3. Identify the reducing agent in the following reaction:

$$\overset{+5}{NO_3^-}(aq) + \overset{0}{S_8}(s) \rightarrow \overset{+4}{NO_2}(g) + \overset{+6}{SO_4^{2-}}(aq)$$

A) NO_3^-

B) S_8

C) NO_2

D) SO_4^{2-}

(1)

4.1 Study the reaction between chromium chloride and sodium hydroxide and answer the questions that follow.

$$CrCl_3(aq) + 3NaOH(aq) \rightarrow Cr(OH)_3 + 3NaCl$$

i) Using the rules for solubility, predict the solubility of the products.

$Cr(OH)_3(s)$ & $NaCl(aq)$ (1)

ii) Write the net ionic reaction for this equation. (1)

$$Cr^{+3}_{(aq)} + 3OH^-_{(aq)} \rightarrow Cr(OH)_3$$

4.2 The following reaction occurs in a basic medium:

$$\overset{0}{Cl_2}(g) \rightarrow \overset{+1}{ClO^-}(aq) + \overset{-1}{Cl^-}(aq)$$

Balance the redox equation using the half reaction method. Show your working. (4)

$2H_2O + Cl_2 \rightarrow 2ClO^- + 8H^+ + 6e^-$

$(6e^- + 3Cl_2 \rightarrow 6Cl^-)3$

$2H_2O + 4Cl_2 \rightarrow 2ClO^- + 6Cl^- + 8H^+$

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CHEM 110 Worksheet - **Aqueous Reactions and Solution Stoichiometry**

Additional Problems

You are expected to go through the **following problems from your textbook:**

Chapter 3. Nos. 3.9, 3.10, 3.11, 3.12, 3.18, 3.20, 3.32, 3.37, 3.39, 3.45, 3.66, 3.78.

Past Exam Questions

Multiple Choice Questions

1. Identify a neutralization reaction:

A) $AgNO_3(aq) + HCl(aq) \rightarrow AgCl(s) + HNO_3(aq)$

B) $2HI(aq) + H_2O_2(aq) \rightarrow I_2(s) + 2H_2O(l)$

C) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

D) $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$ (1)

2. The oxidation state for the element in the reactant that is oxidised in the equation below is:

0 0 +3 -2

$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

A) 0

B) -2

C) +2

~~D) +3~~ (1)

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AP Chemistry – Types of Reactions

Directions: 1. Identify the type of reaction 2. Balance the reaction

1. $MgCl_2 + Li_2CO_3 \rightarrow MgCO_3 + 2\ LiCl$ — Precipitation/DR
2. $C_6H_{12} + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ — Redox/Combustion
3. $Pb + FeSO_4 \rightarrow PbSO_4 + Fe$ — Redox/SR
4. $P_4 + 3O_2 \rightarrow 2\ P_2O_3$ — Redox/Synthesis
5. $Ca(OH)_2 + 2\ HNO_3 \rightarrow Ca(NO_3)_2 + 2\ H_2O$ — Neutralization/DR
6. $AgNO_3 + HCl \rightarrow AgCl + HNO_3$ — Precipitation/DR
7. $Cr(OH)_3 + Br_2 \rightarrow CrO_4^{-2} + Br^{-1}$ — Redox

*balance in acidic solution

$2H_2O + Cr(OH)_3 \rightarrow 2CrO_4^{-2} + 10H^+ + 6e^-$

$6e^- + 3Br_2 \rightarrow 6Br^-$

$2H_2O + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^- + 10H^+ + 6Br^-$

*balance in basic solution

$10OH^- + 2H_2O + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^- + 10H^+ + 6Br^- + 10OH^-$

(8 H_2O)

$10\ OH^- + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^- + 8H_2O + 6Br^-$

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Solution Stoichiometry

Chem Worksheet 15-6

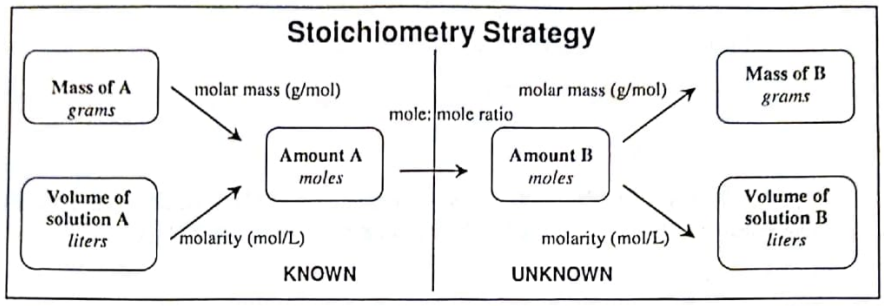
Name _____

The **molarity** of a solution is a ratio of the moles of solute per liters of solution. The units for molarity are written as mol/L or *M*. This measurement is used to perform stoichiometric calculations. The strategy used for solving these solution stoichiometry problems is to set up the problem so that the units cancel.

