Chem 1515 Section 1 - 6
Review Problem Set
Spring 2002

Name_____

TA Name _____

Lab Section #_____

ALL work must be shown to receive full credit. **Due in lecture, at 8:30 a.m. on Friday, January 25, 2002.**

RPS.1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Soluble ionic compounds should be written in the form of their component ions.

a) sulfuric acid*(aq)* + barium nitrate*(aq)* → **$BaSO_{4(s)}$ + $2H^+_{(aq)}$ + $2NO_3^-{}_{(aq)}$**

b) heptane*(l)* + **11**oxygen*(g)* $\xrightarrow{\Delta}$ **$7CO_{2(g)}$ + $8H_2O_{(l)\text{ or }(g)}$**

c) nitric acid*(aq)* + sodium hydroxide*(aq)* → **$Na^+_{(aq)}$ + $NO_3^-{}_{(aq)}$ + $H_2O_{(l)}$**

d) **2**sodium iodide*(aq)* + mercury (II) nitrate*(aq)* → **$HgI_{2(s)}$ + $2Na^+_{(aq)}$ + $2NO_3^-{}_{(aq)}$**

e) zinc*(s)* + copper (II) nitrate*(aq)* → **$Zn^{2+}_{(aq)}$ + $2NO_3^-{}_{(aq)}$ + $Cu_{(s)}$**

f) **10**aluminum*(s)* + **6**ammonium perchlorate*(s)* → **$4Al_2O_{3(s)}$ + $12H_2O_{(g)}$ + $N_{2(g)}$ + $2AlCl_{3(g)}$**

g) potassium carbonate*(s)* + hydrochloric acid*(aq)* → **$CO_{2(g)}$ + $H_2O_{(l)}$ + $2K^+_{(aq)}$ + $2Cl^-_{(aq)}$**

h) barium hydroxide*(aq)* + **2**acetic acid*(aq)* → **$Ba^{2+}_{(aq)}$ + $2C_2H_3O_2^-{}_{(aq)}$ + $H_2O_{(l)}$**

RPS.2. Write the ionic and net ionic chemical equations for 1a), 1c), 1d), 1e) and 1g).

1a. Ionic equation:

Ba^{2+}*(aq)* + $2NO_3^-$*(aq)* + $2H^+$ *(aq)* + SO_4^{2-}*(aq)* → $2H^+$ *(aq)* + $2NO_3^-$*(aq)* + $BaSO_4$*(s)*

Net Ionic equation:

Ba^{2+}*(aq)* + ~~$2NO_3^-$*(aq)*~~ + ~~$2H^+$ *(aq)*~~ + SO_4^{2-}*(aq)* → ~~$2H^+$ *(aq)*~~ + ~~$2NO_3^-$*(aq)*~~ + $BaSO_4$ *(s)*

Ba^{2+} *(aq)* + SO_4^{2-}*(aq)* → $BaSO_4$ *(s)*

1c. Ionic equation:

H^+*(aq)* + NO_3^-*(aq)* + Na^+ *(aq)* + ^-OH*(aq)* → $Na^+_{(aq)}$ + $NO_3^-{}_{(aq)}$ + $H_2O_{(l)}$

1c. Net Ionic equation:

H^+*(aq)* + ~~NO_3^-*(aq)*~~ + ~~Na^+ *(aq)*~~ + ^-OH*(aq)* → ~~$Na^+_{(aq)}$ + $NO_3^-{}_{(aq)}$~~ + $H_2O_{(l)}$

H^+*(aq)* + ^-OH*(aq)* → $H_2O_{(l)}$

1d. Ionic equation:

$$2Na^{+}(aq) + 2I^{-}(aq) + 6Hg^{2+}(aq) + 2NO_3^{-}(aq) \rightarrow HgI_{2(s)} + 2Na^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)}$$

