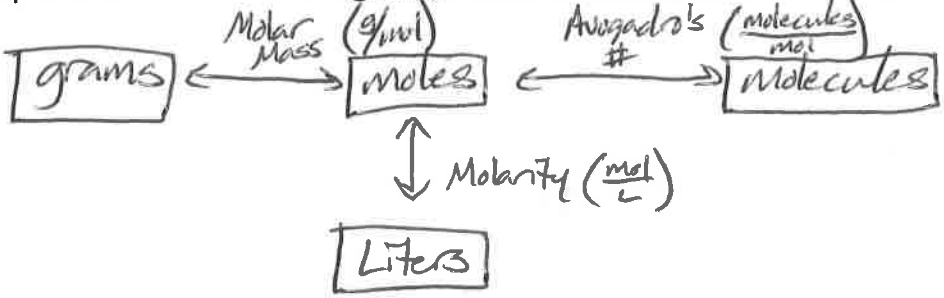
Solution Stoich & Limiting Reagent Review Packet

Name Key

Date ______________ Block ____

Background

1) Draw a concept map that relates the units of grams, moles, molecules, and liters to one another.



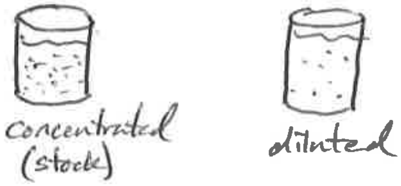
2) Define molarity and identify the units that describe it.

- Moles of solute dissolved in a volume of solution, ie concentration
- $M = \frac{mol}{L}$

3) Describe the difference between a dilute and a concentrated solution using the terms solute and solvent in your answer.

A concentrated (stock) solution has a higher amount of solute dissolved per liter of solution than a diluted solution. A diluted solution is made from a stock solution by adding more solvent to a given volume of stock (increases the volume without adding solute = lower conc.)

4) Identify the phase that matches the following terms:
   a. Vapor (g)
   b. Precipitate (s)
   c. Solution (aq)



5) Explain what it means for a reactant to be present in excess.

There was more present in the reaction than will be used/ converted into product. It will be left over in excess, (A) making the other reactant (B) limiting. You therefore should use the other reactant (B) to determine a yield of product (C).

$$\boxed{\underset{excess}{A} + \underset{limiting}{B} \rightarrow C}$$

6) What is the difference between the following problems? Identify what type of problem each is and how you would solve it.

A. How many grams of $AlBr_3$ are there in 250.0mL of a 1.4M solution?

Molarity Calc. – use

B. How many grams of AlF_3 will be made from mixing 250.0mL of a 0.35M $AlBr_3$ solution and 150.0mL of a 0.45M NaF solution?

Solution stoich – use molarity as a conversion factor & molar ratio from balanced equation.

C. How many milliliters of a 2.50M stock $AlBr_3$ solution would be needed to make 500.0mL of a 0.15M dilute solution?

Dilution – use $M_1V_1 = M_2V_2$

Molarity Calculations

7) How many liters of 0.45M solution could be made from 1.3g of $NaC_2H_3O_2$?

$$1.3\,g\left(\frac{1\,mol}{82.03\,g}\right) = 0.016\,mol$$

$$\underset{NaC_2H_3O_2}{0.016\,mol}\left(\frac{1\,L}{0.45\,mol}\right) = \boxed{0.035\,L}$$ 2 s.f.

8) What is the concentration (molarity) of a 155mL solution containing 3.39g of dissolved $Ba(OH)_2$?

$$155\,mL\left(\frac{1\,L}{1000\,mL}\right) = 0.155\,L$$

$$3.39\,g\left(\frac{1\,mol}{171.35\,g}\right) = 0.0198\,mol$$

$$M = \frac{0.0198\,mol}{0.155\,L} = \boxed{\underset{Ba(OH)_2}{0.128\,M}}$$ 3 s.f.

9) How many grams of $Mg(NO_3)_2$ would be needed to make 450.0mL of a 1.2M solution?

$$450.0\,mL\left(\frac{1\,L}{1000\,mL}\right) = 0.4500\,L$$

$$0.4500\,L\left(\frac{1.2\,mol}{1\,L}\right) = \underset{Mg(NO_3)_2}{0.054\,mol}\left(\frac{148.33\,g}{1\,mol}\right) = \boxed{\underset{Mg(NO_3)_2}{80.\,g}}$$ 2 s.f.

Solution Stoichiometry

Limiting

10) Excess magnesium is dipped into a 150.0mL solution of 0.340M silver nitrate. How much precipitate would be produced?

