US110 Exam 2. October
Name Key

$M = \frac{\text{moles}}{L}$ LEO says GER

(1)(6 points) A flask containing 5.00 g of Al and 14.1 g of Fe_2O_3 were reacted according to the following equation.

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

159.7 g/mole 26.98 g/mole

(a) Which reagent is the limiting reagent?

Fe_2O_3 $14.1\,g \div 159.7\,g/mole = 0.0883\ moles\ Fe_2O_3$

Al $5.00\,g \div 26.98\,g/mole = 0.185\ moles\ Al$

$$0.185\ moles\ Al \times \frac{1\ mole\ Fe_2O_3}{2\ moles\ Al} = 0.0926\ moles\ Fe_2O_3 \text{ needed}$$

Fe_2O_3 limiting reagent

(b) How much Al_2O_3 should form?

$$0.0883\ moles\ Fe_2O_3 \times \frac{1\ mole\ Al_2O_3}{1\ mole\ Fe_2O_3} = 0.0883\ moles\ Al_2O_3$$

$$0.0883\ moles\ Al_2O_3 \times 101.96\,g/mole = 9.00\,g\ Al_2O_3$$

(c) If the amount of Al_2O_3 formed was 7.62 g, what is the % yield?

$$\frac{7.62\,g\ Al_2O_3}{9.00\,g\ Al_2O_3} \times 100\% = 84.7\%$$

(2)(2 points) How would you make a 500.0 mL, 0.100 M solution of HCl from a 6.80 M stock solution?

$(0.500\ L)\left(0.100\ \frac{moles}{L}\right) = 0.0500\ moles\ HCl\ needed$

$0.0500\ moles \div \frac{6.80\ moles}{L} = 7.35 \times 10^{-3}\ L = 7.35\ mL$

7.35 mL of 6.80M HCl will be diluted to 500 mL

(3)(4 points) If it takes 22.1 mL of 0.108 M H_2SO_4 to fully react with the $NaHCO_3$ (according to the unbalanced reaction below) in a 15.00 mL sample of water. How much $NaHCO_3$ was present (in grams)?

$$2\ NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

$(0.0221\,L)(0.108\,M) = 2.39 \times 10^{-3}$ mole H_2SO_4

2.39×10^{-3} mole $H_2SO_4 \times \frac{2\ mole\ NaHCO_3}{1\ mole\ H_2SO_4} = 4.77 \times 10^{-3}$ mole $NaHCO_3$

4.77×10^{-3} mole $NaHCO_3 \times 84.01\ g/mole = 0.401\ g\ NaHCO_3$

(4)(4 points) Aspirin is acetylsalicylic acid, $C_9H_8O_4$. It is derived from salicylic acid ($C_7H_6O_3$) which is found in willow tree bark. What is the elemental composition of aspirin (in mass %)?

9 C	$9(12.01\ g/mole) = 108.1\ g/mole$	
8 H	$8(1.01\ g/mole) = 8.08\ g/mole$	
4 O	$4(16.00\ g/mole) = 64.00\ g/mole$	
total		180.2 g/mole

$\%C = \frac{108.1\ g}{180.2\ g} \times 100\% = 60.0\%$

$\%H = \frac{8.08\ g/mole}{180.2\ g/mole} \times 100\% = 4.48\%$

$\%O = \frac{64.00\ g}{180.2\ g} \times 100\% = 35.5\%$

more to problem →

(5)(4 points) The active component in cannabis is tetrahydrocannibinol (THC) which has a chemical formula of $C_{21}H_{30}O_2$. This is produced as a prescription drug called Dronabinol (or Marinol). Some unknown powder was collected by police (who suspected it was THC) although they are told it is a headache powder. If the results of the elemental analysis are 60.0% C, 4.48% H, and 35.6 % O, what is the empirical formula for the sample? Can it be THC (remember to show work)?

Assm 100 g,

C 60.0 g ÷ 12.01 g/mol = 4.996 mol C ÷ 2.225 = 2.24

H 4.48 g ÷ 1.01 g/mol = 4.45 mol H ÷ 2.225 = 2 H

O 35.6 g ÷ 16.00 g/mol = 2.225 mol O ÷ 2.225 = 1 Oxygen

4/($C_{2.24}H_2O_1$) = $C_9H_8O_4$

No, it can't be THC.

