QUESTIONS ABOUT GASES

1. a. $543 \text{ torr} \times \dfrac{1 \text{ atm}}{760 \text{ torr}} = 0.714 \text{ atm}$ b. $1.75 \text{ atm} \times \dfrac{760 \text{ torr}}{1 \text{ atm}} = 1.33 \times 10^3 \text{ torr}$

    c. $43.2 \text{ L} \times \dfrac{10^3 \text{ mL}}{1 \text{ L}} = 4.32 \times 10^4 \text{ mL}$ d. $\dfrac{1.004 \text{ g}}{\text{mL}} \times \dfrac{10^3 \text{ mL}}{1 \text{ L}} = 1.004 \times 10^3 \text{ g/L}$

    e. $20 \text{ °C} + 273.15 = 293 \text{ K}$ f. $100 \text{ K} - 273.15 = -173 \text{ °C}$

2. Since a torr is defined as a mm Hg at 0 °C and sea level, the mercury would be more dense (it would contract at the sub-zero temperatures at the north pole) and thus one would need to add mm Hg to the reading to get the correct pressure. Conversely, at the equator (here the temperature is much higher than zero and the mercury would expand) one would need to subtract mm Hg from the reading to get the correct pressure.

3. a. $P_1 \bullet V_1 = P_2 \bullet V_2 \quad \text{or} \quad V_2 = \dfrac{V_1 \bullet P_1}{P_2} = \dfrac{1.18 \text{ L} \times 760 \text{ torr}}{800 \text{ torr}} = 1.12 \text{ L}$

    b. $P_1 \bullet V_1 = P_2 \bullet V_2 \quad \text{or} \quad V_2 = \dfrac{V_1 \bullet P_1}{P_2} = \dfrac{1.18 \text{ L} \times 760 \text{ torr}}{0.526 \text{ atm}} \times \dfrac{1 \text{ atm}}{760 \text{ torr}} = 2.24 \text{ L}$

    c. $P_1 \bullet V_1 = P_2 \bullet V_2 \quad \text{or} \quad P_2 = \dfrac{P_1 \bullet V_1}{V_2} = \dfrac{P_1 \bullet V_1}{2 \, V_1} = \dfrac{P_1}{2} = \dfrac{760 \text{ torr}}{2} = 380 \text{ torr}$

4. a. $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2} \quad \text{or} \quad V_2 = \dfrac{V_1 \bullet T_2}{T_1} = \dfrac{100 \text{ mL} \times 333._{15} \text{ K}}{250._{15} \text{ K}} = 133 \text{ mL}$

    b. $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2} \quad \text{or} \quad T_2 = \dfrac{V_2 \bullet T_1}{V_1} = \dfrac{154 \text{ mL} \times 250._{15} \text{ K}}{100 \text{ mL}} = 385._{23} \text{ K} \quad \text{or} \quad 112 \text{ °C}$

    c. $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2} \quad \text{or} \quad V_2 = \dfrac{V_1 \bullet T_2}{T_1} = \dfrac{V_1 \times 2 \, T_1}{T_1} = 2 \bullet V_1 = 100 \text{ mL} \times 2 = 200 \text{ mL}$

5. a. $\dfrac{V_1}{n_1} = \dfrac{V_2}{n_2} \quad \text{or} \quad V_2 = \dfrac{V_1 \bullet n_2}{n_1} = \dfrac{400 \text{ mL} \times 1.25 \text{ mol}}{0.250 \text{ mol}} = 2.00 \times 10^3 \text{ mL}$

    b. $\dfrac{V_1}{n_1} = \dfrac{V_2}{n_2} \quad \text{or} \quad n_2 = \dfrac{n_1 \bullet V_2}{V_1} = \dfrac{0.250 \text{ mol} \times 320 \text{ mL}}{400 \text{ mL}} = 0.200 \text{ mol}$

c. $\dfrac{V_1}{n_1} = \dfrac{V_2}{n_2}$ or $V_2 = \dfrac{V_1 \cdot n_2}{n_1} = \dfrac{V_1 \times 2 \cdot n_1}{n_1} = 2 \cdot V_1 = 400\,\text{mL} \times 2 = 800\,\text{mL}$

6. $\dfrac{P_1 \cdot V_1}{n_1 \cdot T_1} = \dfrac{P_2 \cdot V_2}{n_2 \cdot T_2}$ or $P_2 = \dfrac{P_1 \cdot V_1 \cdot n_2 \cdot T_2}{V_2 \cdot n_1 \cdot T_1} = \dfrac{P_1 \cdot V_1\ (\frac{1}{2} \times n_1)\ (4 \times T_1)}{(3 \times V_1)\ n_1 \cdot T_1} = \dfrac{2\,P_1}{3}$

7. $P \cdot V = n \cdot R \cdot T = \dfrac{g \cdot R \cdot T}{MM}$ or $V = \dfrac{g \cdot R \cdot T}{MM \cdot P}$

$\therefore \quad V = \dfrac{35.2\ \text{g N}_2 \times 0.082058\ \text{L·atm/mol·K} \times 308._{15}\ \text{K}}{28.0134\ \text{g N}_2/\,\text{mol N}_2 \times 741\ \text{torr}} \times \dfrac{760\ \text{torr}}{1\ \text{atm}} = 32.6\ \text{L N}_2$

8. The easiest way to work this problem, perhaps, is to first figure out how many moles of He are left in the cylinder from the volume, temperature and pressure data. Then, after converting to mass of He, subtract from the original mass of He to find how much must be removed.

The moles of He remaining, $n = \dfrac{P \cdot V}{R \cdot T} = \dfrac{1.75\ \text{atm} \times 25.0\ \text{L}}{0.082058\ \text{L·atm/mol·K} \times 283._{15}\text{K}} = 1.88_3\ \text{mol He}$

The grams of He remaining, $g = 1.88_3\ \text{mol He} \times \dfrac{4.002602\ \text{g He}}{\text{mol He}} = 7.54\ \text{g He}$

The grams of He remaining, $g = 36.6\ \text{g He} - 7.54\ \text{g He} = 29.1\ \text{g He released.}$

9. $P \cdot V = n \cdot R \cdot T = \dfrac{g \cdot R \cdot T}{MM}$

$MM = \dfrac{g \cdot R \cdot T}{P \cdot V} = \dfrac{0.316\ \text{g Y} \times 0.082058\ \text{L·atm/mol·K} \times 273._{15}\ \text{K}}{1\ \text{atm} \times 100\ \text{mL}} \times \dfrac{1\ \text{mL}}{10^{-3}\ \text{L}} = 70.8\ \text{g/mol Y}$

10. a. Since one mole of any gas at STP occupies 22.414 L we can calculate the density of ozone simply by combining the molar volume of O_3 (22.414 L/mol) with the molar mass of O_3 (47.9982 g/mol).