Net Ionic equation:

$$\cancel{2Na^{+}(aq)} + 2I^{-}(aq) + 6Hg^{2+}(aq) + \cancel{2NO_3^{-}(aq)} \rightarrow HgI_{2(s)} + \cancel{2Na^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)}}$$

$$2I^{-}(aq) + 6Hg^{2+}(aq) \rightarrow HgI_{2(s)}$$

1e. Ionic equation:

$$Zn(s) + 2NO_3^{-}(aq) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu_{(s)} + 2NO_3^{-}{}_{(aq)}$$

Net Ionic equation:

$$Zn(s) + \cancel{2NO_3^{-}(aq)} + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu_{(s)} + \cancel{2NO_3^{-}{}_{(aq)}}$$

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu_{(s)}$$

1g. Ionic equation:

$$2H^{+}(aq) + 2Cl^{-}(aq) + K_2CO_3(s) \rightarrow CO_{2(g)} + H_2O_{(l)} + 2K^{+}_{(aq)} + 2Cl^{-}{}_{(aq)}$$

Net Ionic equation:

$$2H^{+}(aq) + \cancel{2Cl^{-}(aq)} + K_2CO_3(s) \rightarrow CO_{2(g)} + H_2O_{(l)} + \cancel{2K^{+}_{(aq)}} + \cancel{2Cl^{-}{}_{(aq)}}$$

$$2H^{+}(aq) + K_2CO_3(s) \rightarrow CO_{2(g)} + H_2O_{(l)} + 2K^{+}_{(aq)}$$

RPS.3. Propane, C_3H_8, is a hydrocarbon that is commonly used as a fuel for cooking.

a) Write a balanced chemical equation for the complete combustion of propane gas.

$$\mathbf{C_3H_{8(g)} + 5O_{2(g)} \xrightarrow{\Delta} 3CO_{2(g)} + 4H_2O_{(g)\ or\ (l)}}$$

b) Calculate the volume of air at 30 ˚C and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0 percent O_2 by volume.

$$\mathbf{10.0\ g\ C_3H_8 \left(\frac{1\ mol}{44.0\ g}\right) = 0.227\ mol\ C_3H_8}$$

$$\mathbf{0.227\ mol\ C_3H_8 \left(\frac{5\ mol\ O_2}{1\ mol\ C_3H_8}\right) = 1.13\ mol\ O_2}$$

$$\mathbf{V = \frac{nRT}{P} = \left(\frac{1.13\ mol \cdot 0.0821\ L{\cdot}atm{\cdot}mol^{-1}{\cdot}K^{-1}{\cdot}303K}{1.00\ atm}\right) = 28.1\ L\ O_2}$$

$$\mathbf{28.1\ L\ O_2 \left(\frac{100\ L\ air}{21.0\ L\ O_2}\right) = 134\ L\ air}$$

c) The heat of combustion of propane is –2220.1 kJ mol^{-1}. Calculate the heat of formation, ΔH°_f, of propane given that ΔH°_f of $H_2O(l)$ = –285.3 kJ mol^{-1} and ΔH°_f of $CO_2(g)$ = –393.5 kJ mol^{-1}. (Note: I expect you to calculate the ΔH°_f of propane from the data provided in this problem.)

