Chemistry Course – Problem Solving Sessions – PA 2

1. Determine the Lewis structure of the following molecules: a) SO_2Cl_2; b) $POCl_3$; c) ClF_3; and d) $XeOF_4$. Determine the most probable geometry according to Valence Shell Electron Pair Repulsion (VSEPR) theory, as well as their polarity, explaining your reasoning.
   Ans: a) Distorted tetrahedron and polar; b) Trigonal pyramid and polar; c) T-shaped and polar; d) Square pyramid and polar.

2. A compound gave the following percentages in analysis: C 30.45; H 3.83; Cl 45.69; O 20.23. The vapor density of the compound is 5.48 times that of air, which is equal to 1.29 g L^{-1} at STP. What is the molecular formula of the compound?
   Ans: $C_4H_6Cl_2O_2$.

3. A storage tank contains a gas at 5 °C and 5 atm. Determine the limiting temperature (in Kelvin) to which the gas can be heated so that the safety valve opens, if it is set at 10 atm.
   Ans: 556 K.

4. Dioxygen is usually supplied in 15 L cylinders containing about 400 g. If these cylinders can withstand a maximum temperature of 50 °C, calculate the pressure (in atm) for which they must be designed.
   Ans: Maximum pressure 22.1 atm.

5. A certain gas has a density of 1.429 g/L at standard conditions (STP). Calculate its density at 30 °C and 750 mmHg.
   Ans: 1.3 g/L.

6. Inside a 5 L container filled with nitrogen at 25 °C and 2.4 atm pressure, a capsule containing 5 g of helium breaks. Calculate the partial pressures of both gases and the total pressure, as well as the composition of the mixture in mole fraction and volume %.
   Ans: P_{He} = 6.1 atm, P_{N_2} = 2.4 atm; total pressure = 8.5 atm; $X(N_2)$ = 0.282; X(He) = 0.718; % V(N_2) = 28.2% and % V(He) = 71.8%.

7. In a 1000 cm^3 container, 10 g of solid iodine are introduced; it is then filled with nitrogen gas to a pressure of 750 mmHg at 20°C, and sealed. The whole system is heated to 300°C, causing all the iodine to vaporize (assume only I_2 molecules are formed). Calculate the total pressure inside the container. Assume the volume of solid iodine is negligible.
   Ans: 3.78 atm.

8. When 100 mL of dry oxygen measured at 20°C and 750 torr are collected over water at 25°C and 750 torr, the resulting volume is 105 mL. Calculate the vapor pressure of water at 25°C.
   Ans: 23.5 torr.

9. In a 200 cm^3 cylinder, there is nitrogen saturated with water vapor at 80 °C and a total pressure of 1 atm. The contents of the cylinder are transferred to another 50 cm^3 cylinder at the same temperature. What will be the partial pressure of nitrogen and water vapor, as well as the total pressure in the new cylinder? The vapor pressure of water at 80 °C is 355 mmHg.
   Ans: P_nitrogen = 1620 mmHg; P_total = 1975 mmHg.

10. At a total pressure of 740 mmHg and 30 °C, 1 m^3 of humid air contains an amount of water whose partial pressure is 22.0 mmHg. The air is cooled at constant pressure to a temperature of 15 °C, becoming saturated with water. The vapor pressure of water at 15 °C is 12.7 mmHg. Calculate: a) the final volume after cooling the mixture; b) the mass of water contained in the cold air; c) the mass of liquid water.
    Ans: a) 939 L; b) 11.9 g of water; c) 9.2 g of liquid water.

11. One liter of air saturated with benzene (C_6H_6) vapor at 20 °C and a total pressure of 750 mmHg expands at that temperature, in contact with liquid benzene, to a volume of 3 L. The vapor pressure of benzene at 20 °C is 74.7 mmHg. Calculate the final pressure of the air saturated with benzene vapor.
    Ans: 300 mmHg.

12. 100 L of air at 20 °C and 1 atm pressure are slowly bubbled through ethyl ether, $C_4H_{10}O$. The air saturated with ether vapor exits at 20 °C and a total pressure of 1 atm. Calculate: a) the final volume of the mixture; b) the grams of ether that evaporate; c) if the mixture is compressed isothermally to 10 atm, how many grams of ether are recovered back in the liquid state? The vapor pressure of ethyl ether at 20 °C is 422 mmHg. Assume the volume of liquid ethyl ether formed is negligible.
    Ans: a) 225 L; b) 385 g of ether; c) 367 g of ether.

13. Air saturated to 60.0% with ethyl alcohol at 40 °C and 760 mmHg is compressed into a 100.0 L capacity tank to 10 atm and 30 °C. Calculate the volume of air under the initial conditions. The vapor pressures of ethyl alcohol at 30 and 40 °C are 78.80 and 135.3 mmHg, respectively. Assume the volume of condensed ethyl alcohol is negligible.
    Ans: 1144 L.