

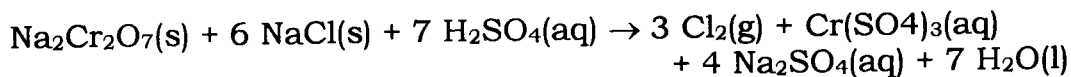
CHEM-1110
Sept. 25, 2002

TEST # 1

NAME ANSWERS

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

1. For the following equation:



a) If a total of 6.41 g of $\text{Na}_2\text{Cr}_2\text{O}_7$ (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]

$$\frac{6.41}{262.0} = 2.45 \times 10^{-2} \text{ mol } \text{Na}_2\text{Cr}_2\text{O}_7$$

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

$$0.1314 \text{ mol } \text{NaCl} \times \frac{1 \text{ mol } \text{Na}_2\text{Cr}_2\text{O}_7}{6 \text{ mol } \text{NaCl}} = 0.0219 \text{ mol } \text{Na}_2\text{Cr}_2\text{O}_7 \text{ needed.}$$

So $\text{Na}_2\text{Cr}_2\text{O}_7$ is in excess and NaCl is limiting reagent

$$0.1314 \text{ mol } \text{NaCl} \times \frac{3 \text{ mol } \text{Cl}_2}{6 \text{ mol } \text{NaCl}} \times \frac{70.90 \text{ g } \text{Cl}_2}{1 \text{ mol } \text{Cl}_2} = \underline{4.658 \text{ g } \text{Cl}_2}$$

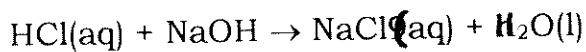
$$\% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{3.44}{4.658} \times 100 = \underline{73.9 \%}$$

EXCESS REAGENT IS $\text{Na}_2\text{Cr}_2\text{O}_7$

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

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

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.



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

$$\text{mol HCl added} = 0.0500 \times 0.500 = 0.0250$$

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

$$\therefore \text{mol of excess HCl} = 0.00999$$

$$\therefore \text{mol HCl used} = 0.0250 - 0.00999 = 0.0150$$

$$\therefore \text{mol OH}^- \text{ in the tablet} = \underline{\underline{0.0150}}$$

- 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]

$$\text{Let the mass of Mg(OH)}_2 = x \text{ g}$$

$$\therefore \text{ " " " Al(OH)}_3 = x \text{ g}$$

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

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

$$0.0343 x + 0.0385 x = 0.0150$$

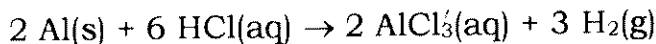
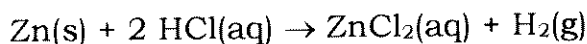
$$x = \underline{\underline{0.206}}$$

$$\therefore \text{mass of Mg(OH)}_2 = 0.206 \text{ g} = 206 \text{ mg}$$

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

$$\% \text{ Al(OH)}_3 = 41.2$$

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:



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

$$n_{\text{H}_2} = \frac{PV}{RT} = \frac{\{(760 - 19.8)/760\} (3.78)}{0.0821 \times 295} = 0.152 \text{ mol H}_2$$

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

$$x \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.4 \text{ g Zn}} \times \frac{1 \text{ mol H}_2}{1 \text{ mol Zn}} = 0.0153 x \text{ mol H}_2$$

$$(5.00 - x) \text{ g Al} \times \frac{1 \text{ mol Al}}{27.0 \text{ g Al}} \times \frac{3 \text{ mol H}_2}{2 \text{ mol Al}} = 0.0556(5.00 - x) \text{ mol H}_2$$

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

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

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 ^{CO₂}water. Calculate the molecular formula of xylene. [5]

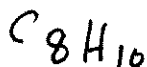
$$PV = nRT = \frac{g RT}{MM}$$

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



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

$$\therefore 100 - 90.5 = 9.5\% \text{ H} \quad (9.5 \text{ mol H}) \quad 1.25 \quad 5$$