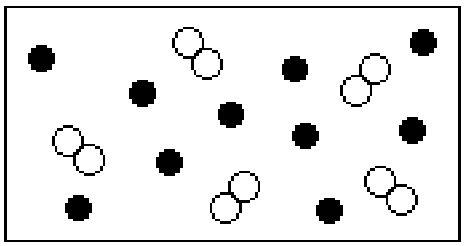
$$\mathbf{\Delta H^\circ_{rxn} = \Sigma \Delta H^\circ_f\ (P)\ - \Sigma \Delta H^\circ_f\ (R)}$$
$$\mathbf{\Delta H^\circ_{rxn} = 3\Delta H^\circ_f\ (CO_{2(g)})\ +\ 4\Delta H^\circ_f\ (H_2O_{(l)})\ - (\Delta H^\circ_f\ (C_3H_{8(g)})\ )}$$
$$\mathbf{-2220.1\ kJ\ mol^{-1} = 3(-393.5\ kJ) + 4(-285.3\ kJ) - \Delta H^\circ_f\ (C_3H_{8(g)})}$$
$$\mathbf{-2220.1\ kJ\ mol^{-1} = -1141.2\ kJ - 1180.5\ kJ - \Delta H^\circ_f\ (C_3H_{8(g)})}$$
$$\mathbf{-2220.1\ kJ\ mol^{-1} = -2321.7\ kJ - \Delta H^\circ_f\ (C_3H_{8(g)})}$$
$$\mathbf{\Delta H^\circ_f\ (C_3H_{8(g)}) = -101.6\ kJ}$$

d) Assuming that all of the heat evolved in buring 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat = 4.184 J g^{-1} ˚C^{-1}), calculate the increase in temperature of the water.

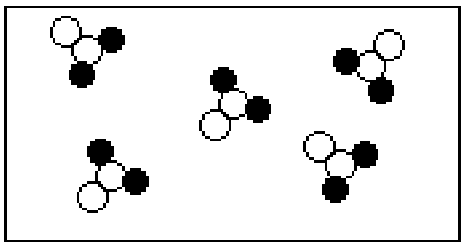
$$\mathbf{30.0\ g\ C_3H_8 \left(\frac{1\ mol}{44.0\ g}\right)\left(\frac{2220.1\ kJ}{1\ mol\ C_3H_8}\right) = 1.51 \times 10^3\ kJ}$$

$$\mathbf{1.51 \times 10^3\ kJ = 1.51 \times 10^6\ J = 8000\ g\ H_2O \cdot\ 4.184\ J\ g^{-1}\ {}^\circ C^{-1} \cdot \Delta T}$$
$$\mathbf{\Delta T = 45.1\ {}^\circ C}$$

RPS.4. A mixture of A ( ) and B_2 ( ) is placed in a container as shown on the left. After a few hours the contents of the container are found to be as shown on the right.



initially



after a period of time

a) Write a balanced chemical equation that describes the reaction.

$$\mathbf{2A_{(g)} + B_{2(g)} \rightarrow A_2B_{2(g)}}$$

b) Identify the limiting reagent(s) in the reaction. Explain your reasoning.

Both are limiting reagents. When the reaction is complete all of the A and B_2 are used up. Neither reactant remains unreacted.

RPS.5. An unknown compound contains only the three elements C, H, and O. A pure sample of the compound is analyzed and found to contain 65.60 percent C and 9.44 percent H by mass.

a) Determine the empirical formula of the compound.

$$\mathbf{65.60\ g\ C \left(\frac{1\ mol}{12.0\ g}\right) = 5.462\ mol\ C}$$

$$\mathbf{9.44\ g\ H \left(\frac{1\ mol}{1.008\ g}\right) = 9.366\ mol\ H}$$

$$\mathbf{24.96\ g\ O \left(\frac{1\ mol}{16.0\ g}\right) = 1.560\ mol\ O}$$

$$\mathbf{\left(\frac{5.462\ mol\ C}{1.560\ mol\ O}\right) : \left(\frac{9.366\ mol\ H}{1.560\ mol\ O}\right) : \left(\frac{1.560\ mol\ O}{1.560\ mol\ O}\right)}$$

$$\mathbf{3.5\ mol\ C : 6.0\ mol\ H : 1.0\ mol\ O = C_{3.5}H_6O}$$

$$\mathbf{2 \cdot (3.5\ mol\ C : 6.0\ mol\ H : 1.0\ mol\ O) = C_7H_{12}O_2}$$

b) When 1.570 grams of the compound is vaporized at 300 ˚C and 1 atmosphere, the gas occupies a volume of 577 milliliters. What is the molar mass of the compound based on this result?

