Solution Stoichiometry

Name____Section_____________

DCI14.1a. How many grams of magnesium sulfate are required to prepare 500.00 mLs of 0.500 M NaOH?

$$\mathbf{.500\ L\left(\frac{0.500\ mol\ NaOH}{1\ L}\right) = 0.250\ mol\ NaOH}$$

$$\mathbf{0.\ 250\ mol\ NaOH\left(\frac{40.0\ g\ NaOH}{1\ mol\ NaOH}\right) = 10.0\ g\ NaOH}$$

b)Describe how you would prepare this solution?

Weigh 10.00 g $NaOH_{(s)}$ using a balance. Add some water, about 300 mL to a 500 mL volumetric flask, then add the $NaOH_{(s)}$ to the flask. and mix the solution until all the NaOH dissolves. Then add enough water so the final volume is 500.00 mL.

DCI14.2. Calculate the volume of 0.750 M KNO_3 that contains 17.0 g of KNO_3.

$$\mathbf{17.0\ g\ of\ KNO_3\left(\frac{1\ mol\ KNO_3}{101\ g\ KNO_3}\right) = 0.168\ mol\ KNO_3}$$

$$\mathbf{0.168\ mol\ KNO_3\left(\frac{1\ Liter}{0.750\ mol}\right) = 0.224\ L}$$

DCI14.3. What is the concentration of HCl in a 250.0 mL sample of hydrochloric acid if 15.5 mL of 0.0100 M NaOH is needed to react with all of the hydrochloric acid.

$$\mathbf{0.0155\ L\ NaOH\left(\frac{0.0100\ mol\ NaOH}{1\ L}\right) = 1.55 \times 10^{-4}\ mol\ NaOH\ reacting}$$

	$NaOH_{(aq)}$	+	$HCl_{(aq)}$	→	$NaCl_{(s)}$	+	$H_2O_{(l)}$
Initial			**?**		**0**		**0**
Change	**-1.55×10^{-4} mol**						
Final							

$$\mathbf{1.55 \times 10^{-4}\ mol\ NaOH\left(\frac{1\ mol\ HCl}{1\ mol\ NaOH}\right) = 1.55 \times 10^{-4}\ mol\ HCl}$$

$$\mathbf{1.55 \times 10^{-4}\ mol\ NaOH\left(\frac{1\ mol\ H_2O}{1\ mol\ NaOH}\right) = 1.55 \times 10^{-4}\ mol\ H_2O}$$

$$\mathbf{1.55 \times 10^{-4}\ mol\ NaOH\left(\frac{1\ mol\ NaCl}{1\ mol\ NaOH}\right) = 1.55 \times 10^{-4}\ mol\ NaCl}$$

$$\mathbf{NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(s)} + H_2O_{(l)}}$$

Initial	**1.55×10^{-4} mol**	**1.55×10^{-4} mol**	**0**	**0**
Change	**-1.55×10^{-4} mol**	**-1.55×10^{-4} mol**	**$+1.55 \times 10^{-4}$ mol**	**$+1.55 \times 10^{-4}$ mol**
Final				

$$\frac{1.55 \times 10^{-4} \text{ mol HCl}}{0.250 \text{ L}} = 6.20 \times 10^{-4} \text{ M HCl}$$

DCI14.4. Given the reaction

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

a) If a piece of sodium weighing 1.25 grams is added to 450 mL of water, calculate the grams of H_2 produced.

$$1.25 \text{ g Na} \left(\frac{1 \text{ mol Na}}{23.0 \text{ g Na}}\right) = 0.0543 \text{ mol Na}$$

$$450 \text{ mL } H_2O \left(\frac{1.00 \text{ g } H_2O}{1 \text{ mL } H_2O}\right)\left(\frac{1 \text{ mol } H_2O}{18 \text{ g } H_2O}\right) = 25.0 \text{ mol } H_2O$$

	$2Na(s)$	**+ $2H_2O(l)$**	**$\rightarrow$ $2NaOH(aq)$**	**+ $H_2(g)$**
Initial	**0.0543 mol**	**25.0 mol**	**0**	**0**
Change				
Final				

Clearly Sodium is the limiting reagent when there are 25.0 mole of H_2O present initially.