$D\ O_3 = \dfrac{47.9982\ \text{g O}_3}{\text{mol O}_3} \times \dfrac{\text{mol O}_3}{22.414\ \text{L O}_3} = \dfrac{2.1414\ \text{g O}_3}{\text{L O}_3}$

b. $P \cdot V = n \cdot R \cdot T = \dfrac{g \cdot R \cdot T}{MM}$ or $\dfrac{g}{V} = \dfrac{P \cdot MM}{R \cdot T} = D$

Therefore,

$D = \dfrac{g}{V} = \dfrac{P \cdot MM}{R \cdot T} = \dfrac{700\ \text{torr} \cdot 47.9982\ \text{g O}_3/\,\text{mol}}{0.082058\ \text{L·atm/mol·K} \cdot 298._{15}\ \text{K}} \times \dfrac{1\ \text{atm}}{760\ \text{torr}} = \dfrac{1.81\ \text{g O}_3}{\text{L O}_3}$

11. **Determination of empirical formula.**

$$\frac{9.93 \text{ g C}}{12.011 \text{ g C/mol C}} = 0.827 \text{ mol C} \quad ; \quad \frac{58.64 \text{ g Cl}}{35.453 \text{ g Cl/mol Cl}} = 1.654 \text{ mol Cl}$$

$$\frac{31.43 \text{ g F}}{18.998403 \text{ g F/mol F}} = 1.654 \text{ mol F}$$

Dividing by the smallest value gives,

$$\frac{0.827 \text{ mol C}}{0.827} = 1.00 \text{ mol C} \quad ; \quad \frac{1.654 \text{ mol Cl}}{0.827} = 2.00 \text{ mol Cl}$$

$$\frac{1.654 \text{ mol F}}{0.827} = 2.00 \text{ mol F} \qquad \text{Therefore, the empirical formula is } CCl_2F_2.$$

**Determination of the molar mass involves using the gas density.**

$$MM = \frac{g \cdot R \cdot T}{P \cdot V} = \frac{0.540 \text{ g Z} \times 0.082058 \text{ L} \cdot atm/mol \cdot K \times 273._{15} \text{ K}}{1 \text{ atm} \times 100 \text{ mL}} \times \frac{1 \text{ mL}}{10^{-3} \text{ L}} = 121 \text{ g/mol Z}$$

Determination of the molecular formula.

The molar mass of Z is 121 g/mol and therefore the molecular mass of Z is 121 amu/molecule. The formula unit, CCl_2F_2, has a formula mass of 121 amu/FU. The number of formula units per molecule can be calculated from these two numbers.

$$\frac{121 \text{ amu/ molecule}}{121 \text{ amu/FU}} = 1 \text{ FU/molecule} \quad \text{Therefore, the molecular formula is } CCl_2F_2 \text{ also.}$$

12. a. $\quad 3 \text{ H}_2 \text{ (g)} + \text{N}_2 \text{ (g)} \longrightarrow 2 \text{ NH}_3 \text{ (g)}$
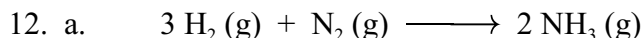
   b. At a fixed temperature and pressure (STP) the volume of a gas is proportional to the number of moles of gas. Since the mole ratio of N_2 to H_2 is 1:3, the gases will react in a volume ratio of 1:3 also. Thus 3.0 L of H_2 will react with 1.0 L of N_2 (3.0 L × ⅓ = 1.0 L).

   c. Since the mole ratio of NH_3 to H_2 is 2:3, they will have a volume ratio of 2:3 also. Thus, 3.0 L of H_2 will form 2.0 L of NH_3. The conversion of this volume into moles is easy at STP.

$$2.0 \text{ L NH}_3 \times \frac{1 \text{ mol NH}_3}{22.414 \text{ L NH}_3} = 0.089 \text{ mol NH}_3$$

   d. $\quad 10.0 \text{ g H}_2 \times \dfrac{1 \text{ mol H}_2}{2.0158 \text{ g H}_2} \times \dfrac{1 \text{ mol N}_2}{3 \text{ mol H}_2} \times \dfrac{28.0134 \text{ g N}_2}{1 \text{ mol N}_2} = 46.3 \text{ g N}_2 \text{ needed}$

   $\therefore N_2$ is Limiting Reagent.

$$4.0 \text{ g N}_2 \times \frac{1 \text{ mol N}_2}{28.0134 \text{ g N}_2} \times \frac{2 \text{ mol NH}_3}{1 \text{ mol N}_2} \times \frac{22.414 \text{ L NH}_3}{1 \text{ mol NH}_3} = 6.40 \text{ L NH}_3 \text{ formed}$$

13. a. $X_{O_2} = \dfrac{\text{mol O}_2}{\text{mol O}_2 + \text{mol N}_2} = \dfrac{\dfrac{\text{g O}_2}{\text{MM O}_2}}{\dfrac{\text{g O}_2}{\text{MM O}_2} + \dfrac{\text{g N}_2}{\text{MM N}_2}}$

$$X_{O_2} = \frac{\dfrac{96.0 \text{ g O}_2}{31.9988 \text{ g/mol O}_2}}{\dfrac{96.0 \text{ g O}_2}{31.9988 \text{ g/mol O}_2} + \dfrac{140 \text{ g N}_2}{28.0134 \text{ g/mol N}_2}} = 0.375$$

and therefore, $X_{N_2} = \dfrac{\text{mol N}_2}{\text{mol O}_2 + \text{mol N}_2} = 1 - X_{O_2} = 1 - 0.375 = 0.625$

b. $P_{N_2} = P_{Tot} \times X_{N_2} = 800 \text{ torr} \times 0.625 = 500 \text{ torr}$

c. Since the volume and the temperature of the system are fixed then the pressure of N_2 is proportional to the moles of N_2. Therefore, because the moles of N_2 remained constant, the pressure exerted by the N_2 would remain constant at 500 torr.