$$\mathbf{n = \left(\frac{PV}{RT}\right) = \left(\frac{1.00\ atm \cdot 0.577\ L}{0.0821\ L{\cdot}atm{\cdot}mol^{-1}{\cdot}K^{-1}{\cdot}673\ K}\right) = 0.0123\ mol}$$

$$\mathbf{molar\ mass = \frac{g}{mol} = \frac{1.570\ g}{0.0123\ mol} = 128\ \frac{g}{mol}}$$

RPS.6. A sample of dolomite limestone containing only $CaCO_3$ and $MgCO_3$ was analyzed.

a) When a 0.2800 gram sample of this limestone was decomposed by heating, 75.0 milliliters of CO_2 at 750 mm Hg and 20 ˚C were evolved. How many grams of CO_2 were produced?

$$\mathbf{n = \left(\frac{PV}{RT}\right) = \left(\frac{\left(\frac{750\ mm\ Hg}{760\ mm\ Hg}\right) atm \cdot 0.0750\ L}{0.0821\ L \cdot atm \cdot mol^{-1} \cdot K^{-1} \cdot 293\ K}\right) = 0.00308\ mol\ CO_2}$$

$$\mathbf{0.00308\ mol\ CO_2 \left(\frac{44.0\ g}{1\ mol}\right) = 0.136\ g\ CO_2}$$

b) Write equations for the decomposition of both carbonates described above.

$$\mathbf{CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}}$$
$$\mathbf{MgCO_{3(s)} \xrightarrow{\Delta} MgO_{(s)} + CO_{2(g)}}$$

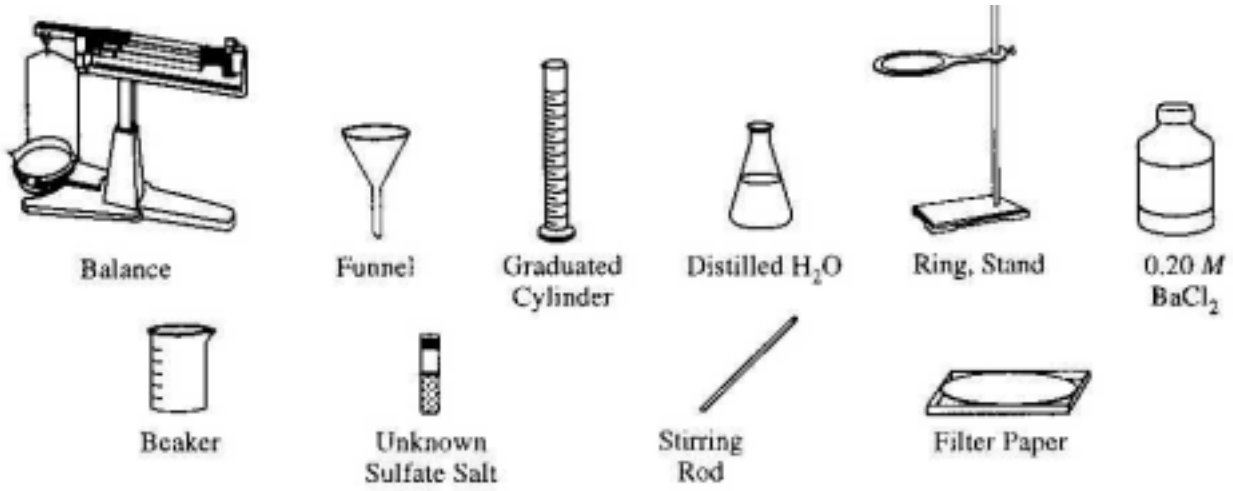
c) It was also determined that the initial sample contained 0.0488 gram of calcium. What percent of the limestone by mass was $CaCO_3$?

