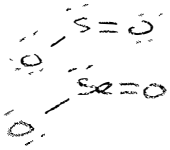
General Chemistry I
25 June 2020

1. Predict which substance in each of the following pairs would have the greater intermolecular force:

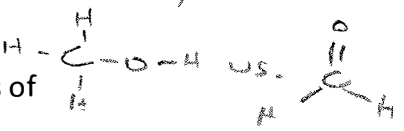


SeO_2 or SO_2 SeO_2 is larger and more polarizable.

$CH_3CH_2CH_2NH_2$ or $H_2NCH_2CH_2NH_2$ can form more H bonds with each other.

CH_3CH_3 or H_2CO H_2CO can form stronger polar-polar interactions.

CH_3OH or H_2CO can form H bonds, H_2CO cannot.



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

HF (20 °C); HCl (-85°C)
HF can form H bonds, so attraction between molecules is stronger.

HCl(-85°C); LiCl (1360 °C)
ionic attractions are much stronger than dipole-dipole interactions

Br_2 (59°C) and ICl (97°C)
Both molecules have similar molar masses, but I-Cl bond is slightly polar so it can form dipole-dipole interactions.

$CHCl_3$ (61°C) and $CHBr_3$ (150°C)
Even though C-Cl bond slightly more polar than C-Br bond, $CHBr_3$ is so much bigger that it is very polarizable

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

a) CCl_4 and H_2O — no - CCl_4 is symmetric and non polar, so it doesn't interact well with water, which is very polar.

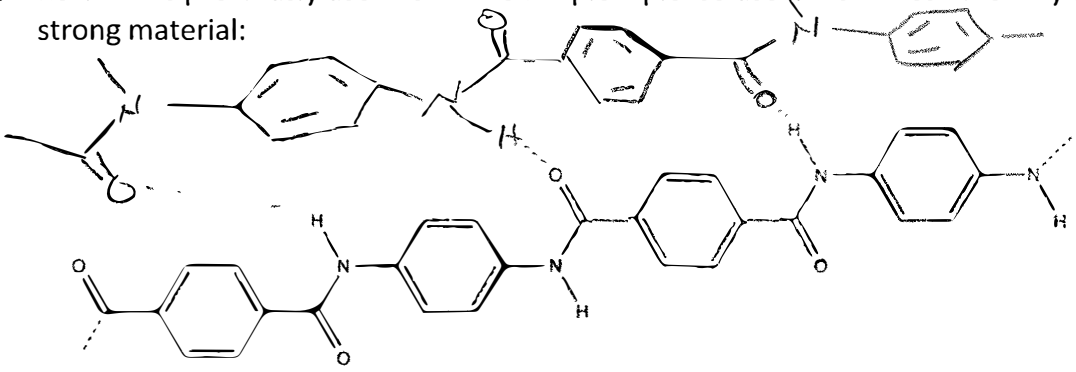
b) KCl and H_2O
yes - favorable ion-dipole interactions between dissolved KCl and H_2O. (LDFs also taking place).

c) Br_2 and CCl_4
yes - both are non polar and interact using induced dipole-induced dipole interactions. Both are large and polarizable.

d) CH_3CH_2OH and H_2O yes - mainly due to H-bonding and other dipole-dipole interactions. (LDFs also exist but less important).

e) CH_3OH and $CH_3(CH_2)_4CH_3$ no - polar vs. non polar molecule.

4. Kevlar was previously used as a PLI example – please use IMFs to describe why Kevlar is a strong material:



5. The partial pressure of oxygen was observed to be 156 torr in air with a total atmospheric pressure of 743 torr. Calculate the mole fraction of O_2 present.

$$\chi_{O_2} = \frac{P_{O_2}}{P_{total}} = \frac{156 \text{ torr}}{743 \text{ torr}} = \boxed{0.210}$$

* note that mole fraction has no units.

6. The partial pressure of CH_4 (g) is 0.175 atm and that of O_2 (g) is 0.250 atm in a mixture of the two gases.

   a. What is the mole fraction of each gas in the mixture?

$$\chi_{CH_4} = \frac{P_{CH_4}}{P_{total}} = \frac{0.175 \text{ atm}}{0.175 + 0.250 \text{ atm}} = \boxed{0.412}$$

$$\chi_{O_2} = \frac{P_{O_2}}{P_{total}} = \frac{0.250 \text{ atm}}{0.175 + 0.250 \text{ atm}} = \boxed{0.588}$$

   b. If the mixture occupies a volume of 10.5 L at 65°C, calculate the total number of moles of gas in the mixture.

$PV = nRT$

$P = 0.175 \text{ atm} + 0.250 \text{ atm}$

$V = 10.5 \text{ L}$

$T = 65^\circ\text{C} = 338 \text{ K}$

$R = 0.082 \frac{\text{L·atm}}{\text{mol·K}}$

$$n = \frac{PV}{RT} = \frac{0.425 \text{ atm}\,(10.5 \text{ L})}{0.082 \frac{\text{L·atm}}{\text{mol·K}}\,(338 \text{ K})} = \boxed{0.161 \text{ mol}}$$

   c. Calculate the number of grams of each gas in the mixture.

mass = total moles × mole fraction × molar mass

CH_4: $0.161 \text{ mol}\,(0.412)\left(\frac{16 \text{ g } CH_4}{\text{mol}}\right) = \boxed{1.06 \text{ g } CH_4}$

O_2: $0.161 \text{ mol}\,(0.588)\left(\frac{32 \text{ g } O_2}{\text{mol}}\right) = \boxed{3.03 \text{ g } O_2}$

7. A person accidentally swallows a drop of liquid oxygen, O_2 (l), which has a density of 1.149 g/mL. Assuming the drop has a volume of 0.050 mL, what volume of gas will be produced in the person's stomach at body temperature (37°C) and a pressure of 1.0 atm?

① Find moles of O_2: $0.050 \text{ mL}\left(\frac{1.149 \text{ g}}{\text{mL}}\right)\left(\frac{1 \text{ mol}}{32 \text{ g}}\right) = 0.001795 \text{ mol } O_2$

② Find volume with $PV = nRT$:

$$V = \frac{nRT}{P} = \frac{0.001795 \text{ mol } O_2\,(0.082 \frac{\text{L·atm}}{\text{mol·K}})\,(310 \text{ K})}{1.0 \text{ atm}}$$

$$= 0.0456 \text{ L} = \boxed{46 \text{ mL}}$$

8. For each pair of compounds, pick the one with the highest boiling point. Explain your reasoning.

a. CH_3OH or CH_3SH CH_3OH (methanol) can form H-bonds

b. CH_3OCH_3 or CH_3CH_2OH same reason - ethanol can form H-bonds

c. CH_4 or H_3CH_3 CH_3CH_3 is larger and favors stronger LDFs