CHEM 103
R&R 18
25 June 2024
Adapted from a 30 June 2021 document

1. Rationalize the difference in boiling points for each of the following pairs of substances:

a. HF (20 °C); HCl (-85 °C) HF H-bonding stronger than HCl dipole-dipole

b. HCl (-85 °C); LiCl (1360 °C) ionic interactions (LiCl) stronger than dipole-dipole

c. Br_2 (59 °C); ICl (97 °C) Br_2 is nonpolar with LDFs; ICl is polar with dipole-dipole

d. $CHCl_3$ (61 °C); $CHBr_3$ (150 °C) $CHBr_3$ is much more massive and larger ⇒ more polarizable.

2. Based on the principle that like dissolves like (i.e., molecules with similar classes of IMFs will form homogeneous mixtures with each other), predict with pairs of substances you would expect to form homogeneous solutions when combined. What types of IMFs are involved for each pair?

a. CCl_4 and H_2O Het. dipole-induced dipole (CCl_4 is nonpolar, H_2O polar)

b. KCl and H_2O Hom. ion-dipole

c. Br_2 and CCl_4 Hom. induced dipole-induced dipole. LDFs.

d. CH_3CH_2OH and H_2O Hom. H-bonding

e. CH_3OH and $CH_3(CH_2)_4CH_3$ Het. dipole-induced dipole (CH_3OH polar, n-hexane nonpolar)

3. The enthalpy of vaporization of acetone is 32.0 kJ mol^{-1}. The normal boiling point of acetone is 56.5 °C. What is the vapor pressure of acetone at 25.0 °C?

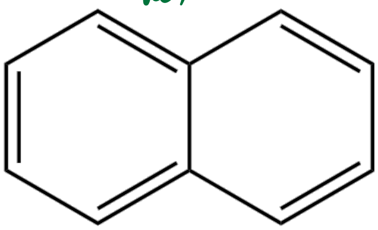
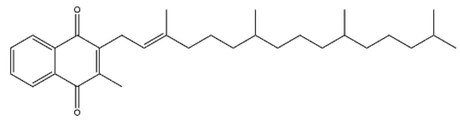
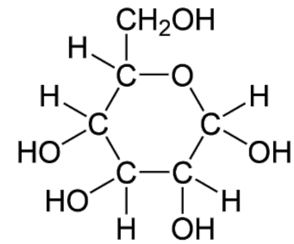
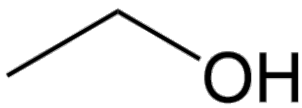
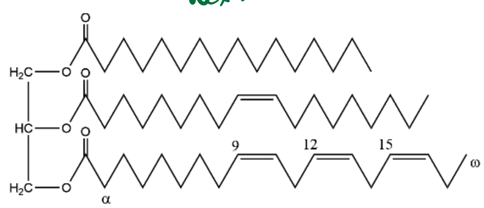
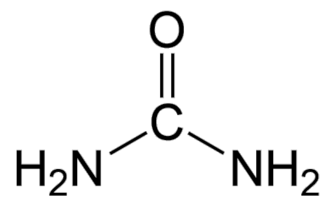
$$\ln\left(\frac{P_1}{P_2}\right) = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln\left(\frac{P_1}{1\text{ atm}}\right) = \frac{-32.0\ \text{kJ}\cdot\text{mol}^{-1}}{8.314\ \text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}}\left(\frac{1}{298.15\text{ K}} - \frac{1}{329.65}\right) = -1.233$$

2 SFs b/c logarithm

$P_1 = 0.29$ atm

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

Naphthalene	Vitamin K	Glucose
hexane 	hexane 	water 
Ethanol	**Triglyceride**	**Urea**
water 	hexane 	water 

5. In the ground state of antimony, Sb,

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

For Sb, any electrons in p or d orbital.

2p→6, 3p→6, 3d→10, 4p→6, 4d→10, 5p→3. Total: 41

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

All s orbital e⁻s → 10

$\frac{1}{3}$ of p orbital e⁻s for Sb → 7

$\frac{1}{5}$ of d orbital e⁻s for Sb → 4

Total: 21

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

$\frac{1}{3}$ of p orbital e⁻s for Sb → 7

$\frac{1}{5}$ of d orbital e⁻s for Sb → 4

Total: 11

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

a. (Li), Na, K
b. (P), As
c. (O^+), O, O^-
d. S, (Cl), Kr
e. Pd, (Ni), Cu

An exception due to transition metals.
Ni : [Ar] $3d^8 4s^2$; 28 protons w/ 26 core e⁻ ⇒ $Z_{eff} = 2$
Cu : [Ar] $3d^{10} 4s^1$; 29 protons w/ 28 core e⁻ ⇒ $Z_{eff} = 1$.
Therefore, Ni pulls on its valence e⁻s more stronger than Cu does.

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.

$$PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT}$$

$$\text{density} = \frac{\text{mass}}{V} = \frac{\text{mass}}{n} \cdot \frac{n}{V} = [\text{molar mass}] \cdot \frac{n}{V} = [\text{molar mass}] \cdot \frac{P}{RT}$$

$$\text{molar mass} = [\text{density}] \cdot \frac{RT}{P} = \frac{1.65\ g}{L} \cdot \frac{0.08206\ atm \cdot L}{mol \cdot K} \cdot \frac{760\ torr}{atm} \cdot \frac{300.15\ K}{734\ torr}$$

$$= 42.1\ \frac{g}{mol}$$

molecular formula is C_3H_6