$$\mathbf{0.0448\ g\ Ca \left(\frac{1\ mol}{40.8\ g\ Ca}\right) \left(\frac{1\ mol\ CaCO_3}{1\ mol\ Ca}\right) \left(\frac{100\ g\ CaCO_3}{1\ mol\ CaCO_3}\right) = 0.112\ g\ CaCO_3}$$

$$\mathbf{\left(\frac{0.112\ g\ CaCO_3}{0.2800\ g\ sample}\right) \cdot 100\% = 40.0\%}$$

d) How many grams of magnesium-containing product were present in the sample in (a) after it had been heated?

$$\mathbf{0.2800\ g\ sample \cdot 60.0\% = 0.168\ g\ MgCO_3}$$
$$\mathbf{0.168\ g\ MgCO_3 \left(\frac{1\ mol}{84.3\ g\ MgCO_3}\right) \left(\frac{1\ mol\ MgO}{1\ mol\ MgCO_3}\right) \left(\frac{40.3\ g\ MgO}{1\ mol\ MgO}\right) = 0.0802\ g\ MgO}$$



RPS.7. An experiment is to be performed to determine the mass percent of sulfate in an unknown soluble sulfate salt. The equipment shown above is available for the experiment. A drying oven is also available.

a) Briefly list the steps needed to carry out this experiment.

1. **mix the unknown soluble sulfate salt with the 0.20 M $BaCl_2$**
2. **pour the mixture through a piece of filter paper that has been placed in a filter funnel.**
3. **Dry the filter paper and precipitate in the oven.**

b) What experimental data need to be collected to calculate the mass percent of sulfate in the unknown?

1. **measure the mass of the unknown soluble salt that is added to the 0.20 M $BaCl_2$**
2. **measure the mass of dry $BaSO_4$ (dried precipitate)**

c) List the calculations necessary to determine the mass percent of sulfate in the unknown.

1. **convert the grams of $BaSO_4$ to moles**
2. **Convert the moles of $BaSO_4$ to moles of SO_4^{2-}**
3. **Convert the moles of SO_4^{2-} to grams SO_4^{2-}**
4. **Divide the grams SO_4^{2-} by the mass of original sample added to the 0.20 M $BaCl_2$**

d) Would 0.20 M $MgCl_2$ be an acceptable substitute for the $BaCl_2$ solution provided in the experiment? Explain.

$MgCl_2$ is not a suitable replacement for $BaCl_2$, because $MgSO_4$ is a soluble salt.

RPS.8. Complete the following table

Compound	Number of bonding groups on central atom	Number of non-bonding pairs on central atom	Name of the molecular geometry	Bond Angle(s)	Polarity
NO_3^-	**3**	**0**	**Trigonal planar**	**120˚**	
SCN^-	**2**	**0**	**Linear**	**180˚**	
NF_3	**3**	**1**	**Pyramidal**	**107˚**	**polar**
SF_4	**4**	**1**	**Seesaw**	**90˚, 120˚, 180˚**	**polar**
CH_2Cl_2	**4**	**0**	**tetrahedral**		**polar**

RPS.9a. Write the electron configuration for S, Mg, O, Cr, Br and Al.

S: $1s^2 2s^2 2p^6 3s^2 3p^4$ or $[Ne]3s^2 3p^4$

Mg: $1s^2 2s^2 2p^6 3s^2$ or $[Ne]6s^2$

O: $1s^2 2s^2 2p^4$ or $[He]2s^2 2p^4$

Cr: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ or $[Ar]4s^1 3d^5$

Br: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ or $[Ar]4s^2 3d^{10} 4p^5$

Al: $1s^2 2s^2 2p^6 3s^2 3p^1$ or $[Ne]3s^2 3p^1$

b) Which elements in part a) are metals and which are nonmetals?

O, S and Cl are nonmetals

Mg, Cr, and Al are metals

c) As it relates to electron gain or loss, explain the difference between metals and nonmetals. Use the electron configuration of a neutral atom and its ion to support your explanation.

