Sample Chemistry Question (Ch. 9 - 11) - CH 222

Questions for Chapters Nine, Ten and Eleven:

1. When 7.00 grams of Helium and 14.0 grams of argon were mixed in a flask, the pressure was measured as 712 torr. What is the partial pressure of helium?

a. 593 torr
b. 356 torr
c. 833 torr
d. 1070 torr
e. 1420 torr

2. The empirical formula of a certain hydrocarbon is CH_2. When 0.125 moles of this hydrocarbon are completely combusted with excess oxygen, it is observed that 11.2 L of H_2O gas is produced at STP. What is the molecular formula of the unknown hydrocarbon?

a. C_2H_4
b. C_2H_3
c. C_3H_6
d. C_4H_8
e. C_6H_{12}

3. Lead (atomic mass 207.2 g/mol) crystallizes in a face-centered cubic arrangement. The radius of an atom of lead is $1.75*10^{-8}$ cm. What is the density of lead?

a. 9.85 g/cm^3
b. 11.4 g/cm^3
c. 13.2 g/cm^3
d. 14.7 g/cm^3
e. 19.7 g/cm^3

4. Rank the compounds NH_3, CH_4, and SiH_4 in order of increasing boiling point.

a. $NH_3 < CH_4 < SiH_4$
b. $CH_4 < NH_3 < SiH_4$
c. $NH_3 < SiH_4 < CH_4$
d. $CH_4 < SiH_4 < NH_3$
e. $SiH_4 < NH_3 < CH_4$

5. A 1.34 M $NiCl_2$ aqueous solution has a density of 1.12 g/cm^3. What is the molality of the solution?

a. 0.913 m
b. 1.42 m
c. 1.55 m
d. 2.55 m
e. 3.13 m

6. A solution is prepared by dissolving 0.500 g of non-dissociating solute in 12.0 g of cyclohexane. The freezing point depression of the solution is 8.94 °C. K_f for cyclohexane is 20.0 °C/m. Calculate the molar mass of the solute.

a. 93.3 g/mol
b. 112 g/mol
c. 128 g/mol
d. 182 g/mol
e. 205 g/mol

Here are the answers to the previous questions:

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1. When 7.00 grams of Helium and 14.0 grams of argon were mixed in a flask, the pressure was measured as 712 torr. What is the partial pressure of helium?

a. 593 torr
b. 356 torr
c. 833 torr
d. 1070 torr
e. 1420 torr

Answer: Pressure is proportional to the quantity of moles present in a gas, and Dalton's Law of Partial Pressures says that the total pressure will be equal to the sum of the respective pressures. The mole fraction of the gas times the total pressure (712 torr) will give the respective pressures of the components. There are (7.00 g / 4.00 g/mol) = 1.75 mol He and (14.0 g / 39.9 g/mol) = 0.351 mol Ar. The mole fraction of He is 1.75 / (1.75 + 0.351) = 0.833, and the partial pressure of helium will be 0.833 * 712 torr = **593 torr**, answer **(a)**.

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2. The empirical formula of a certain hydrocarbon is CH_2. When 0.125 moles of this hydrocarbon are completely combusted with excess oxygen, it is observed that 11.2 L of H_2O gas is produced at STP. What is the molecular formula of the unknown hydrocarbon?

a. C_2H_4
b. C_2H_3
c. C_3H_6
d. C_4H_8
e. C_6H_{12}

Answer: First, find the moles of H_2O produced, and then compare this number to 0.125 mol to find the ratio of "H_2" units in the hydrocarbon. Ex: ethane, C_2H_4, has two "H_2" units, so each mole of ethane will give two moles of water.

Also recall that STP implies a temperature of 273 K and 1 atm of pressure.

To find the moles of water: n = PV/RT = 1 atm*11.2 L / 0.082057 * 273 K = 0.500 mol H_2O.

The ratio (0.500 / 0.125) = 4, and this is how many "H_2" units are present in the hydrocarbon. Since the empirical formula is CH_2, we can imply there are four carbons with the four "H_2" units.