(6)(4 points) Write the net acid-base reactions for the following neutralizations

(a) $H_2SO_4(aq) + 2NaOH(aq) \longrightarrow$ Na_2SO_4

strong strong

$H_3O^+ + OH^- \rightarrow 2H_2O$

(b) $HCl(aq) + NH_3(aq) \longrightarrow$

strong weak

$H^+ + NH_3 \rightarrow NH_4^+$

(7)(4 points) Write the balanced molecular, ionic and net ionic equations for the following reactions

(a) $FeCl_{2(aq)} + K_2CO_{3(aq)}$ ----> $FeCO_3(s) + 2KCl_{(aq)}$ molecular

ionic $Fe^{2+}_{(aq)} + 2Cl^-_{(aq)} + 2K^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow FeCO_3(s) + 2K^+_{(aq)} + 2Cl^-_{(aq)}$

net ionic $Fe^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow FeCO_3(s)$

(b) $Ba(OH)_{2(aq)} + CoSO_{4(aq)}$ ----> $BaSO_4(s) + Co(OH)_2(s)$ molecular

$Ba^{2+}_{(aq)} + 2OH^-_{(aq)} + Co^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_4(s) + Co(OH)_2(s)$ ionic and net ionic

(8)(4 points) Complete the following neutralization reactions and balance them for complete neurtralization (all acidic protons neutralized, all basic units neutralized).

(a) $H_2SO_{3(aq)} + Ca(OH)_{2(aq)}$ ----> $CaSO_{3(aq)} + 2H_2O$

(b) $H_2SO_4(aq) + NH_{3(aq)}$ ----> $(NH_4)_2SO_{4(aq)}$

(9)(2 points) Label the following strong electrolytes, weak electrolytes, or nonelectrolytes

(a) PBr_3 non electrolyte

(b) HBr strong electrolyte

(c) NH_3 weak electrolyte

(d) MgS strong electrolyte

(10)(4 points) Break the following reaction into an oxidation and a reduction 1/2 reaction. Show all work and the oxidation states of the species being oxidized and reduced. You don't have to balance the 1/2 reactions.

$$ClO_4^- + SO_4^{2-} \rightarrow S_2O_3^{2-} + ClO^-$$

$ClO_4^- \rightarrow ClO^-$

$Cl^{+7} \quad Cl^{+1}$ oxidation

$SO_4^{2-} \rightarrow S_2O_3^{2-}$ reduction

$S^{+6} \quad S^{+2}$

(11)(6 points) Balance the following half-reactions in base

(a) $Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

balance e⁻

$2(Cr^{6+}) + 6e^- \rightarrow 2Cr^{3+}$

$6e^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

$8^- \rightarrow 6^+ +$ [illegible] $+14OH^-$

↓ add OH^-

$6e^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 14OH^-$

↓ add H_2O

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

(b) $Cu \rightarrow Cu^{2+}$

$Cu \rightarrow Cu^{2+} + 2e^-$

(12)(4 points) Balance the following oxidation-reduction reaction in base

$Cr_2O_7^{2-} + Cu \rightarrow Cu^{2+} + Cr^{3+}$

$3Cu \rightarrow 3Cu^{2+} + 6e^-$

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

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

$7H_2O + 3Cu + Cr_2O_7^{2-} \rightarrow 3Cu^{2+} + 2Cr^{3+} + 14OH^-$

(13)(4 points) Construct an activity series based on the following experimental results

$Fe^{2+}(aq) + 2K(s) \text{ ----> } 2K^+ + Fe(s)$ K more reactive than Fe (higher)

$Ti(s) + Au^{3+}(aq) \text{ -----> } Ti^{3+}(aq) + Au(s)$ Ti high than Au

$Ti\ (aq) + Fe^{2+}(s) \text{-----> NR}$

Ti lower than Fe

higher activity

$K \rightarrow K^+ + e^-$

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

$Ti \rightarrow Ti^{3+} + 3e^-$

$Au \rightarrow Au^{3+} + 3e^-$

(14)(4 points) Name a reagent that you could use to separate the Ni^{2+} and Ba^{2+} from a solution of $Ni(NO_3)_2$ and $Ba(NO_3)_2$ by a precipitation. Write out the precipitation reaction and list which metal will be in the precipitate and which will be left in solution.

NaOH

$Ba^{2+} + 2OH^- \rightarrow Ba(OH)_2(aq)$ ← still in solution

$Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2(s)$ ← precipitate

(15)(4 points) Write out the ground state electron configurations for the following atoms

Don't use the noble gas shortcut.

(d) Na $1s^2 2s^2 2p^6 3s^1$

(c) Cl^- $1s^2 2s^2 2p^6 3s^2 3p^6$

(b) S $1s^2 2s^2 2p^6 3s^2 3p^4$

(a) N^{3-} $1s^2 2s^2 2p^6$

Extra credit (2 points): On problem #5, if you found that it could be THC, could you list anything other than THC that has that formula? If you found that it could not be THC, what could it be?