But, the mole fraction of N_2 would change.

$$X_{N_2} = \frac{\text{mol N}_2}{\text{mol O}_2 + \text{mol N}_2 + \text{mol He}} = \frac{\dfrac{\text{g O}_2}{\text{MM O}_2}}{\dfrac{\text{g O}_2}{\text{MM O}_2} + \dfrac{\text{g N}_2}{\text{MM N}_2} + \dfrac{\text{g He}}{\text{MM He}}}$$

or

$$X_{N_2} = \frac{\dfrac{140 \text{ g N}_2}{28.0134 \text{ g/mol N}_2}}{\dfrac{96.0 \text{ g O}_2}{31.9988 \text{ g/mol O}_2} + \dfrac{140 \text{ g N}_2}{28.0134 \text{ g/mol N}_2} + \dfrac{12.0 \text{ g He}}{4.002602 \text{ g/mol He}}} = 0.455$$

14. a. No, it will __not__ form in the middle. It will form closer to the end with the slower moving gas. In this case, HCl is heavier than NH_3 and therefore is slower moving. Thus, the solid NH_4Cl will form closer to the end at which HCl was introduced.

   b. First calculate relative speeds. Note that the speed of a gas is proportional to the rate. Thus,

$$\frac{\text{speed } (NH_3)}{\text{speed } (HCl)} = \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}} \quad \text{or} \quad \text{speed } (NH_3) = \text{speed } (HCl) \times \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}}$$

   Then calculate the relative distances traveled by each gas. Since the distance traveled by each gas is proportional to the speed of that gas then,

$$\frac{\text{distance } (NH_3)}{\text{distance } (HCl)} = \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}} \quad \text{or} \quad \text{distance } (NH_3) = \text{distance } (HCl) \times \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}}$$

   The **fraction** of the total distance traveled by HCl is:

$$\frac{\text{dist. } (HCl)}{\text{dist. } (HCl) + \text{dist. } (NH_3)} = \frac{\text{dist. } (HCl)}{\text{dist. } (HCl) + \text{dist. } (HCl) \times \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}}} =$$

Factoring out "distance of HCl" gives the **fraction** of the total distance traveled by HCl as:

$$\frac{1}{1 + \sqrt{\frac{\text{MM } (HCl)}{\text{MM } (NH_3)}}} = \frac{1}{1 + \sqrt{\frac{36.461 \text{ g/mol}}{17.0304 \text{ g/mol}}}} = 0.40598$$

Since the total distance of the tube and therefore the total distance traveled by both gases is 1.00 m, then the distance traveled by the HCl prior to reaction is 1.00 m times the fraction of the distance traveled by HCl. Thus, the ring will form at

1.00 m $\times$ 0.40598 = 0.406 m = 40.6 cm (from HCl end of tube).

15. a. Gas molecules exert forces on the walls of the "container." If one of the surfaces of the "container" is the surface of a liquid, the liquid can be forced to flow up a column until the force of gravity acting on the column is equal to the force (of the gas molecules) acting on the surface of the liquid.

   b. When a gas is compressed to half of its original volume, the number of molecules striking the walls in 1 sec. will double. This, in turn, causes a doubling of the force and thus a doubling of the pressure (or the force per area) on the walls.

   c. Heated gas molecules have greater kinetic energies and thus are more able to overcome the force of gravity. (Hence move up!)

d. Upon cooling, the KE of the CO_2 molecules decreases. Eventually the attractions between molecules will exceed the KE allowing the CO_2 to condense.

e. The friction between the road and the tire causes the temperature of the tire to rise. The higher temperature is a result of an increase in KE of the molecules. Thus, the molecules are traveling at a higher speed. This causes more molecules to strike the walls per second and thus a higher pressure is exerted.

f. As the bubble rises, the pressure exerted by the water decreases. Since the pressure decreases the volume occupied by the gas will increase.

QUESTIONS ABOUT LIQUIDS

16. The most drastic difference is in the volume occupied. The gas occupies approximately 1000 times the volume of the liquid and solid.

17. It is difficult to characterize the liquid because it is not ordered (as in the solid where the position can be predicted). It is also not totally disordered (as in the gas where statistics can be used).

18. This indicates that the attractive forces in liquid H_2O are greater than those in liquid ether.

19. The strength of the intermolecular forces doesn't change (well, not much anyway) when a liquid is heated, but the molecules have greater kinetic energy and can overcome these forces more easily. The molecules have more kinetic energy, so they can slide past their neighbors more easily.

20. a. As the attractive forces increase, the amount of kinetic energy of the molecules (and hence high temperature) required to break the molecules loose increases.

b. As the attractive forces increase the molecules are pulled closer together and hence the density increases.

c. With an increases in the strength of the attractive forces the molecules "slip" by one another more slowly. Thus the viscosity increases.

d. Ideal behavior assumes no attractive forces between molecules. Thus the greater the attractive forces the more the molecules are held together and the greater the deviation from ideality.

e. As the attractive forces increase the strength with which the molecules are held together increases. Thus more energy is required to "pull" them apart. So ΔH_{vap} increases with attractive forces.

f. As the attractive forces increase, the molecules are held together more strongly and there will be fewer molecules with enough KE to overcome these attractions. Hence the vapor pressure decreases with increasing attractive forces.

21.
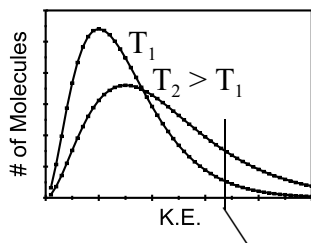
Min KE needed to escape the liquid.

As the graph shows, the area to the right of the minimum KE line is greater at T_2 than at T_1. Thus, there are more molecules that have <u>at least</u> the minimum KE at T_2 than at T_1. It is this collection of molecules that will leave the liquid to enter the gas phase. Since more molecules can escape at T_2 than can escape at T_1 the pressure exerted by these molecules must be greater at T_2 than at T_1.

22. $P_1 = 100$ torr $\qquad\qquad P_2 = 760$ torr

$T_1 = 39.5\ °C = 312.6_5\ K \qquad T_2 = NBP = ?$

$\Delta H_{vap} = 43.7\ kJ/mol = 43.7 \times 10^3\ J/mol$

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

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

$$\frac{1}{T_2} = \frac{8.314\ J/mol \cdot K}{43.7 \times 10^3\ J/mol} \times \ln\left(\frac{100\ torr}{760\ torr}\right) + \frac{1}{312.6_5\ K} = 2.81_3 \times 10^{-3}\ K^{-1}$$

$$\therefore \left(\frac{1}{T_2}\right)^{-1} = T_2 = \frac{1}{2.81_3 \times 10^{-3}\ K^{-1}} = 355._5\ K = 82._4\ °C = 82\ °C$$

QUESTIONS ABOUT IMF's

23. **London forces**: These are instantaneous dipole - induced dipole interactions which occur in any collection of molecules.