	$2Na(s)$	**+ $2H_2O(l)$**	**$\rightarrow$ $2NaOH(aq)$**	**+ $H_2(g)$**
Initial	**0.0543 mol**	**25.0 mol**	**0**	**0**
Change	**-0.0543 mol**	**-0.0543 mol**	**+0.0543 mol**	**+0.0272 mol**
Final				

$$0.0543 \text{ mol Na} \left(\frac{2 \text{ mol } H_2O}{2 \text{ mol Na}}\right) = 0.0543 \text{ mol } H_2O \text{ reacting}$$

$$0.0543 \text{ mol Na} \left(\frac{2 \text{ mol NaOH}}{2 \text{ mol Na}}\right) = 0.0543 \text{ mol NaOH forming}$$

$$0.0543 \text{ mol Na} \left(\frac{1 \text{ mol } H_2}{2 \text{ mol Na}}\right) = 0.0272 \text{ mol } H_2 \text{ forming}$$

	$2Na(s)$	**+ $2H_2O(l)$**	**$\rightarrow$ $2NaOH(aq)$**	**+ $H_2(g)$**
Initial	**0.0543 mol**	**25.0 mol**	**0**	**0**
Change	**-0.0543 mol**	**-0.0543 mol**	**+0.0543 mol**	**+0.0272 mol**
Final	**0 mol**	**25.0 mol**	**+0.0543 mol**	**+0.0272 mol**

$$0.0543 \text{ mol Na} \left(\frac{1 \text{ mol } H_2}{2 \text{ mol Na}}\right)\left(\frac{2.02 \text{ g}}{1 \text{ mol } H_2}\right) = 0.0548 \text{ g } H_2$$

b) Calculate the concentration of NaOH in the solution after the reaction is complete, assume a negligible volume change.

$$\mathbf{0.0543\ mol\ Na}\left(\frac{\mathbf{2\ mol\ NaOH}}{\mathbf{2\ mol\ Na}}\right) = \mathbf{0.0543\ mol\ NaOH}$$

$$\frac{\mathbf{0.0543\ mol\ NaOH}}{\mathbf{0.450\ L\ H_2O}} = \mathbf{0.121\ M\ NaOH}$$

NOTE: The amount of water that reacts is negligible compared to the amount of water present, so the volume of solution is the same as the volume of water initially present. Since the amount of sodium added is very small compared to the amount of water we will assume the volume of the solution is the same as the volume of water. We can only do this when the amount of solute is very, very much smaller than the volume of water.

DCI14.4. What volume of 0.406 M KOH is required to completely react with 18.50 mL of 0.287 M H_2SO_4

Important reaction is

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

We can use an ICE table to solve this problem:

	$2KOH(aq)$	+	$H_2SO_4(aq)$	→	$K_2SO_4(aq)$	+	$2H_2O(l)$
Initial							
Change							
Final							

The initial amount of H_2SO_4 can be determined,

$$\mathbf{0.01850\ L\ H_2SO_4}\left(\frac{\mathbf{0.287\ mol\ H_2SO_4}}{\mathbf{1\ L}}\right) = \mathbf{5.31 \times 10^{-3}\ mol\ H_2SO_4}$$

add this amount of H_2SO_4 to the ICE table

	$2KOH(aq)$	+	$H_2SO_4(aq)$	→	$K_2SO_4(aq)$	+	$2H_2O(l)$
Initial			5.31×10^{-3} mol		0		0
Change			-5.31×10^{-3} mol				
Final							

Determine the amount of KOH that will react,

$$\mathbf{5.31 \times 10^{-3}\ mol\ H_2SO_4}\left(\frac{\mathbf{2\ mol\ KOH}}{\mathbf{1\ mol\ H_2SO_4}}\right) = \mathbf{1.06 \times 10^{-2}\ mol\ KOH}$$

and add to the ICE table and complete the ICE table,

$$2KOH(aq) \quad + \quad H_2SO_4(aq) \quad \rightarrow \quad K_2SO_4(aq) \quad + \quad 2H_2O(l)$$

Initial	**1.06×10^{-2} mol**	**5.31×10^{-3} mol**	**0**	**0**
Change	**-1.06×10^{-2} mol**	**-5.31×10^{-3} mol**	**$+5.31 \times 10^{-3}$ mol**	**$+1.06 \times 10^{-2}$ mol**
Final	**0**	**0**	**0**	**0**

$$1.06 \times 10^{-2} \text{ mol KOH} \left(\frac{1 \text{ L}}{0.406 \text{ mol KOH}}\right) = 2.62 \times 10^{-2} \text{ L or } 26.2 \text{ mL}$$