CHEM-1110 TEST # 1 NAME ANSWERS
Sept. 25, 2002

SHOW ALL WORK. MESSY AND UNORGANIZED WORK WILL NOT BE MARKED. STRICT ADHERENCE TO INDEPENDENT WORK.

1. For the following equation:

$$Na_2Cr_2O_7(s) + 6\ NaCl(s) + 7\ H_2SO_4(aq) \rightarrow 3\ Cl_2(g) + Cr(SO4)_3(aq) + 4\ Na_2SO_4(aq) + 7\ H_2O(l)$$

a) If a total of 6.41 g of $Na_2Cr_2O_7$ (MM=262.00) is added to 7.68 g of NaCl (MM=58.45) and an excess of H_2SO_4, a total of 3.44 g of Cl_2 (MM=70.90) was isolated. Determine the percent yield of the reaction and the mass of the excess reagent left over at the end of the reaction. **[8]**

$\frac{6.41}{262.0} = 2.45 \times 10^{-2}$ mol $Na_2Cr_2O_7$

$\frac{7.68}{58.45} = 0.1314$ mol NaCl

$0.1314 \text{ mol NaCl} \times \frac{1 \text{ mol } Na_2Cr_2O_7}{6 \text{ mol NaCl}} = 0.0219 \text{ mol } Na_2Cr_2O_7$ needed.

So $Na_2Cr_2O_7$ is in excess and NaCl is limiting reagent

$0.1314 \text{ mol NaCl} \times \frac{3 \text{ mol } Cl_2}{6 \text{ mol NaCl}} \times \frac{70.90 \text{ g } Cl_2}{1 \text{ mol } Cl_2} = 4.658 \text{ g } Cl_2$

$\% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{3.44}{4.658} \times 100 = 73.9\ \%$

EXCESS REAGENT IS $Na_2Cr_2O_7$

2.45×10^{-2} (given) $- 2.19 \times 10^{-2}$ (used) $= 2.60 \times 10^{-3}$ mol left

$2.60 \times 10^{-3} \times 262.00 = 0.68$ g left

2. A 500.0 mg tablet containing antacids plus inert material was dissolved in 50.00 mL of 0.5000 M HCl. The resulting solution required 26.50 mL of 0.3770 M NaOH for neutralization.

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

a) How many moles of OH^- were in the tablet? **[5]**

mol HCl added = $0.0500 \times 0.500 = 0.0250$

mol OH^- (i.e NaOH) = $0.02650 \times 0.377 = 0.00999$

∴ mol of excess HCl = 0.00999

∴ mol HCl used = $0.0250 - 0.00999 = 0.0150$

∴ mol OH^- in the tablet = 0.0150

b) If the tablet contained equal masses of $Al(OH)_3$ and $Mg(OH)_2$, what is the percent, by mass, of each hydroxide in the tablet? **[6]**

Let the mass of $Mg(OH)_2$ = x g

∴ " " " $Al(OH)_3$ = x g

$$x \text{ g } Mg(OH)_2 \times \frac{1 \text{ mol } Mg(OH)_2}{58.3 \text{ g } Mg(OH)_2} \times \frac{2 \text{ mol } OH^-}{1 \text{ mol } Mg(OH)_2} = 0.0343x \text{ mol } OH^-$$

$$x \text{ g } Al(OH)_3 \times \frac{1 \text{ mol } Al(OH)_3}{78.0 \text{ g } Al(OH)_3} \times \frac{3 \text{ mol } OH^-}{1 \text{ mol } Al(OH)_3} = 0.0385x \text{ mol } OH^-$$

$0.0343x + 0.0385x = 0.0150$

$x = 0.206$

∴ mass of $Mg(OH)_2$ = 0.206 g = 206 mg

% $Mg(OH)_2 = \frac{206}{500} \times 100 = 41.2$

% $Al(OH)_3$ = 41.2

3. A 5.00 g mixture of zinc and aluminum was reacted with HCl(aq). 3.78 L of hydrogen gas produced was collected over water at 22.0°C and 760.0 mmHg. Vapor pressure of water at 22.0°C = 19.8 mmHg. The reactions are:

$$Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

$$2\ Al(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

Calculate the percent by mass of zinc in the original mixture. **[8]**

$n_{H_2} = \frac{PV}{RT} = \frac{\{(760-19.8)/760\}(3.78)}{0.0821 \times 295} = 0.152$ mol H_2

Let there be $\underline{\underline{x}}$ g of Zn, so there are $(5.00-x)$ g Al

x g Zn $\times \frac{1 \text{ mol Zn}}{65.4 \text{ g Zn}} \times \frac{1 \text{ mol } H_2}{1 \text{ mol Zn}} = 0.0153x$ mol H_2

$(5.00-x)$ g Al $\times \frac{1 \text{ mol Al}}{27.0 \text{ g Al}} \times \frac{3 \text{ mol } H_2}{2 \text{ mol Al}} = 0.0556(5.00-x)$ mol H