USEFUL EQUATIONS

$$\text{molarity} = \frac{\text{mol solute}}{\text{L solution}} \qquad 1\text{ L} = 1000\text{ mL}$$

When the volume of a solution is multiplied by the molarity of a solution the resulting units are moles. A balanced equation allows us to convert from moles of a known substance to moles of an unknown. Finally, the moles of an unknown substance can be converted into grams, liters of solution, molarity, or other units.



Example

How many grams of solid calcium hydroxide, $Ca(OH)_2$, are required to react with 350 mL of 0.40 *M* HCl?

$$\_\,HCl + \_\,Ca(OH)_2 \rightarrow \_\,CaCl_2 + \_\,H_2O$$

- balance the equation: $2\,HCl + \_\,Ca(OH)_2 \rightarrow \_\,CaCl_2 + 2\,H_2O$

- convert mL to L: $\frac{350\text{ mL HCl}}{1} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.350\text{ L HCl}$

- write the 'given' and 'unknown' units: $\frac{350\text{ L HCl}}{1} \times \frac{\quad}{\quad} \times \frac{\quad}{\quad} \times \frac{\quad}{\quad} = \quad \text{grams } Ca(OH)_2$

- fill in factors and solve: $\frac{0.350\text{ L HCl}}{1} \times \frac{0.40\text{ mol HCl}}{1\text{ L HCl}} \times \frac{1\text{ mol } Ca(OH)_2}{2\text{ mol HCl}} \times \frac{74.10\text{ g } Ca(OH)_2}{1\text{ mol } Ca(OH)_2} = 5.19\text{ grams } Ca(OH)_2$

Answer the following questions. Show all work and report answers with units.

1. How many grams of aluminum are required to react with 35 mL of 2.0 *M* hydrochloric acid, HCl?
   $6\,HCl + 2\,Al \rightarrow 2\,AlCl_3 + 3\,H_2$

2. How many grams of sodium can be reacted with 750 mL of a 6.0 *M* solution of sulfuric acid, H_2SO_4?
   $2\,Na + \_\,H_2SO_4 \rightarrow \_\,Na_2SO_4 + \_\,H_2$

3. If 45 mL of a 1.5 *M* $AgNO_3$ is added to KCl how many grams of AgCl can be formed?
   $\_\,AgNO_3 + \_\,KCl \rightarrow \_\,AgCl + \_\,KNO_3$

4. How many liters of a 0.75 *M* solution of $Ca(NO_3)_2$ will be required to react with 148 g of Na_2CO_3?
   $\_\,Ca(NO_3)_2 + \_\,Na_2CO_3 \rightarrow \_\,CaCO_3 + 2\,NaNO_3$

5. How many liters of a 3.0 *M* H_3PO_4 solution are required to react with 4.5 g of zinc?
   $2\,H_3PO_4 + 3\,Zn \rightarrow \_\,Zn_3(PO_4)_2 + 3\,H_2$

6. How many milliliters of 0.10 *M* $Pb(NO_3)_2$ are required to react with 75 mL of 0.20 *M* NaI?
   $\_\,Pb(NO_3)_2 + 2\,NaI \rightarrow \_\,PbI_2 + 2\,NaNO_3$

7. How many grams of solid $BaSO_4$ will form when Na_2SO_4 reacts with 25 mL of 0.50 *M* $Ba(NO_3)_2$?
   $\_\,Ba(NO_3)_2 + \_\,Na_2SO_4 \rightarrow \_\,BaSO_4 + 2\,NaNO_3$

8. If 525 mL of 0.80 *M* HCl solution is neutralized with 315 mL of $Sr(OH)_2$ solution what is the molarity of the $Sr(OH)_2$?
   $2\,HCl + \_\,Sr(OH)_2 \rightarrow \_\,SrCl_2 + 2\,H_2O$

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(1) $0.035\,L \left| \frac{2.0\,mol\,HCl}{1\,L} \right| \frac{2\,mol\,Al}{6\,mol\,HCl} \left| \frac{26.97\,g\,Al}{1\,mol\,Al} \right. = 0.63\,g\,Al$

(2) $0.750\,L \left| \frac{4.0\,mol\,H_2SO_4}{1\,L} \right| \frac{2\,mol\,Na}{1\,mol\,H_2SO_4} \left| \frac{22.99\,g}{1\,mol\,Na} \right. = 210\,g\,Na$