Dipole-dipole forces: These are additional interactions which occur in collections of molecules which have permanent dipoles (polar molecules).

H-Bonding These are unusually strong form of dipole-dipole forces which occur when a H is bonded directly to a small but highly EN atom (N, O, or F).

24. If at a given instant the electron distribution within a molecule is unsymmetric, that instantaneous dipole can induce a temporary dipole within another neighboring molecule by causing the electrons in the second molecule to shift for a short time.

25. No, London forces are the result of the interaction between an instantaneous dipole (which can occur in any **uncharged** species by uneven distribution of electrons) and in induced dipole (which can be created in any **uncharged** species by a neighboring dipole). Therefore, it follows that London forces exist only between **uncharged** species (i.e., **MOLECULES**).

26. a) Xe; Xe is larger and therefore more polarizable than Ar.

    b) $CH_3CH_2CH_2CH_3$; Elongated molecules are more easily distorted than small compact ones.

    c) H_2Se; H_2Se has the same shape as H_2O but H_2Se is larger and therefore more polarizable.

27. CO is slightly polar which contributes a small additional intermolecular attraction and therefore, the CO should have a higher ($-191\ °C > -196\ °C$) B.P.

28. a) London forces and dipole-dipole present with the London forces making the greatest contribution.

    b) Only London forces are present.

    c) London forces and H-bonding with H-bonding making the greatest contribution.

    d) London forces and dipole-dipole forces with London forces making the greatest contribution.

29. a) CCl_4; Both molecules are nonpolar with only London forces present. However, CCl_4 is larger and more polarizable than CF_4 and thus the strengths of the London forces are greater in CCl_4 which causes the BP of CCl_4 to be higher than CF_4.

    b) LiCl; LiCl is an ionic compound while HCl is a polar molecule. The ionic bonding in LiCl is much stronger than the sum of the London forces and dipole-dipole forces present in HCl. Thus LiCl has the higher BP.

    c) NH_3; NH_3 is a small polar molecule with an N-H bond and therefore possesses H-bonding in addition to relatively small London forces. PH_3 has the same shape as NH_3 but is somewhat larger than NH_3 and thus PH_3's London force contribution is larger than NH_3's. However, in NH_3, the H-bonding is much stronger than the London forces in PH_3 and therefore NH_3 has the higher BP.

    d) CH_3F; The two molecules are about the same size and shape which means that the London forces present in each sample are comparable. However, CH_3F is a polar molecule and the small additional dipole-dipole forces present in this molecule causes the BP to be higher than CH_3CH_3.

    e) $CH_3-C{\equiv}C-CH_3$; Of these two isomers only $CH_3-C{\equiv}C-CH_3$ is an elongated molecule which makes it more polarizable than the other isomer. Thus $CH_3-C{\equiv}C-CH_3$ has the higher BP.

    f) $CH_3(CH_2)_{10}CH_3$; Although H_2O has H-bonding, $CH_3(CH_2)_{10}CH_3$ is such a large molecule that the strength of the London forces in this substance are so large that once again the London forces are stronger than the dipole-dipole forces (even if those dipole-dipole forces are H-bonds!) in H_2O. Thus, $CH_3(CH_2)_{10}CH_3$ has the higher BP (in fact more than 100 °C higher) than H_2O.

30. These are all linear, polar molecules. Therefore, their trend in B.P. will be dictated by the relative strength of the London forces (which increase with an increase in molecular mass) and dipole-dipole forces (which remain fairly constant for these molecules). However, HF forms strong H-bonds and thus HF possess another IMF which is stronger than the London forces. Therefore the B.P. trend is: HF >> HI > HBr > HCl

31. The strength of the H-bond increase as the H-X bond polarity increases. The polarity of any bond depends on the electronegativity difference between the two bonded atoms increase. Since the electronegativity trend is $N < O < F$, then it follows that the bond polarity trend is N-H < O-H < F-H. Thus, the H-bond strength trend is $NH_3 < H_2O < HF$

32. In I the H-Bonding is an **intra**molecular attraction (between O-H and NO group's on the <u>same</u> molecule) and thus contributes little to the **inter**molecular attractions. In II the H-Bonding is strictly **inter**molecular in nature and thus contributes much to the **inter**molecular attractions. Thus, II should have a higher B.P.

QUESTIONS ABOUT SOLIDS

33. Since the slope of the heating curve in the liquid region is smaller than in the gaseous or solid regions it indicates that more heat is needed to raise the temperature 1°C. Thus liquid water must have a higher specific heat that either ice or steam.

34. a. A-B represents the temperature-pressure combinations where the solid and gas are in equilibrium. B-C represents the temperature-pressure combinations where liquid and solid are in equilibrium. B-D represents the temperature-pressure combinations where the liquid and gas are in equilibrium.

    b. A gas

    c. The solid would be converted directly to the gas without forming a liquid.

    d. First, the solid would be converted into the liquid as it passes across line B-C and the liquid would be converted into the gas as it passes across line B-D.

    e. The triple point - the single temperature-pressure combination where the solid, liquid and gas are in equilibrium.

    f. It is the critical point - the liquid cannot exist above this temperature. FIX

35. Since both ionic and macromolecular materials are hard, brittle, and high melting, I find macro-molecular solids and ionic solids to be more similar than are molecules and macromolecular solids. Indeed, the bonding in macromolecular solids and ionic solids extend throughout the entire structure. In molecules the bonding extends over a small number of atoms only.

36. Let's recall our molecular geometry and the types, and relative strengths, of interparticle attractions.

    a) Cl_2 is a nonpolar molecule which has London forces as the only attractions. BrCl a higher molar mass than Cl_2 (∴ more significant London attractions exist in BrCl than in Cl_2). In addition BrCl is polar molecule (∴ dipole-dipole forces also exist). Thus, BrCl has the higher M.P.

b) CsBr is an ionic solid and BrCl is a polar molecule. Since interionic attractions among ions are very strong as compared to dipole-dipole attractions among polar molecules, CsBr is by far the higher melting.

c) BrF has a higher molar mass than ClF and therefore, BrF has greater London interactions than ClF. In addition, ΔEN greater for BrF than for ClF, thus BrF is more polar than ClF ($\therefore$ dipole-dipole force in BrF are greater than those in ClF. Thus, BrF has the higher M.P.

d) Mg is a metallic element which you know is hard and high melting. Br_2 is a non-polar molecular element held together by London forces. Hence, Mg is by far the higher melting.

e) C (diamond) is probably the toughest, hardest, macromolecular substance known. The 3-D sp^3 hybrid bonds in the diamond lattice give rise to an extremely strong covalently bound network. London forces between Cl_2 molecules are very feeble comparatively. Diamond has the higher melting point.