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]

$$\begin{aligned} \text{Moles of S} &= 0.1200 \times 0.250 = 0.0300 \\ \text{Moles of M} &= 0.0400 \times 0.500 = 0.0200 \end{aligned}$$

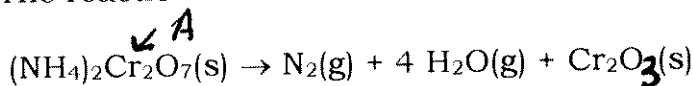
$$\text{Mol ratio: } \frac{0.0200}{0.0200} : \frac{0.0300}{0.0200} = 1 : 1.5 = 2 \text{ mol M} : 3 \text{ mol S}$$

$$\therefore \text{Formula is } M_2S_3$$

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

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

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:



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

$$5.00 \text{ g } \cancel{A} \times \frac{1 \text{ mol } \cancel{A}}{252 \text{ g } \cancel{A}} \times \frac{5 \text{ mol gases}}{1 \text{ mol } \cancel{A}} = 0.0992$$

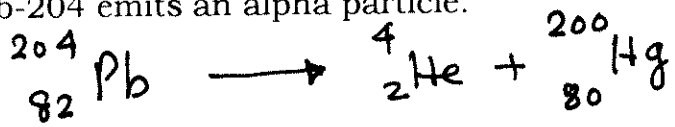
$$P = \frac{0.0992 \times 0.0821 \times 300}{2.00} = 1.22 \text{ atm (TOTAL)}$$

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

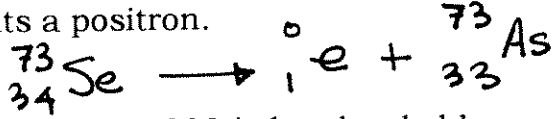
$$P_{H_2O} = \frac{4}{5} \times 1.22 \text{ atm} = 0.976 \text{ atm}$$

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

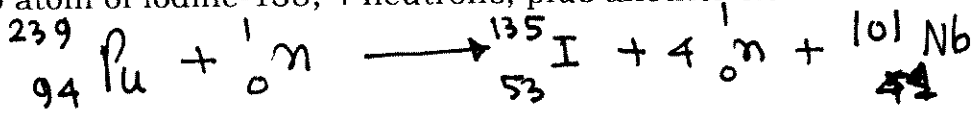
a) Pb-204 emits an alpha particle.



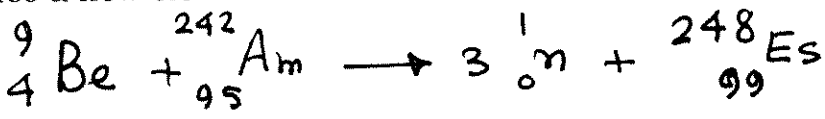
b) Se-73 emits a positron.



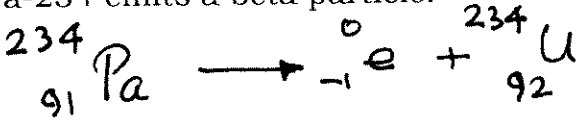
c) An atom plutonium-239 is bombarded by a neutron, splitting into atom of Iodine-135, 4 neutrons, plus another element.



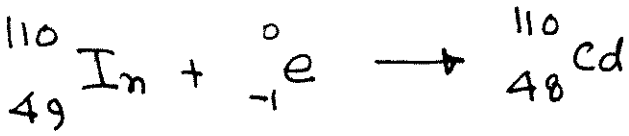
d) An atom of Beryllium-9 collides with an atom of americium-242 to produce a new element and three neutrons.



e) Pa-234 emits a beta particle.



f) Indium-110 undergoes electron capture.



The nuclide ${}^{210}\text{Po}$ (atomic mass = 209.9829 amu) decays by alpha decays to ${}^{206}\text{Pb}$ (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 ${}^{210}\text{Po}$. [4]

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

$$\Delta \text{mass} = (211.7492) - (209.9829) = 1.7663 \text{ amu}$$

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

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