$0.0153x + 0.0556(5.00-x) = 0.152$

$\therefore x = 3.13$ g $\qquad \%\ Zn = \frac{3.13}{5.00} \times 100 = \underline{\underline{62.6}}$

4. The density of xylene, a compound containing only carbon and hydrogen is 4.74 g/L at STP. In an other experiment, combustion of 5.00 g of xylene gave 16.60 g of ~~water~~ CO_2. Calculate the molecular formula of xylene. **[5]**

$PV = nRT = \frac{g RT}{MM}$

$MM = \frac{gRT}{PV} = \frac{(4.74 g)(R)(273 K)}{(1 atm)(1 L)} = 106.2$ g/mol

$C \longrightarrow CO_2$

mol ratio

$16.60 \times \frac{12.0}{44.0} \times \frac{100}{5.00} = 90.5\%$ C , 7.5 1 4

$\therefore 100 - 90.5 = 9.5\%$ H (9.5 mol H) 1.25 5

C_8H_{10}

5. A sample of a sulfide of metal M (formula M_xS_y) is analyzed. The sulfur in the system is recovered as 120.0 mL of 0.250 M Na_2S solution. The metal in the same sample is recovered as 40.0 mL of 0.500 M solution of the metal ion. The molar mass of the sulfide of the metal is 150.0 g/mol. Find the formula of the metal sulfide and identify M. **[5]**

moles of S = $0.1200 \times 0.250 = 0.0300$

moles of M = $0.0400 \times 0.500 = 0.0200$

mol ratio is 2 mol M : 3 mol S

∴ FORMULA IS M_2S_3

$2 \times m + 3 \times 32.1 = 150$

$m = \frac{150 - 96.3}{2} = 26.9$ Al

6. A miniature laboratory volcano can be made from ammonium dichromate, $(NH_4)_2Cr_2O_7$. When ignited it decomposes in a fiery display. The reaction is:

$$(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + 4\ H_2O(g) + Cr_2O_3(s)$$

If the decomposition of 5.00 g of ammonium dichromate is done and gases are trapped in a 2.00 L flask at 27°C, what is the total gaseous pressure and the partial pressures of gases? **[6]**

$5.00\ g\ A \times \frac{1\ mol\ A}{252\ g\ A} \times \frac{5\ mol\ gas}{1\ mol\ A} = 0.0992$

$P = \frac{0.0992 \times 0.0821 \times 300}{2.00} = 1.22\ atm$ (TOTAL)

$P_{N_2} = \frac{1}{5} \times 1.22\ atm = 0.244\ atm$

$P_{H_2O} = \frac{4}{5} \times 1.22\ atm = 0.976\ atm$

Write balanced equations for the following nuclear reactions. **[6]**

a) Pb-204 emits an alpha particle.

$$^{204}_{82}Pb \longrightarrow {}^{4}_{2}He + {}^{200}_{80}Hg$$

b) Se-73 emits a positron.

$$^{73}_{34}Se \longrightarrow {}^{0}_{1}e + {}^{73}_{33}As$$

c) An atom plutonium-239 is bombarded by a neutron, splitting into atom of Iodine-135, 4 neutrons, plus another element.

$$^{239}_{94}Pu + {}^{1}_{0}n \longrightarrow {}^{135}_{53}I + 4\,{}^{1}_{0}n + {}^{101}_{41}Nb$$

d) An atom of Beryllium-9 collides with an atom of americium-242 to produce a new element and three neutrons.

$$^{9}_{4}Be + {}^{242}_{95}Am \longrightarrow 3\,{}^{1}_{0}n + {}^{248}_{99}Es$$

e) Pa-234 emits a beta particle.

$$^{234}_{91}Pa \longrightarrow {}^{0}_{-1}e + {}^{234}_{92}U$$

f) Indium-110 undergoes electron capture.

$$^{110}_{49}In + {}^{0}_{-1}e \longrightarrow {}^{110}_{48}Cd$$

The nuclide ^{210}Po (atomic mass = 209.9829 amu) decays by alpha decays to ^{206}Pb (atomic mass = 205.9745 amu).The mass of alpha particle is 4.0026 amu. Mass of a proton = 1.007276 amu, mass of a neutron = 1.008665 amu, and mass of an electron = 0.00055 amu. Also 1 amu = 931.5 MeV. Calculate the average binding energy for ^{210}Po. **[4]**

mass of $(84\,p^+ + 84\,\bar{e} + 126\,n) = 211.7492$ amu

$\triangle$ mass $= (211.7492) - (209.9829) = 1.7663$ a

$$1.7663 \text{ amu} \times \frac{931.5 \text{ MeV}}{1 \text{ amu}} = 1645.3 \text{ MeV}$$

$$\frac{1645.3 \text{ MeV}}{210 \text{ nucleons}} = 7.835 \text{ MeV/nucleon}$$