Metals lose electrons to attain an octet. For example, Ba has two valence electrons. The loss of the two electrons in the *6s* subshell leaves the atom with eight electrons in its outer-most level.	**Mg:** $1s^2 2s^2 2p^6 3s^2$ **Mg^{2+}:** $1s^2 2s^2 2p^6$
Nonmetals may gain or lose electrons. When combined with metals, nonmetals gain electrons. When combined with more electronegative nonmetals another nonmetal will lose electrons.	**S:** $1s^2 2s^2 2p^6 3s^2 3p^4$ **In MgS** **S^{2-}:** $1s^2 2s^2 2p^6 3s^2 3p^6$ **In SO_2** **S^{4+}:** $1s^2 2s^2 2p^6 3s^2$

d) By combining a metal and a nonmetal, or a nonmetal and a nonmetal, from the elements listed in part a), write the formula and name of at least eight compounds. The compounds should include 5 ionic and 3 covalent examples.

Ionic Compounds:

$MgCl_2$	**magnesium chloride**	**$CrCl_2$**	**chromium(II) chloride**
MgS	**magnesium sulfide**	**CrS**	**chromium (II) sulfide**
MgO	**magnesium oxide**	**CrO_2**	**chromium (IV) oxide**
$AlCl_3$	**aluminum chloride**	**$CrCl_3$**	**chromium (III) chloride**
Al_2S_3	**aluminum sulfide**	**CrS_2**	**chromium (IV) sulfide**
Al_2O_3	**aluminum oxide**	**Cr_2O_3**	**chromium (III) oxide**

Covalent Compounds:

SO_2	**sulfur dioxide**	**Cl_2O**	**dichlorine oxide**
SO_3	**sulfur trioxide**	**Cl_2O_7**	**dichlorine heptoxide**

RPS.10. Solve

a) $\log (2.91 \times 10^{8}) =$ **8.46**

b) $\log (8.12 \times 10^{-2}) =$ **–1.09**

c) $-\log (3.56 \times 10^{-5}) =$ **4.45**

d) antilog (-11.194) = **6.40×10^{-12}**

e) antilog (0.423) = **2.65**

f) ln 625 = **6.44**

g) ln 0.0904 = **–2.40**

h) $e^{-2.62} =$ **0.0728**

i) $e^{8.21} =$ **3.68×10^{3}**

j) $\ln\left(\frac{623}{588}\right) =$ **0.578**

k) $\ln\left(\frac{348}{x}\right) = 0.569$ Solve for x

$\mathbf{e^{\ln\left(\frac{348}{x}\right)} = e^{0.569}}$

$\mathbf{\frac{348}{x} = 1.77}$

x = 197

l) $\frac{1}{0.150} - \frac{1}{x} = 5.02$ Solve for x

$\mathbf{\frac{1}{.150} - 5.02 = \frac{1}{x}}$ **x = 0.607**

$\mathbf{1.647 = \frac{1}{x}}$

m) $1.32 = 1.57 - \frac{0.0591}{2} \log\left(\frac{1}{1 \cdot x^{8}}\right)$ Solve for x

$\mathbf{(1.32 - 1.57) \bullet \left(\frac{-2}{.0591}\right) = 1\log \frac{1}{x^{8}}}$

$\mathbf{8.46 = 1\log \frac{1}{x^{8}}}$

$\mathbf{-8.46 = 1\log x^{8}}$

$\mathbf{\frac{-8.46}{8} = 1\log x}$

-1.06 = 1og x **0.087 = x**

RPS.10. (Continued)

n) $x^2 + 5x - 20 = 0$ Solve for x

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{-5 \pm \sqrt{(5)^2 - 4(1)(-20)}}{2}$$

x = +2.62

= -7.62

o) $x^3 - 0.52x^2 + 1.36x - 0.422 = 0$ Solve for x