Problem Set Chapter 9

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1. Name the intermolecular force the following is using in the liquid state:

   (a) CCl_4

   London Dispersion

   (b) CH_3F

   Dipole

   (c) NH_3

   Hydrogen Bonding

   (d) N_2H_4

   Hydrogen Bonding

   (e) F_2

   London Dispersion

2. Choose the lower boiling compound and explain why:

   (a) $\underline{F_2}$ or Cl_2 – F_2 has a lower boiling point because, even though both use the same intermolecular forces, F_2 has bigger molecules, meaning the distance between them is greater, resulting in a weaker intermolecular force.

   (b) $\underline{PH_3}$ or AsH_3 – PH_3 has a lower boiling point because, even though both use the same intermolecular forces, PH_3 has bigger molecules, meaning the distance between them is greater, resulting in a weaker intermolecular force.

   (c) NH_3 or $\underline{BF_3}$ – BF_3 uses London Dispersion forces, instead of hydrogen bonding (which is much stronger). As a result, BF_3 would have a lower boiling point.

   (d) $\underline{SO_2}$ or SiO_2 – Silicon Oxides are known for extremely strong bonds. As such, $\underline{SO_2}$ must be weaker, and, therefore, have a lower boiling point.

3. Only one of the following is a gas at STP: NI_3, BF_3, PCl_3, CH_3COOH. Which do you think and why?

   Most likely, BF_3 is a gas at STP. This is because, although NI_3, BF_3, and PCl_3 all use the same type of bonding, BF_3 has the biggest molecules, and, therefore weakest intermolecular forces, resulting in a high vapor pressure. It is definitely not CH_3COOH because the molecule uses hydrogen bonding.

4. Arrange the following substances in the expected order of increasing boiling point: C_4H_9OH, NO, C_6H_{14}, N_2, $(CH_3)_2O$.

   Least N_2 C_6H_{14} NO $(CH_3)_2O$ C_4H_9OH Greatest

5. Explain the following:

   (a) I_2 has a lower melting point than NaI

   I_2 uses London Dispersion forces, while NaI uses dipole forces. Therefore, I_2 has a lower melting point.

   (b) H_2O has a higher boiling point than C_2H_6

   H_2O uses hydrogen bonding, while C_2H_6 uses London Dispersion. As such, a hydrogen bond indicates a higher boiling point.

   (c) N_2 has a lower boiling point than CO

   N_2 uses London Dispersion forces, meaning it has weaker bonds than the dipole force used by CO. Therefore, N_2 has a lower boiling point.

   (d) SiH_4 has a higher vapor pressure than GeH_4

   Although both use London Dispersion forces, the size of the Si atom makes this true.

6. Underline the molecule with the lower vapor pressure and explain why

   (a) Ne or $\underline{Ar}$ – Argon is a bigger molecule than neon. This means that it has a lower vapor pressure.

   (b) $\underline{C_2H_5OH}$ or C_2H_6 – C_2H_5OH uses hydrogen bonding, meaning that it is stronger than the London Dispersion of C_2H_6.

   (c) $\underline{C_2H_6}$ or CH_4 – C_2H_6 has stronger bonds because the central C atoms are bonded to each other. As a result, it has a lower vapor pressure.

   (d) C_2H_5OH or $\underline{NaF}$ – NaF has stronger bonds, which gives it the property of lower vapor pressure.

(e) CO_2 or $\underline{H_2S}$ − CO_2 has nonpolar bonding, meaning it uses London Dispersion, while H_2S uses polar, and, therefore dipole bonding. This stronger bond means it has a lower vapor pressure.

(f) $\underline{CO}$ or N_2 − CO_2 uses dipole bonding, which is stronger than the London bonding of the N_2, making it have a lower vapor pressure.

7. A 1.82[g] sample of water is injected into a 2.55[L] flask at 30[°C] (VP = 31.8[mmHg]). How many grams of water are in the liquid phase and in the gas phase?

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\begin{aligned}
H_2O \rightarrow 18 \left[\frac{g}{mol}\right] \\
\frac{1.82}{18} = .101[mol] \\
P = \frac{nRT}{V} \\
P = \frac{.101 \cdot .0821 \cdot 303}{2.55} \\
.985[\text{ATM}] = 748.83[mmHg] \qquad (1) \\
748.83 - 31.8 = 717.03[mmHg] = .93[\text{ATM}] \\
n = \frac{PV}{RT} \\
\frac{.93 \cdot 2.55}{.0821 \cdot 303} = .095[mol] \\
.095 \cdot 18 = 1.71[g_{solid}] \\
1.82 - 1.71 = .11[g_{gas}]
\end{aligned}
$$

8. A 1.25[g] sample of water is injected into a 178.5[g] flask at 0[°C] (VP = 4.6[mmHg]). How many atoms of water are in the liquid phase and in the gas phase?

$$
\begin{aligned}
\frac{1.25}{18} = .0694[mol] \\
P = \frac{nRT}{V} \\
P = \frac{.0694 \cdot .0821 \cdot 273}{178.5} = .0087[\text{ATM}] \qquad (2) \\
.0087[\text{ATM}] = 6.62[mmHg] \\
6.62 > 4.6
\end{aligned}
$$

Because $6.62 > 4.6$, liquid and gas exist in the flask