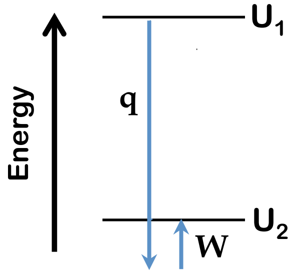
#1. (10 points) Short Answer Questions

a) Starting with an atom of germanium-72, we add 3 protons, add 6 neutrons, and add 3 electrons to the atom. Fill in the blanks for our new species:

Number of protons	Number of neutrons	Number of electrons	Chemical Symbol
35	46	35	$^{81}_{35}Br$

b) 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. Xe SO_3 O_2 [✓ CH_4]

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



- ☒ EXOTHERMIC CONTRACTION
- ☐ ENDOTHERMIC CONTRACTION
- ☐ EXOTHERMIC EXPANSION
- ☐ ENDOTHERMIC EXPANSION

d) Name the following compounds:

$Co(NO_2)_2$ ___cobalt (II) nitrite____________________

$MgCrO_4 \bullet 4\ H_2O$ ___magnesium chromate tetrahydrate__________

e) When the power was turned on to a 105 L water heater, the temperature of the water raised from 21.0°C to 66.5°C. The amount of heat, in kilojoules, transferred to/from the water was: ______$q = mc\Delta T = 2.0 \times 10^4$ kJ__________________.

f) A solution of CH_3Cl and H_2O is 46% H_2O *by mass*; H_2O is the solvent. TRUE **FALSE**

g) Toothpaste contains 0.24% m/v sodium fluoride. This concentration expressed in mol/L is: ________0.057 mol/L____________________________

BONUS: The standard heat of formation of solid silver nitrate is –127 kJ. Write the chemical equation for the reaction to which this value applies (include phases).

$$\tfrac{1}{2}\ N_2\ (g)\ +\ Ag\ (s)\ +\ \tfrac{3}{2}\ O_2\ (g)\ \rightarrow\ AgNO_3\ (s)$$

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

$$Sn(OH)_3^- \text{ (aq)} \rightarrow Sn \text{ (s)}$$

$$Fe(OH)_2 \text{ (s)} \rightarrow Fe(OH)_3 \text{ (s)}$$

THIS IS SILBERBERG SUGGESTED PROBLEM 19.16c

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

$$Sn(OH)_3^- \text{ (aq)} \rightarrow Sn \text{ (s)}$$

$$3OH^- \text{ (aq)} + 3H^+ \text{ (aq)} + Sn(OH)_3^- \text{ (aq)} \rightarrow Sn \text{ (s)} + 3\,H_2O \text{ (l)} + 3\,OH^- \text{ (aq)}$$

$$2e^- \text{ (aq)} + Sn(OH)_3^- \text{ (aq)} \rightarrow Sn \text{ (s)} + 3\,OH^- \text{ (aq)}$$

$$Fe(OH)_2 \text{ (s)} \rightarrow Fe(OH)_3 \text{ (s)}$$

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

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

$$2\,Fe(OH)_2 \text{ (s)} + Sn(OH)_3^- \text{ (aq)} \rightarrow Sn\text{(s)} + 2\,Fe(OH)_3 \text{ (s)} + OH^- \text{ (aq)}$$

reducing agent

oxidizing agent

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

c) **(5 pts) 1.093 g of $Fe(OH)_2$ is added to 120.0 mL of a 0.0894 M aqueous basic solution of $Sn(OH)_3^-$ and 0.633 g of solid tin is obtained. What was the yield of the redox reaction?**

THIS IS VERY SIMILAR TO A LECTURETOOLS QUESTION DONE IN CLASS

$$\text{? g Sn from Fe(OH)}_2 = 1.093 \text{ g Fe(OH)}_2 \times \frac{\text{mol Fe(OH)}_2}{89.86 \text{ g Fe(OH)}_2} \times \frac{1 \text{ mol Sn}}{2 \text{ mol Fe(OH)}_2} \times \frac{118.7 \text{ g Sn}}{\text{mol Sn}}$$
$$= 0.722 \text{ g}$$

$$\text{? g Sn from Sn(OH)}_3^- = 0.1200 \text{ L solution} \times \frac{0.0894 \text{ mol Sn(OH)}_3^-}{\text{L solution}} \times \frac{1 \text{ mol Sn}}{1 \text{ mol Sn(OH)}_3^-} \times \frac{118.7 \text{ g Sn}}{\text{mol Sn}}$$
$$= 1.27 \text{ g}$$

Therefore, $Fe(OH)_2$ is the limiting reagent.

$$\%\text{ yield} = \frac{0.633 \text{ g}}{0.722 \text{ g}} \times 100\% = 87.6\%$$

Answer: ______________________________

#3. You are trying to identify an unknown gas. A 100.0 mL glass vessel weighs 45.1066 g when evacuated and 45.1863 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 148.8 mmHg and 20.75°C respectively, what is the molar mass of the gas, in g/mol?

