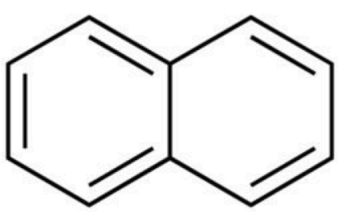
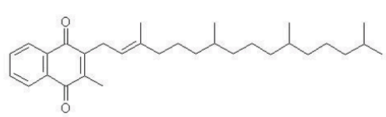
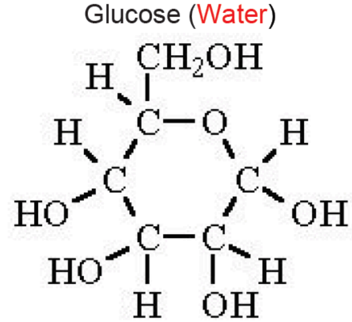
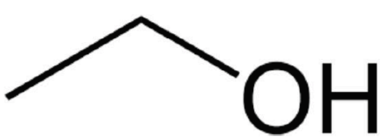
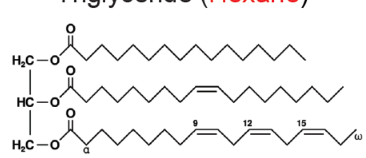
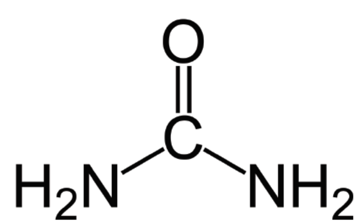
General Chemistry I

June 30, 2021

1. **Rationalize the difference in boiling points for each of the following pairs of substances:**
   a. **HF (20°C); HCl (-85°C):** HF has hydrogen bonding, HCl doesn't
   b. **HCl (-85°C); LiCl (1360°C):** Ionic attractions (LiCl) are very strong
   c. **Br_2 (59°C); ICl (97°C):** Dipole-Dipole interactions (present in ICl, not Br_2)
   d. **$CHCl_3$ (61°C); $CHBr_3$ (150°C):** $CHBr_3$ is much larger, so is more polarizable

2. **Based on the principle that like dissolves like (i.e. molecules with similar IMFs will form homogeneous mixtures with each other), predict which pairs of substances you would expect to form homogenous solutions when combined. What types of IMFs are involved?**
   a. **CCl_4 and H_2O:** No – CCl_4 is nonpolar, while H_2O is polar
   b. **KCl and H_2O:** Yes – ion-dipole interactions
   c. **Br_2 and CCl_4:** Yes – LDFs
   d. **CH_3CH_2OH and H_2O:** Yes – hydrogen bonding
   e. **CH_3OH and $CH_3(CH_2)_4CH_3$:** No – CH_3OH is polar, while $CH_3(CH_2)_4CH_3$ is not

3. **Predict whether the following molecules would be more soluble in water or hexane (C_6H_{14}).**

Napthalene (Hexane) 	Vitamin K (Hexane) 	Glucose (Water) 
Ethanol (Water) 	Triglyceride (Hexane) 	Urea (Water) 

4. **The enthalpy of vaporization of acetone is 32.0 kJ/mol. The normal boiling point of acetone is 56.5°C. What is the vapor pressure of acetone at 25.0°C?**

$$ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$ln\left(\frac{P_2}{1\ atm}\right) = \frac{-32000\,\frac{J}{mol}}{8.314\,\frac{J}{mol * K}}\left(\frac{1}{298.15\ K} - \frac{1}{329.65\ K}\right)$$

$$\ln\left(\frac{P_2}{1\ atm}\right) = -1.233566514$$

$$\frac{P_2}{1\ atm} = 0.291251969$$

$$P_2 = 0.29\ atm$$

5. **In the ground state of antimony, Sb,**

   a. **How many electrons have l ≥ 1 as one of their quantum numbers?**

   41. l = 1 refers to p, d, and f orbitals. Thus, this includes filled 2p, 3p, 3d, 4p, and 4d subshells, and three electrons in 5p.

   b. **How many electrons have m_l = 0?**

   21. This is a specific orientation of s, p, d, and f subshells. So it refers to one orbital in 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, and 5p subshells. Each orbital holds two electrons, but there is only one electron in each of the 5p orbitals.

   c. **How many electrons have m_l = 1?**

   11. This is a specific orientation of p, d, and f subshells. So it refers to one orbital in 2p, 3p, 3d, 4p, 4d, and 5p subshells. Each orbital holds two electrons but there is only one electron in each of the 5p orbitals.

6. **In each of the following sets, which atom or ion has the smallest radius?**

   a. **Li, Na, K** Li
   b. **P, As** P
   c. **O^+, O, O^-** O^+
   d. **S, Cl, Kr** Cl

e. **Pd, Ni, Cu** Ni. This is one of the exceptions in the transition metals

7. **A gas consisting of only carbon and hydrogen has an empirical formula of CH_2. The gas has a density of 1.65 g/L at 27°C and 734 torr. Determine the molar mass and molecular formula of the gas.**

Since we know the mass of the gas per liter (1.65 g), let's assume a volume of 1 L and find out how many moles of gas are present. Use the ideal gas law equation to do this:

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$n = \frac{(0.96579\ atm)(1\ L)}{\left(0.08206\ \frac{L * atm}{mol * K}\right)(300.15\ K)} =$$

Now, we know the mass and number of moles of the gas contained in 1 liter. Simply divide to find molar mass.

$$Molar\ mass = \frac{1.65\ g}{0.039211423\ mol} = 42.08\frac{g}{mol}$$

$$Empirical\ formula\ molar\ mass = 12.0107\frac{g}{mol} + 2\left(1.008\frac{g}{mol}\right) =$$

$$\frac{Molecular\ molar\ mass}{Empirical\ formula\ mass} = \frac{42.08\frac{g}{mol}}{14.0267\frac{g}{mol}} = 3$$

Thus, the molecular formula is C_3H_6.