↳ solid

✓ ?

$$Mg(s) + 2AgNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + 2Ag(s)$$

$$150.0\,mL\ AgNO_3 \left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.34\,mol\ AgNO_3}{1\,L}\right)\left(\frac{2\,mol\ Ag}{2\,mol\ AgNO_3}\right)\left(\frac{107.87\,g}{1\,mol\ Ag}\right) = \boxed{5.50\,g\ Ag}$$

3 s.f.

11) How much precipitate (g) could be formed from the combination of 125mL of a 2.3M solution of ammonium hydroxide and a concentrated (excess) solution of copper (II) chloride?

limiting

✓ ?

$$2NH_4OH(aq) + CuCl_2(aq) \longrightarrow 2NH_4Cl(aq) + Cu(OH)_2(s)$$

$$125\,mL\ NH_4OH \left(\frac{1\,L}{1000\,mL}\right)\left(\frac{2.3\,mol\ NH_4OH}{1\,L}\right)\left(\frac{1\,mol\ Cu(OH)_2}{2\,mol\ NH_4OH}\right)\left(\frac{97.57\,g}{1\,mol}\right) = \boxed{14\,g\ Cu(OH)_2}$$

2 s.f.

12) a. 1400.0mL of a 0.6770M magnesium chloride solution is mixed with 1200.0mL of a 0.8050M sodium phosphate solution. What is the limiting reagent in the reaction?

$$2Na_3PO_4(aq) + 3MgCl_2(aq) \longrightarrow Mg_3(PO_4)_2(s) + 6NaCl(aq)$$

$$1400.0\text{ mL } MgCl_2 \left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{0.6770\text{ mol}}{1\text{ L}}\right) = \boxed{0.9478\text{ mol } MgCl_2} \text{ HAVE}$$

$$.09478\text{ mol } MgCl_2 \left(\frac{2\text{ mol } Na_3PO_4}{3\text{ mol } MgCl_2}\right) = \boxed{0.6319\text{ mol } Na_3PO_4 \text{ NEEDED}}$$

$$1200.0\text{ mL } Na_3PO_4 \left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{0.8050\text{ mol}}{1\text{ L}}\right) = \boxed{0.9660\text{ mol } Na_3PO_4}$$

excess

$\boxed{MgCl_2 \text{ is limiting}}$

b. How much precipitate (g) would be formed in the above reaction?

↳ $Mg_3(PO_4)_2(s)$

(use limiting)

$$0.9478\text{ mol } MgCl_2 \left(\frac{1\text{ mol } Mg_3(PO_4)_2}{3\text{ mol } MgCl_2}\right)\left(\frac{262.89\text{ g}}{1\text{ mol } Mg_3(PO_4)_2}\right) = \boxed{83.06\text{ g } Mg_3(PO_4)_2}$$

4 s.f.

c. How many moles of excess reagent would be left over?

Excess Used

$$0.9478\text{ mol } MgCl_2 \left(\frac{2\text{ mol } Na_3PO_4}{3\text{ mol } MgCl_2}\right) = 0.6319\text{ mol } Na_3PO_4$$

$$\begin{array}{rl} & 0.9660\text{ mol (HAVE)} \\ - & 0.6319\text{ mol (USED)} \\ \hline & \boxed{0.3341\text{ mol } Na_3PO_4} \text{ (left-over)} \end{array}$$

d. If 81.59g of precipitate was actually collected during the experiment, what would be the percent yield of the experiment?

$$\%\text{ Yield} = \frac{81.59\text{ g}}{83.06\text{ g}}(100) = \boxed{98.23\ \%}$$

13) a. A 55mL solution of 1.15M potassium hydroxide is mixed with 65mL of a 1.25M hydrogen chloride (hydrochloric acid) solution. What is the limiting reagent in the reaction?

$$KOH\ (aq) + HCl\ (aq) \longrightarrow KCl\ (aq) + H_2O\ (l)$$

$$\underset{KOH}{55\text{ mL}}\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{1.15\text{ mol}}{1\text{ L}}\right) = \boxed{\begin{matrix}0.063\text{ mol} \\ KOH\end{matrix}}\ \text{HAVE}$$

$$\underset{HCl}{65\text{ mL}}\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{1.25\text{ mol}}{1\text{ L}}\right) = \boxed{\begin{matrix}0.081\text{ mol} \\ HCl\end{matrix}} \leftarrow \text{excess}$$

$$\underset{KOH}{0.063\text{ mol}}\left(\frac{1\text{ mol }HCl}{1\text{ mol }KOH}\right) = \boxed{\begin{matrix}0.063\text{ mol} \\ HCl\end{matrix}}$$

NEEDED

KOH is limiting

b. How much water (g) would be formed in the above reaction?