$$m_{gas} = 45.1863\text{ g} - 45.1066\text{ g} = 0.0797\text{ g}$$

$$P = 148.8\text{ mmHg} \times \frac{1\text{ atm}}{760\text{ mmHg}} = 0.1958\text{ atm}$$

$$T = 20.75 + 273.15 = 293.9\text{ K}$$

$$n = \frac{PV}{RT} = \frac{0.1958\text{ atm} \times 0.1000\text{ L}}{0.08206\text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1} \times 293.9\text{ K}} = 0.0008118\text{ mol}$$

$$\therefore \text{MM} = \frac{0.0797\text{ g}}{0.0008118\text{ mol}} = 98.18\text{ g/mol}$$

Answer: ______________________________

b) (2 pts) The empirical formula of the gas is found to be CH_2. What is the molecular formula of the gas?

$$n = \frac{\text{MF mass}}{\text{EF mass}} = \frac{98.12}{14.02} = 7$$

$$\therefore CH_2 \times 7 = C_7H_{14}$$

Answer: ______________________________

c) (3 pts) The temperature of the vessel in part (a) is raised to 469.4 K. 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?

$$m_2 = m_1 \times \frac{T_1}{T_2} = 0.0797\text{ g} \times \frac{293.9\text{ K}}{469.4\text{ K}} = 0.0499\text{ g}$$

$$\Delta m = m_1 - m_2 = 0.0797\text{ g} - 0.0499\text{ g} = 0.0298\text{ g} \times \frac{1000\text{ mg}}{1\text{ g}} = 29.8\text{ mg}$$

Answer: ______________________________

#4. Dr. Fox decides to demonstrate Boyle's law while scuba diving. She takes a syringe filled with 18.0 mL of air from the surface (which is at an atmospheric pressure of 1.014 bar and a temperature of 25.95°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 5.40 mL. What is the pressure at this unknown depth, in bars?**

$$P_2 = P_1 \times \frac{V_1}{V_2} = 1.014 \text{ bar} \times \frac{18.0 \text{ mL}}{5.40 \text{ mL}} = 3.38 \text{ bar}$$

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 1.014 bar at the surface. Therefore, the *increase* in pressure is:

$$\Delta P = 3.38 \text{ bar} - 1.014 \text{ bar} = 2.37 \text{ bar}$$

$$? \text{ m depth} = 2.37 \text{ bar} \times \frac{10 \text{ m}}{1 \text{ bar}} = 23.7 \text{ m}$$

Answer = ______________________________

c) **(4 pts) If the mol fraction of oxygen in air is 0.209, calculate the number of moles of oxygen in the syringe.**

$$P_{O_2} = \chi_{O_2} \times P_T = 0.209 \times 1.014 \text{ bar} = 0.212 \text{ bar}$$

$$\text{T} = 25.95 + 273.15 = 299.1 \text{ K}$$

$$?\text{molO}_2 = \frac{\text{PV}}{\text{RT}} = \frac{0.212 \text{ bar} \times 0.0180 \text{ L}}{0.083145\text{L} \cdot \text{bar} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 299.91 \text{ K}} = 0.000153 \text{ mol}$$

Answer = ______________________________

#5. For the following reaction:

$$2\ C_3H_6\ (g)\ +\ 9\ O_2\ (g)\ \rightarrow\ 6\ CO_2\ (g)\ +\ 6\ H_2O\ (l) \qquad \Delta H^o = -4116\ kJ$$

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 5.00 g of propene?

$$?\ \text{mol}\ C_3H_6 = 5.00\ \text{g} \times \frac{\text{mol}}{42.078\ \text{g}} = 0.1188\ \text{mol}$$

$$?\ \text{mol kJ heat} = 0.1188\ \text{mol}\ C_3H_6 \times \frac{-4116\ \text{kJ}}{2\ \text{mol}\ C_3H_6} = -245\ \text{kJ}$$

Answer: ______________________________

b) (3 pts) What is the quantity of work, in kJ, evolved in the combustion of 5.00 g of propene at 25.00°C? (Assume an exact stoichiometric quantity of oxygen is present).

$$?\ \text{mol}\ O_2 = 0.1188\ \text{mol} \times \frac{9\ \text{mol}\ O_2}{2\ \text{mol}\ C_3H_6} = 0.5346\ \text{mol}$$

$$?\ \text{mol}\ CO_2 = 0.1188\ \text{mol} \times \frac{6\ \text{mol}\ CO_2}{2\ \text{mol}\ C_2H_6} = 0.3540\ \text{mol}$$

$$T = 25.00 + 273.15 = 298.15\ \text{K}$$

$$W = -\Delta n_{gas}RT = -[0.3540 - (0.1188+0.5346)\ \text{mol}] \times 8.3145\ \text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1} \times 298.15\ \text{K}$$

$$= +742\ \text{J} \times \frac{1\ \text{kJ}}{1000\ \text{J}} = +0.742\ \text{kJ}$$

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 5.00 g of propene.

$$\Delta U = q + W = -246\ \text{kJ} + 0.742\ \text{kJ} = -244\ \text{kJ}$$

Answer: ______________________________