f) SF_4 is a polar molecule and SF_6 is a nonpolar molecule with a larger molecular mass. While SF_4 has dipole-dipole forces in addition to London forces and SF_6 has only London forces it must be remembered than London forces generally make the greater contribution to the overall strength of the intermolecular forces. Thus, the increase in the London forces in SF_6 over SF_4 are expected to be stronger than the small contribution of the dipole-dipole forces in SF_4.

g) Here we have two types of perfectly tetrahedral molecules. Consequently, we recognize that since $SiBr_4$ has the higher molecular mass., the London interactions will be greater in $SiBr_4$ than in $SiCl_4$. Thus, $SiBr_4$ is the higher melting.

h) SiC (carborundum) is another macromolecular material with 3-D network covalent bonds like diamond (e). Thus, SiC is by far the higher melting.

i) Both H_2S and H_2O are polar molecules with H_2S having the higher molecular mass. Thus, the London interactions are stronger in H_2S than in H_2O. But, H_2O has strong H-Bonding and therefore, H_2O exhibits the higher M.P.

37. The liquid state is usually the easiest state in which to carry out reactions.

Physical State	Advantages	Disadvantages
Gas	Particles in rapid motion. Therefore, particle mix and react rapidly.	Gases occupy large volumes. Special container needed to contain gases.
Solid	Solids occupy small volumes. No special container needed.	Particle movement nearly absent. Therefore, reaction very slow.
Liquid	Particles in motion. Therefore, particles mix and react reasonably fast. Volumes occupied by liquids are almost as small as solids. No special equipment needed.	????????

38. A solution is defined as a **homogeneous mixture**. This definition does not specify the physical state. Therefore, a solution may be a solid, liquid or a gas mixture (as long as it is homogeneous).

39. The two components of a solution are the solvent and the solute. The distinction between them is arbitrary. The distinction is often based on the relative amounts of the two components with the solvent being present in a larger amount. Sometimes, the difference is based on the final physical state of the mixture. For example, if one of the components is a solid and the other a liquid then the distinction is made based on the state of the mixture. If the mixture is a liquid then the solvent is considered to be the liquid. If the mix is a solid then the solid is the solvent.

40. Reactions are generally carried out in the liquid state for the advantages listed in problem 37. If one or more of the reactants are gases or solids, they are converted into a **liquid solution** by dissolving them into a liquid solvent.

IPF'S IN SOLUTIONS

41. In a two-component solution the three interactions are; solute-solute, solvent-solvent, and solute - solvent.
These interaction are usually abbreviated as; A-A, B-B, and A-B.

42.

Solution Components	A-A	B-B	A-B
1) NP – NP	LF	LF	LF
2) P – P	D-D	D-D	D-D
3) H-Bonding - H-Bonding	HB	HB	HB
4) Ionic – Ionic	Ion-Ion	Ion-Ion	Ion-Ion
5) H-Bonding - P	HB	D-D	D-D
6) NP – P	LF	D-D	Dipole-Induced Dipole
7) NP - H-Bonding	LF	HB	Dipole-Induced Dipole
8) P – Ionic	D-D	Ion-Ion	Ion-Dipole
9) H-Bonding - Ionic	HB	Ion-Ion	Ion-Dipole
10) NP – Ionic	LF	Ion-Ion	Ion-Induced Dipole

43. All of the interparticle forces of attraction involve the attraction of some positive charge for some negative charge and therefore all are governed by Coulomb's Law. Since ions have much higher positive and negative charges than any of the partial charges on permanent or induced dipoles, it follows that the force of attraction between positive and negative ions must be larger than any of the other types of interparticle forces.

44. Since all ionic compounds are solids at room temperature it follows that an ionic compound cannot be used as the solvent if a **liquid** solution is desired. If a liquid solution is desired then a molecular solvent is needed. In order to best overcome the strong ion-ion forces of the ionic solute a polar molecular solvent is needed (like water).

45. Scenario 1: **The A-A, B-B and the A-B forces are approximately equal.**
    Under these conditions ΔH_{soln} is approximately zero. Solution formation will occur and is driven by entropy (increase in disorder). There will be no temperature change accompanying the dissolution.

    Scenario 2: **The A-A and B-B forces are either a little less or much less than the A-B forces.**
    Under these conditions ΔH_{soln} is less than zero and is therefore favorable. The stronger A-B forces tend to pull the solute and solvent together in solution. Therefore a solution is expected unless there is a large and unfavorable entropy change (not common). The solution formation will be accompanied by an increase in the solution temperature.

    Scenario 3: **The A-A and B-B forces are a little greater than the A-B forces.**
    Under these conditions ΔH_{soln} is greater than zero and is therefore unfavorable. The stronger A-A and B-B forces tend to keep the solute and solvent apart. A solution may form if driven by a favorable entropy change (common). The solution formation will be accompanied by a decrease in the solution temperature.

    Scenario 4: **The A-A and B-B forces are much greater than the A-B forces.**
    Under these conditions ΔH_{soln} is very positive and is therefore very unfavorable. The stronger A-A and B-B forces tend to keep the solute and solvent apart. No solution formation is expected since entropy cannot compensate for the large positive ΔH_{soln}.

46. a) Both hexane (C_6H_{14}) and CCl_4 are nonpolar molecules. Therefore, ΔH_{soln} is expected to be near or equal to zero. Thus, aided by entropy, solution formation is expected.

    b) Hexane is a nonpolar molecular substance held together by London forces. Water is a polar molecular substance held together by strong H-bonding. This strong H-bonding would be lost if a solution were to form. Therefore, no solution is expected (scenario 4).

    c) NaCl is an ionic solid and water is a polar molecular substance held together by H-bonding. The strong ion-ion forces in the NaCl will be replaced by weaker ion-dipole forces between the ion the water molecules. Collectively, the ion-dipole forces approach the ion-ion forces in magnitude (see Q38). Therefore, ionic compounds tend to dissolve in water aided by entropy. The ΔH_{soln} may be either positive or negative.

    d) NaCl is an ionic solid and hexane is a nonpolar molecular substance held together by London forces. The strong ion-ion force in the NaCl are too strong to be overcome by the relatively weak ion-induced dipole interactions between the ions and the hexane. Therefore, no solution formation is expected.

47. This is possible since in solution each ion is interacting with more than one water molecule. While the interaction between an Na^+ ion and a Cl^- ion is stronger than the interaction between an Na^+ ion and a water molecule, in solution the Na^+ ion typically interacts with six water molecules not one molecule. So collectively the ion-dipole force may be stronger than the ion-ion force in the solid.