(3) $0.045\,L \left| \frac{1.5\,mol\,AgNO_3}{1\,L} \right| \frac{1\,mol\,AgCl}{1\,mol\,AgNO_3} \left| \frac{143.55\,g}{1\,mol} \right. = 9.7\,g\,AgCl$

(4) $148\,g\,Na_2CO_3 \left| \frac{1\,mol\,Na_2CO_3}{105.99\,g} \right| \frac{1\,mol\,Ca(NO_3)_2}{1\,mol\,Na_2CO_3} \left| \frac{164.1\,g}{1\,mol} \right. = 230\,g\,Ca(NO_3)_2$

$0.75 = \frac{1.40\,mol}{x}$ $\quad x = 1.9\,L$

(5) $4.5\,g\,Zn \left| \frac{1\,mol\,Zn}{65.38\,g\,Zn} \right| \frac{2\,mol\,H_3PO_4}{3\,mol\,Zn} \left| \frac{1\,L}{3.0\,mol\,H_3PO_4} \right. = 0.015\,L\,H_3PO_4$

(6) $0.075\,L \left| \frac{0.20\,mol\,NaI}{1\,L} \right| \frac{1\,mol\,Pb(NO_3)_2}{2\,mol\,NaI} \left| \frac{1\,L}{0.10\,mol} \right| \frac{1000\,mL}{1\,L} = 75\,mL\,Pb(NO_3)_2$

(7) $0.025\,L \left| \frac{0.50\,mol\,Ba(NO_3)_2}{1\,L} \right| \frac{1\,mol\,BaSO_4}{1\,mol\,Ba(NO_3)_2} \left| \frac{233.38\,g}{1\,mol\,BaSO_4} \right. = 2.9\,g$

(8) $0.525\,L \left| \frac{0.80\,mol\,HCl}{1\,L} \right| \frac{1\,mol\,Sr(OH)_2}{2\,mol\,HCl} \left| \frac{}{0.315\,L} \right. = 0.667\,M$

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* Either use Stoichiometry (mole ratio coefficients) OR $nMV = nMV$ OR $\#H^+$ $\#OH$

Titrations worksheet

W 336

1) It takes 83 mL of a 0.45 M NaOH solution to neutralize 235 mL of an HCl solution. What is the concentration of the HCl solution? $nMV = nMV$

$(1)(M)(235) = (1)(0.45)(83)$

$M = 0.16\,M\ HCl$

2) You are titrating an acid into a base to determine the concentration of the base. The endpoint of the neutralization is reached but the stopcock on the buret sticks slightly and allows a few more drops of acid to fall into the solution. How will this affect your calculations for the concentration of the base?

Concentration of the base would seem to be larger

3) It takes 38 mL of 0.75 M NaOH solution to completely neutralize 155 mL of a sulfuric acid solution (H_2SO_4). What is the concentration of the H_2SO_4 solution?

$2\,NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

$$0.038L \left| \frac{0.75\,mol\,NaOH}{1L} \right| \frac{1\,mol\,H_2SO_4}{2\,mol\,NaOH} \Big| \frac{}{0.155L} = 0.092\,M$$

4) A few small drops of water are left in a buret that is then used to titrate a base into an acid solution to determine the concentration of the acid. Will this small amount of water have any effect on the determined value for the concentration of the acid? If so, how is it affected? probably won't but if it did it would ↓ conc. of base and require more base to reach endpt. making it seem like the acid has a higher conc.

5) It takes 12.5 mL of a 0.30 M HCl solution to neutralize 285 mL of NaOH solution. What is the concentration of the NaOH solution?

$HCl + NaOH \rightarrow NaCl + H_2O$

$$0.0125L \left| \frac{0.30\,mol\,HCl}{1L} \right| \frac{1\,mol\,NaOH}{1\,mol\,HCl} \Big| \frac{}{0.285L} = 0.013\,M$$

6) Lulu Labwrecker carefully pipets 25.0 mL of 0.525 M NaOH into a test tube. She places the test tube into a small beaker to keep it from spilling and then pipets 75.0 mL of 0.355 M HCl into another test tube. When Lulu reaches to put this test tube of acid into the beaker along with test tube of base she accidentally knocks the test tubes together hard enough to break them and their respective contents combine in the bottom of the beaker. Is the solution formed from the contents of the two test tubes acidic or basic? What is the pH of the resulting solution?

