text{ bar}$$

$$\text{T} = 26.78 + 273.15 = 299.93 \text{ K}$$

$$?\text{mol}O_2 = \frac{\text{PV}}{\text{RT}} = \frac{0.225 \text{ bar} \times 0.0160 \text{ L}}{0.083145 \text{L} \cdot \text{bar} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 299.93 \text{ K}} = 0.000144 \text{ mol}$$

**Answer =** _____

**#5. For the following reaction:**

$$2\ C_2H_6\ (g) + 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (l) \qquad \Delta H^o = -3119\ kJ$$

**THIS QUESTION IS VERY SIMILAR TO AN EXAMPLE SHOWN IN THE DGD**

**a) (3 pts) How much heat, in kJ, is associated with the combustion of 10.0 g of ethane?**

$$?\ mol\ C_2H_6 = 10.0\ g \times \frac{mol}{30.07\ g} = 0.3326\ mol$$

$$?\ mol\ kJ\ heat = 0.3326\ mol\ C_2H_6 \times \frac{-3119\ kJ}{2\ mol\ C_2H_6} = -518\ kJ$$

**Answer:** _____

**b) (3 pts) What is the quantity of work, in kJ, evolved in the combustion of 10.0 g of ethane at 25.00°C? (Assume an exact stoichiometric quantity of oxygen is present).**

$$?\ mol\ O_2 = 0.3326\ mol \times \frac{7\ mol\ O_2}{2\ mol\ C_2H_6} = 1.164\ mol$$

$$?\ mol\ CO_2 = 0.3326\ mol \times \frac{4\ mol\ CO_2}{2\ mol\ C_2H_6} = 0.6652\ mol$$

$$T = 25.00 + 273.15 = 298.15\ K$$

$$W = -\Delta n_{gas} RT = -[0.6652 - (1.164+0.3326)\ mol] \times 8.3145\ J \cdot mol^{-1} \cdot K^{-1} \times 298.15\ K$$

$$= +2061\ J \times \frac{1\ kJ}{1000\ J} = +2.06\ kJ$$

**Answer:** _____

**c) (2 pts) Explain the significance of the *sign* of your answer in part (a) in one or two sentences.**

**The sign is NEGATIVE, indicating that heat is transferred from the system to the surroundings. This makes sense, because the reaction is EXOTHERMIC.**

**d) (2 pts) Calculate the change in internal energy for the combustion of 10.0 g of ethane.**

**$\Delta U = q + W = -518\ kJ + 2.06\ kJ = -516\ kJ$**

**Answer:** _____