48. In the gas state methanol and hexane are free from any appreciable intermolecular forces of attractions and can intermix at random. In the liquid state, hexane (a nonpolar molecule) has significant London forces. In methanol liquid the polar molecules show sizable H-bonding. Thus in the mixture the relatively weak dipole-induced dipole interactions are too weak to overcome the relatively strong H-bondingg in the methanol.

49. KNO_3 is more soluble in H_2O than in CCl_4. The ion-dipole interactions between the ions of KNO_3 and the H_2O molecules are more capable of pulling apart the relatively strong ion-ion forces in the solid KNO_3 than are the relatively weak ion-induced dipole forces between the ions and CCl_4.

50. $CHCl_3$ is more soluble in hexane than in H_2O. $CHCl_3$ is a large (slightly) polar molecule in which the main intermolecular forces holding it together are London dispersion forces. Thus the relatively large dispersion forces between hexane and $CHCl_3$ are comparable to the London forces within each sample and thus miscibility is expected for this mixture. However, the small dipole-dipole forces and the weak London forces between $CHCl_3$ and H_2O are not sufficient to pull apart the strong H-bonding in H_2O and thus limited solubility is expected for $CHCl_3$ in H_2O.

51. a) ion-dipole   b) dipole-dipole   c) dipole-induced dipole   d) London forces

    e) dipole-induced dipole   f) H-bonding   g) dipole-dipole   h) ion-induced dipole

52. a) HCl is more soluble. Diethyl ether is a large slightly polar molecular substance. The dipole-dipole and London forces between HCl and diethyl ether are comparable to those found in pure diethyl ether and thus miscibility is expected. However, the relatively weak ion-dipole forces between the ions of NaCl and diethyl ether are not sufficiently strong to overcome the strong ion-ion forces in the solid NaCl and thus limited solubility is expected for NaCl in diethyl ether.

    b) $CH_3CH_2CH_2Br$ is more soluble. $CH_3CH_2CH_2Br$ is a large polar molecule like diethyl ether with strong London forces. He is a very small atom with very weak London forces Thus, the forces between $CH_3CH_2CH_2Br$ and diethyl ether are sufficiently strong so as to overcome the forces holding the diethyl ether together but the weak London forces between the He and the diethyl ether are insufficient to overcome the Large London forces in liquid diethyl ether.

53. Charge density is the ratio of the charge on the species to its volume. The higher the charge density the more negative is ΔH_{hyd}. The magnitude of ΔH_{hyd} increases with increasing charge and decreases with increasing volume.

    I.e. $$\Delta H_{hyd} \; \propto \; \frac{charge}{volume}$$

54. a) Na^+ has a higher charge density and higher ΔH_{hyd} since it is smaller than Cs^+.

    b) CO_3^{-2} is more charge dense and has a higher ΔH_{hyd} since it has a larger charge than NO_3^-.

    c) Na^+ has a higher charge density and larger ΔH_{hyd} since it is smaller than Br^-.

    d) Fe^{+3} is more charge dense and has a higher ΔH_{hyd} as it is smaller and has a larger charge than Fe^{+2}.

55. a) Since the temperature falls as the solid NH_4Cl dissolves, the salt is absorbing heat from the surroundings (the water) and therefore the dissolving process is endothermic.

    b) Both ΔH_{hyd} and ΔH_{lat} are negative numbers. Since $\Delta H_{soln} = \Delta H_{hyd} - \Delta H_{lat}$, it follows that ΔH_{lat} must be a larger (negative) number than ΔH_{hyd} in order for ΔH_{soln} to be a positive number.

    c) As with all endothermic process, this one is driven by an increase in entropy (due to the increase in disorder resulting from the breakdown of the ionic solid).

56. a) The dissolving of caffeine must be an endothermic process. Since the caffeine is more soluble at higher temperatures then the dissolution process must be aided by the added heat. Only endothermic process which require heat to be added are helped by an increase in temperature.

$$\text{Caffeine (s)} + \text{heat} \quad \rightleftharpoons \quad \text{Caffeine (aq)}$$
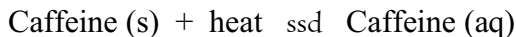
   b) The liquid is saturated. Since caffeine is more soluble at higher temperatures then this cooled mixture cannot be unsaturated. Also since solid has formed it cannot be supersaturated.

57. The relationship, $\Delta H_{soln} = \Delta H_{hyd} - \Delta H_{lat}$, can be used to calculate the ΔH_{hyd} be rearranging the equation to $\Delta H_{hyd} = \Delta H_{soln} + \Delta H_{lat}$.

   Therefore $\Delta H_{hyd} = 17.3$ kJ/mol $+ (-763$ kJ/mol$) = -746$ kJ/mol.

   The hydration of the Na^+ probably produces the greater contribution since it is smaller and thus has a larger charge density.

58. Add a small "pinch" of solid X to each solution. The supersaturated solution is unstable and the added "seed' will induce the crystallization of additional solid X. The solution in which the added solid dissolves is the unsaturated one. The solution in which the additional solid remains undissolved is the saturated solution.

59. An increase in the temperature produces an increase in the average kinetic energy of the molecules. This increased KE means that more molecules have sufficient energy to overcome the intermolecular forces holding them in the solution. Thus fewer molecules remain which do not have the requisite KE to overcome the IMF's.
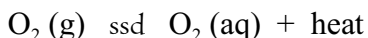
60. a) ΔH_{soln} for $AgNO_3$ is positive since the solubility increases with temperature.

$$AgNO_3 \text{ (s)} + \text{heat} \quad \rightleftharpoons \quad Ag^+ \text{ (aq)} + NO_3^- \text{ (aq)}$$

   b) ΔH_{soln} for Li_2CO_3 is negative since the solubility decreases with temperature.

$$Li_2CO_3 \text{ (s)} \quad \rightleftharpoons \quad 2\,Li^+ \text{ (aq)} + CO_3^{-2} \text{ (aq)} + \text{heat}$$
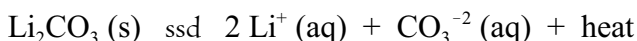
   c) ΔH_{soln} for O_2 is negative since the solubility decreases with temperature.

$$O_2 \text{ (g)} \quad \rightleftharpoons \quad O_2 \text{ (aq)} + \text{heat}$$

61. Henry's law is; $\quad C_{gas} \text{ (soln)} = k_H \times P_{gas}$.

   a) $\quad C_{O_2} = \dfrac{1.28 \times 10^{-3} \text{ mol}}{L \cdot atm} \times 1.0 \text{ atm} = \dfrac{1.28 \times 10^{-3} \text{ mol}}{L}$