The final answer is **(d), C_4H_8.**

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3. Lead (atomic mass 207.2 g/mol) crystallizes in a face-centered cubic arrangement. The radius of an atom of lead is $1.75*10^{-8}$ cm. What is the density of lead?

a. 9.85 g/cm^3
b. 11.4 g/cm^3
c. 13.2 g/cm^3
d. 14.7 g/cm^3
e. 19.7 g/cm^3

Answer: Using unit analysis, we need an answer in g/cm^3. The numerator, g, comes from the molar mass of lead (207.2 g/mol), for the mol can be cancelled using Avogadro's number and by remembering that the face centered cubic requires four atoms per unit cell. The denominator, cm^3, can be obtained from the equation: Edge = $4*radius/(2)^{1/2}$ and remembering that volume (in cm^3) is equal to the cubed root of the edge.

So: numerator (g) = 207.2 g/mol * (mol / $6.022*10^{23}$ atoms) * (4 atoms / cell) = $1.38 *10^{-21}$ g
denominator (cm^3) = $(edge)^3 = (4*1.75*10^{-8}\ cm/2^{1/2})^3 = 1.21 * 10^{-22}\ cm^3$
Therefore, density = $1.38 *10^{-21}$ g / $1.21 * 10^{-22}$ cm^3 = **11.4 g/cm^3**, answer **(b)**.

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4. Rank the compounds NH_3, CH_4, and SiH_4 in order of increasing boiling point.

a. $NH_3 < CH_4 < SiH_4$
b. $CH_4 < NH_3 < SiH_4$
c. $NH_3 < SiH_4 < CH_4$
d. $CH_4 < SiH_4 < NH_3$
e. $SiH_4 < NH_3 < CH_4$

Answer: Two factors affect boiling point: 1) mass (molar mass), and 2) strength of intermolecular forces. The larger the molar mass or intermolecular force, the higher the boiling point.

In terms of molar mass, the order would be CH_4 (16 g/mol) < NH_3 (17 g/mol) < SiH_4 (32 g/mol). However, while CH_4 and SiH_4 have only induced dipole - induced dipole (ID-ID) forces, NH_3 experiences hydrogen bonding forces, which is much stronger than the ID-ID force. Because the mass difference is not too large between NH_3 and SiH_4, we would expect the order to be **$CH_4 < SiH_4 < NH_3$**, answer **(d)**.

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5. A 1.34 M $NiCl_2$ aqueous solution has a density of 1.12 g/cm^3. What is the molality of the solution?

a. 0.913 m
b. 1.42 m
c. 1.55 m
d. 2.55 m
e. 3.13 m

Answer: Converting from molarity to molality (or weight percent or mole fraction) requires a solution density value. 1.34 M implies that there are 1.34 moles of $NiCl_2$ in 1 L of solution.

We wish to calculate molality, which is the moles of solute per kg of solvent. We have 1.34 mol of solute in 1 L of solution, so if we can calculate the kg of solvent, we'll be good to go.

1.34 mol * 129.6 g/mol = 174 g $NiCl_2$
1 L * (1000 mL / L) * (cm^3 / mL) * (1.12 g/cm^3) = 1120 g of solution (which equals the g of $NiCl_2$ and water)
g H_2O = 1120 g - 174 g = 950 g water * (1 kg / 1000 g) = 0.95 kg water

molality = mol solute / kg solvent = 1.34 mol / 0.95 kg = **1.4 m**, answer **(b)**.

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6. A solution is prepared by dissolving 0.500 g of non-dissociating solute in 12.0 g of cyclohexane. The freezing point depression of the solution is 8.94 °C. K_f for cyclohexane is 20.0 °C/m. Calculate the molar mass of the solute.

a. 93.3 g/mol
b. 112 g/mol
c. 128 g/mol
d. 182 g/mol
e. 205 g/mol

Answer: molar mass = g/mol. We have 0.500 g for the mass, so we need to calculate the moles of solute present. We can use the freezing point depression equation, $\Delta T = k_f * m * i$.

Since the solute is non-dissociating, we can assume that i = 1.

Solve for m: $m = \Delta T / k_f$ = 8.94 °C / 20.0 °C/m = 0.447 m = 0.447 mol solute / kg solvent (cyclohexane)

Since the problem used 12.0 g of solvent,
{0.447 mol solute / kg solvent (cyclohexane)}* 0.0120 kg solvent = $5.36*10^{-3}$ mol solute

Molar mass = g solute / mol solute = 0.500 g / $5.36*10^{-3}$ mol = **93.3 g/mol**, answer **(a)**.