$$0.025L \left| \frac{0.525\,mol\,NaOH}{1L} \right. = 0.0131\,mol\,NaOH$$

$$0.075L \left| \frac{0.355\,mol\,HCl}{1L} \right. = 0.0266\,mol\,HCl$$

since mol HCl > mol NaOH soln would be acidic

not a test *

$0.0266 - 0.0131 = 0.0135\,mol$ acid not reacted

$\frac{0.0135\,mol\ HCl}{0.100L\ \text{total volume}} = 0.135\,M\ HCl$

$-\log 0.135 = 0.870$

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Name: _____ Date: _____ AP CHEMISTRY BIG IDEA 3

Worksheet: Redox Titration

1. A $KMnO_4$ solution is standardized with oxalic acid. The balanced equation for the redox reaction is:

$$5\ H_2C_2O_4 + 2\ MnO_4^- + 6\ H^+ \rightarrow 10\ CO_2 + 2\ Mn^{2+} + 8\ H_2O$$

What is the molar concentration of the $KMnO_4$ solution, if 18.6 mL of the solution was required to titrate 0.105 g $H_2C_2O_4 \cdot 2\ H_2O$?

$$0.105\text{g } H_2C_2O_4 \cdot 2H_2O \left| \frac{1\text{mol}}{90.036\text{g}} \right| \frac{2\text{mol } MnO_4^-}{5\text{mol } H_2C_2O_4} \left| \frac{}{0.0186\text{L}} \right.$$

$$= 0.0251\text{M } KMnO_4$$

$Cr_2O_7^{2-} + I^- \rightarrow Cr^{3+} + I_2$ (acidic)

2. A student titrates 15.0 mL of $KI_{(aq)}$ (in acidic solution) to the equivalence point with 32.8 mL of 0.200 M $Na_2Cr_2O_7$. Balance the equation using the half-reaction method. What is the concentration of KI?

$$\cancel{6e^-} + 14H^+ + Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O$$

$$6I^- \rightarrow 3I_2 + \cancel{6e^-}$$

$$14H^+ + Cr_2O_7^{-2} + 6I^- \rightarrow 2Cr^{+3} + 7H_2O + 3I_2$$

$$0.0328\text{L } Na_2Cr_2O_7 \left| \frac{0.200\text{mol}}{1\text{L}} \right| \frac{6\text{ mol } I^-}{1\text{mol } Cr_2O_7^{-2}} \left| \frac{}{0.0150\text{L}} \right.$$

$$= 2.62\text{M } KI$$

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3. The legal limit for intoxication while driving in British Columbia used to be the same as in the US (0.08% by mass), but was recently lowered to 0.05% in 2010. A 5.00 g sample of blood from a suspected drunk driver is titrated with 10.15 mL of 0.0150 M $K_2Cr_2O_7$. The dichromate ion reacts with any ethanol, C_2H_5OH, present in the blood to form carbon dioxide and the Cr^{3+} ion.

   a. Balance the equation for the reaction that occurs in this titration in acidic solution. Which reactant is being oxidized?

16
$6e^- + 14H^+ + 2Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 11H_2O$

$3H_2O + C_2H_5OH \rightarrow 2CO_2 + 12H^+ + 12e^-$

$16H^+ + 3H_2O + 2Cr_2O_7^{-2} + C_2H_5OH \rightarrow 4Cr^{+3} + 11H_2O + 2CO_2 + 12H^+$

   b. Calculate the percentage of alcohol by mass in the blood sample. Would this driver be considered legally impaired prior to 2010? Now?

$$0.01015\,L \left| \frac{0.0150\,mol\,Cr_2O_7^{-2}}{1\,L} \right| \frac{1\,mol\,C_2H_5OH}{2\,mol\,Cr_2O_7^{-2}} \left| \frac{46.068\,g}{1\,mol} \right| = 0.0351g$$

$$\frac{0.0351g}{5.00g} * 100 = 0.70\%$$ yes!

$Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$

4. To titrate a 25.0 mL solution of Fe^{2+} to the equivalence point, 16.7 mL of 0.0152 M MnO_4^- in acidic solution was needed. What was the concentration of Fe^{2+}?

$5Fe^{+2} \rightarrow 5Fe^{+3} + 5e^-$

$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{+2} + 4H_2O$

$5Fe^{+2} + 8H^+ + MnO_4^- \rightarrow 5Fe^{+3} + Mn^{+2} + 4H_2O$

$$0.0167\,L \left| \frac{0.0152\,mol\,MnO_4^-}{1\,L} \right| \frac{5\,mol\,Fe^{+2}}{1\,mol\,MnO_4^-} \left| \frac{}{0.025\,L} \right|$$

$= 0.0508\,M\,Fe^{+2}$

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