   $\quad g_{O_2} = \dfrac{1.28 \times 10^{-3} \text{ mol}}{L} \times 2.0 \text{ L} \times \dfrac{31.9988 \text{ g } O_2}{mol} = 8.19 \times 10^{-2} \text{ g } O_2$

b) $\quad C_{O_2} \quad = \quad \dfrac{1.28 \times 10^{-3} \text{ mol}}{\text{L} \cdot \text{atm}} \times 0.209 \text{ atm} \quad = \quad \dfrac{2.67_5 \times 10^{-4} \text{ mol}}{\text{L}}$

$\quad g_{O_2} \quad = \quad \dfrac{2.67_5 \times 10^{-4} \text{ mol}}{\text{L}} \times 2.0 \text{ L} \times \dfrac{31.9988 \text{ g } O_2}{\text{mol}} \quad = \quad 1.71 \times 10^{-2} \text{ g } O_2$

62. People with respiratory problems have insufficient concentrations of O_2 in the blood. This concentration is ultimately determined by Henry's law which states that the concentration molecules in a solution are directly proportional to the pressure of gaseous molecules that are in equilibrium with the solution. Therefore, increasing the concentration of O_2 in the gas phase (i.e., increasing the pressure) will result in higher O_2 levels in the blood leaving the lungs.

QUESTIONS ABOUT SOLUTION CONCENTRATION

63. The classification of a sample as ionic or molecular is not always easy. It is often done through a series of observations. The first step is to determine the physical state of the pure substance. If the pure substance is a gas or liquid under normal laboratory conditions, then this is considered as proof that it is a molecular compound. However, if it is a solid, the sample can still be either ionic or molecular. At this point the chemist usually resorts to conductivity measurements. If the sample is soluble in water and the resulting solution does not conduct, this is evidence that it is molecular. If the sample does conduct, it may still be either ionic or molecular (see problem 16 below). At this point the chemist might melt the sample (if possible) and determine if the melt is conductive. If it does, it is classified as ionic and if it is non-conductive it is considered molecular.

64. H_2O and HCl are expected to be molecular compounds as they are composed of all nonmetal atoms. NaOH and NaCl are expected to be ionic since they are composed of metal and nonmetal atoms.

65. The fact that they are ionic is remarkable since they are composed of all nonmetal atoms. Each compound contains the ammonium ion NH_4^+, a cation made up of nonmetal elements only and not the usual metal atoms that typically form cations.

66. **Electrolytes** are substances that conduct electricity when dissolved in solution.

    Nonelectrolytes are substances that do not conduct electricity when dissolved in solution.

67. Since current electricity is simply the flow of charge a **sample must contain charges that can flow**.

68. A sample of solid NaCl does not conduct electricity because even though the sample does contain charges (the ions) those charges (the ions) cannot move (or flow). In an aqueous solution of NaCl, the charge or ions are free to flow in the liquid state (the water solution) and therefore the solution is an excellent conductor of electricity.

69. There are two basic ways ions can get into solution, by dissociation and by ionization.

    Dissociation refers the process in which the ions dis-associate from each other as they dissolve into a liquid solution.

    Ionization refers to the process of reaction between chemical entities to create ions.

70. Since the solute has actually dissolved into the solution then the solute particles must be separated and mobile. If the solution **does not** conduct electricity then the solution **does not** contain ions. Thus only molecules exist in the solution and therefore the solute must be molecular in nature.

71. Since the solute has actually dissolved into the solution then the solute particles must be separated and mobile. If the solution **does** conduct electricity then the solution **does** contain mobile ions. However, this does not mean that the solute must be ionic. It is true that IF an ionic solute does dissolve then mobile ions will be produced and the resulting solution will conduct electricity. However, it is possible for a reaction to occur <u>between a molecular solute and a molecular solvent to create ions</u> (see Ionization in problem 16) and since this solution would also contain mobile ions then this solution would conduct electricity too. Thus if all we know is that a solution conducts electricity we cannot tell if the solute is ionic or molecular in nature.

72. a) $X_{iso} = \dfrac{mol\ C_3H_8O}{mol\ C_3H_8O + mol\ H_2O} = \dfrac{0.30\ mol\ C_3H_8O}{0.30\ mol\ C_3H_8O + 0.80\ mol\ H_2O} = 0.27$

b) $\%iso = \dfrac{gC_3H_8O}{gC_3H_8O + gH_2O} = \dfrac{MM\,C_3H_8O \times mol\ C_3H_8O}{(MM\,C_3H_8O \times mol\,C_3H_8O) + (MM\,H_2O \times mol\,H_2O)} \times 100\%$

$= \dfrac{\dfrac{60.096\,g\,C_3H_8O}{mol\,C_3H_8O} \times 0.30\,mol\,C_3H_8O}{(\dfrac{60.096\,g\,C_3H_8O}{mol\,C_3H_8O} \times 0.30\,mol\,C_3H_8O) + (\dfrac{18.0152\,g\,H_2O}{mol\,H_2O} \times 0.80\,mol\,H_2O)} \times 100\% = 56\%$

c) $m_{iso} = \dfrac{mol\,C_3H_8O}{kg\,H_2O} = \dfrac{mol\,C_3H_8O}{(MM\,H_2O \times mol\,H_2O \times \dfrac{kg\,H_2O}{1000\,g\,H_2O})}$

$m_{iso} = \dfrac{0.30\,mol\,C_3H_8O}{(\dfrac{18.0152\,g\,H_2O}{mol\,H_2O} \times 0.80\,mol\,H_2O \times \dfrac{kg\,H_2O}{1000\,g\,H_2O})} = 20.8\,m\,C_3H_8O$

73. $\text{g CsCl} = \dfrac{6.30 \text{ g CsCl}}{(100 \text{ g soln} - 6.30 \text{ g CsCl})} \times \dfrac{0.9970 \text{ g H}_2\text{O}}{\text{mL H}_2\text{O}} \times \dfrac{\text{mL H}_2\text{O}}{10^{-3} \text{ L H}_2\text{O}} \times 0.500 \text{ L H}_2\text{O} = 33.5 \text{ g CsCl}$

74. $m_{\text{gly}} = \dfrac{88.4 \text{ g gly}}{1.250 \text{ kg H}_2\text{O}} \times \dfrac{\text{mol gly}}{75.067 \text{ g gly}} = 0.942 \text{ m gly}$