(use limiting)

$$\underset{KOH}{0.063\text{ mol}}\left(\frac{1\text{ mol }H_2O}{1\text{ mol }KOH}\right)\left(\frac{18.02\text{ g}}{1\text{ mol}}\right) = \boxed{1.1\text{ g }H_2O}$$

2 s.f.

c. What concentration (molarity) of excess reagent would be left over after mixing the solutions? ★

↳ final volume = 55 mL + 65 mL = 120 mL

Excess Used

$$\underset{KOH}{0.063\text{ mol}}\left(\frac{1\text{ mol }HCl}{1\text{ mol }KOH}\right) = \begin{matrix}0.063\text{ mol} \\ HCl\end{matrix}$$

$$\begin{array}{l} 0.081\text{ mol }HCl\ (\text{HAVE}) \\ -0.063\text{ mol }HCl\ (\text{USED}) \\ \hline 0.018\text{ mol }HCl\ (\text{left-over}) \end{array}$$

$$M = \frac{\text{mol}}{\text{L}} = \frac{0.018\text{ mol }HCl}{0.120\text{ L} ★} = \boxed{0.15\text{ M }HCl}$$

d. If 1.02g of water was actually collected during the experiment, what would be the percent error of the experiment?

$$\%\text{ Error} = \frac{|1.02\text{ g} - 1.1\text{ g}|}{1.1\text{ g}}(100)$$

$$= \boxed{7.3\ \%}$$

Dilutions

$$M_1V_1 = M_2V_2$$

$V_1 = ?$ V_2

14) How many milliliters of a 2.98M stock HF solution would be needed to make 400.0mL of a 0.050M solution?

M_1

M_2

$$(2.98\ M)V_1 = (0.050\ M)(400.0\ mL)$$

$$\boxed{V_1 = 6.7\ mL}$$ 2 s.f.

$V_2 = ?$

15) How many liters of 0.45M dilute solution can be made from 50.0mL of a 1.22M stock solution?

M_2 V_1 M_1

$$(1.22\ M)(50.0\ mL) = (0.45\ M)V_2$$

$$V_2 = 136\ mL = \boxed{0.14\ L}$$ 2 s.f.

V_1

16) If 150.0mL of a stock solution was used to make 750.0mL of a 0.80M dilute solution, what was the concentration of the stock solution?

V_2 M_2

$M_1 = ?$

$$M_1(150.0\ mL) = (0.80\ M)(750.0\ mL)$$

$$\boxed{M_1 = 4.0\ M}$$ 2 s.f.

V_1 M_1

17) If 35.7mL of a 1.10M stock solution is diluted to a volume of 145.0mL, what is the concentration of the new dilute solution?

V_2

$M_2 = ?$

$$(1.10\ M)(35.7\ mL) = M_2(145.0\ mL)$$

$$\boxed{M_2 = 0.271\ M}$$ 3 s.f.

18) a. Provide a detailed procedure on how to properly make 100.0mL of a 0.500M NaOH solution if you have solid NaOH available for use.

1) Calc appropriate mass of NaOH to weigh & use.

$$100.0\ mL\left(\frac{1L}{1000\ mL}\right)\left(\frac{0.500\ \overset{NaOH}{mol}}{1L}\right)\left(\frac{40.00\ g}{1\ mol\ NaOH}\right)=\boxed{2.00\ g\ NaOH}\ 3\ s.f.$$

2) Weigh out 2.00 g NaOH & quantitatively transfer it into a 100 mL volumetric flask.

3) Fill ½ way with diH_2O, swirl to dissolve.

4) Fill to graduated mark with diH_2O, cap, invert to mix.

b. How would the procedure above change if you have a 1.00M stock solution of NaOH available instead of a solid?

1) Calc volume of stock to measure & use.

$$M_1V_1 = M_2V_2 \qquad (1.00\ M)V_1 = (0.500\ M)(100.0\ mL)$$

$$\boxed{V_1 = 50.0\ mL}\ 3\ s.f.$$

2) Pour ~60 mL stock solution into a clean 100 mL beaker.

3) Volumetrically pipette 50.0 mL of stock solution into a 100 mL volumetric flask.

4) Fill flask to graduated mark with diH_2O, cap, invert to mix.