$\%\text{gly} = \dfrac{88.4 \text{ g gly}}{88.4 \text{ g gly} + 1.250 \text{ kg H}_2\text{O} \times \dfrac{1000 \text{ g H}_2\text{O}}{\text{kg H}_2\text{O}}} \times 100 \% = 6.60 \% \text{ gly}$

75. $m \text{ NH}_3 = \dfrac{8.00 \text{ g NH}_3}{92.0 \text{ g H}_2\text{O}} \times \dfrac{\text{mol NH}_3}{17.0304 \text{ g NH}_3} \times \dfrac{10^3 \text{ g H}_2\text{O}}{\text{kg H}_2\text{O}} = 5.11 \text{ m NH}_3$

$M \text{ NH}_3 = \dfrac{8.00 \text{ g NH}_3}{100 \text{ g soln}} \times \dfrac{\text{mol NH}_3}{17.0304 \text{ g NH}_3} \times \dfrac{0.9651 \text{ g soln}}{\text{mL soln}} \times \dfrac{\text{mL soln}}{10^{-3} \text{ L soln}} = 4.53 \text{ M NH}_3$

$X_{\text{NH}_3} = \dfrac{8.00 \text{ g NH}_3 \times \dfrac{1 \text{ mol NH}_3}{17.0304 \text{ g NH}_3}}{(8.00 \text{ g NH}_3 \times \dfrac{1 \text{ mol NH}_3}{17.0304 \text{ g NH}_3}) + (92.0 \text{ g H}_2\text{O} \times \dfrac{1 \text{ mol H}_2\text{O}}{18.0152 \text{ g H}_2\text{O}})} = 0.0842$

76. Since chemicals combine by number and not by mass it follows that one would wish to determine the moles of the various reactants present in the reaction. Furthermore, since the most convenient property to measure for a liquid is volume (see reasons for using liquid solutions above), it follows that one would need a conversion factor to convert between the volume of liquid used and the moles of solute dissolved in the solution. Therefore, molarity (M) is the most convenient concentration unit for chemists.

77. Molarity $(M) \equiv \dfrac{\text{moles of solute}}{\text{liters of solution}}$

78. $M = \dfrac{53.5 \text{ g C}_{12}\text{H}_{22}\text{O}_{11}}{746 \text{ mL soln}} \times \dfrac{1 \text{ mole C}_{12}\text{H}_{22}\text{O}_{11}}{342.299 \text{ g C}_{12}\text{H}_{22}\text{O}_{11}} \times \dfrac{1 \text{ mL soln}}{10^{-3} \text{ L soln}} = 0.210 \text{ M C}_{12}\text{H}_{22}\text{O}_{11}$

79. $M = \dfrac{1.45 \text{ g KCl}}{50.0 \text{ mL soln}} \times \dfrac{1 \text{ mole KCl}}{74.551 \text{ g KCl}} \times \dfrac{1 \text{ mL soln}}{10^{-3} \text{ L soln}} = 0.389 \text{ M KCl}$

80. $g = \dfrac{84.9947 \text{ g NaNO}_3}{1 \text{ moL NaNO}_3} \times \dfrac{1.00 \text{ mole NaNO}_3}{\text{L soln}} \times \dfrac{10^{-3} \text{ L soln}}{1 \text{ mL soln}} \times 75.0 \text{ mL soln} = 6.37 \text{ g NaNO}_3$

81. a) $\text{g NaCl} = \dfrac{58.443 \text{ g NaCl}}{\text{mol NaCl}} \times \dfrac{1.00 \text{ mol NaCl}}{(\text{kg}_{H_2O} + 0.058443 \text{ kg}_{NaCl}})) \times 0.500 \text{ kg soln} = 27.6 \text{ g NaCl}$

b) $\text{gNaCl} = \dfrac{58.443 \text{ gNaCl}}{\text{molNaCl}} \times \dfrac{1.00 \text{ molNaCl}}{\text{L soln}} \times \dfrac{\text{L soln}}{10^3 \text{ mL soln}} \times \dfrac{\text{mL soln}}{1.025 \text{ gsoln}} \times 500 \text{ gsoln} = 28.5 \text{ gNaCl}$

c) $\text{g NaCl} = \dfrac{5.00 \text{ g NaCl}}{100 \text{ g soln}} \times 500 \text{ g soln} = 25.0 \text{ g NaCl}$

82. a) $\text{M Suc} = \dfrac{42.3 \text{ g suc}}{100.0 \text{ mL soln}} \times \dfrac{\text{mol Suc}}{342.299 \text{ g Suc}} \times \dfrac{\text{mL soln}}{10^{-3} \text{ L soln}} = 1.24 \text{ M Suc}$

b) $\text{M LiNO}_3 = \dfrac{5.50 \text{ g LiNO}_3}{5050 \text{ mL soln}} \times \dfrac{\text{mol LiNO}_3}{68.946 \text{ g LiNO}_3} \times \dfrac{\text{mL soln}}{10^{-3} \text{ L soln}} = 0.0158 \text{ M LiNO}_3$

c) $M_1 \times V_1 = M_2 \times V_2 \quad \text{or} \quad M_2 = M_1 \times \dfrac{V_1}{V_2}$

$\therefore M_2 = 0.250 \text{ M}_1 \text{ NaOH} \times \dfrac{75.0 \text{ mL soln}_1}{250 \text{ mL soln}_2} = 0.0750 \text{ M NaOH}$

83. a) $\text{gKH}_2\text{PO}_4 = \dfrac{136.0865 \text{ gKH}_2\text{PO}_4}{\text{molKH}_2\text{PO}_4} \times \dfrac{8.73 \times 10^{-2} \text{ molKH}_2\text{PO}_4}{\text{L soln}} \times 0.250 \text{ L soln} = 2.97 \text{ gKH}_2\text{PO}_4$

The 2.97 g sample of KH_2PO_4 is weighed out and placed into a 250 mL volumetric flask. Approximately, 150 mL of H_2O is added and the mixture is stirred until all of the solid has dissolved. Then, with further stirring, H_2O is added until a final volume of 250 mL has been reached.

b) $M_1 \times V_1 = M_2 \times V_2 \quad \text{or} \quad V_1 = V_2 \times \dfrac{M_2}{M_1}$

$\therefore V_1 = 500 \text{ mL soln}_2 \times \dfrac{0.320 \text{ M soln}_2}{1.25 \text{ M soln}_1} = 128 \text{ mL soln}_1$

A 128 mL sample of 1.25 M NaOH is measured out and placed into a 500 mL volumetric flask. Water is then added with stirring until a final volume of 500 mL is reached.