**Chem 120**                                  **Name**_____
**Exam 2, Ch 4-6**                            **October 16, 2008**
**100 Points**

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

**Part 0: Warmup.  4 points each**
1.  For a fixed amount of gas at a fixed pressure, changing the temperature from $100^{o}C$ to 200K causes the gas volume to:

    a.  double
    b.  increase
    c.  decrease                              Answer _____
    d.  stay the same

2.  Under what conditions is $Cl_2$ most likely to behave like an ideal gas?

    a.  $100^{o}C$ and 10.0 atm
    b.  $0^{o}C$ and 0.50 atm
    c.  $200^{o}C$ and 0.50 atm               Answer _____
    d.  $400^{o}C$ and 10.0 atm

3.  To precipitate $Zn^{2+}$ from a solution of $Zn(NO_3)_2$, add

    a.  $NH_4Cl$
    b.  $MgBr_2$
    c.  $K_2CO_3$                             Answer _____
    d.  $(NH_4)_2SO_4$
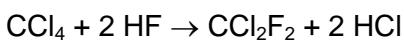
4.  In the half reaction in which $NpO_2^+$ is converted to $Np^{4+}$, the number of electrons appearing in the half reaction is

    a.  1
    b.  2
    c.  3                                     Answer _____
    d.  4

5.  In the reaction of 2 mol $CCl_4$ with an excess of HF, 1.70 mol $CCl_2F_2$ is obtained.

$$CCl_4 + 2\ HF \rightarrow CCl_2F_2 + 2\ HCl$$

    a.  The theoretical yield is 1.70 mol $CCl_2F_2$.
    b.  The theoretical yield is 1.00 mol $CCl_2F_2$.
    c.  The theoretical yield depends on how large an excess of
        HF was used.                         Answer _____
    d.  The percent yield is 85%.

**Part I: Complete all of problems 6-10**

6. Complete the chart below: (12 points)

| Species | Name | Oxidation States | | | Water Soluble? (Y/N) |
|---|---|---|---|---|---|
| $Ca(ClO_4)_2$ | | Ca = | Cl = | O = | |
| $Zn_3(PO_4)_2$ | | Zn = | O = | P = | |

7. Ammonia can be generated by heating together the solids $NH_4Cl$ and $Ca(OH)_2$ to produce $NH_3$, water, and $CaCl_2$. If a mixture containing 33.0 g each of ammonium chloride and calcium hydroxide is heated, how many grams of ammonia will form? (10 points)

8. Write the (1) *overall reaction* and (2) *net ionic equation* for the following reactions. Indicate the state of all reactants and products. (10 points)
   a. Aqueous potassium sulfate with aqueous calcium chloride.
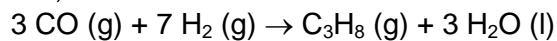
   (1) Overall reaction:

   (2) Net ionic equation:

   b. Aqueous sodium carbonate with aqueous silver nitrate.
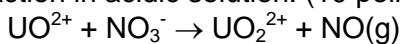
   (1) Overall reaction:

   (2) Net ionic equation:

9. Calculate the volume of hydrogen gas, measured at 26°C and 751 torr required to react with 28.5 L of carbon monoxide, measured at 0°C and 760 torr in the reaction below. (10 points)
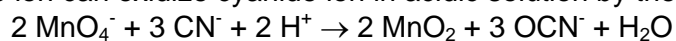
$$3 \text{ CO (g)} + 7 \text{ H}_2 \text{ (g)} \rightarrow \text{C}_3\text{H}_8 \text{ (g)} + 3 \text{ H}_2\text{O (l)}$$

10. Redox reactions:
    a. Balance the following reaction in acidic solution. (10 points)

$$\text{UO}^{2+} + \text{NO}_3^- \rightarrow \text{UO}_2^{2+} + \text{NO(g)}$$

    b. Permanganate ion can oxidize cyanide ion in acidic solution by the reaction below.

$$2 \text{ MnO}_4^- + 3 \text{ CN}^- + 2 \text{ H}^+ \rightarrow 2 \text{ MnO}_2 + 3 \text{ OCN}^- + \text{H}_2\text{O}$$

Write the corresponding balanced reaction that would occur in basic solution. (2 points)

**Part II. Answer two (2) of problems 11-14. Clearly mark the problem you do not want graded. 12 points each.**

11. You are following a laboratory procedure to prepare a dilute chloride solution to use as a standard in an absorbance measurement. You prepare the standard by dissolving 1.45 g $MgCl_2$ in 100.0 mL of solution, which you label solution A. After mixing, you pipet 3.00 mL of solution A to a 50.0 mL volumetric flask, and dilute to the mark to prepare solution B. Finally, you pipet 2.00 mL of solution B into a 25 mL volumetric flask and dilute to the mark to prepare solution C. What is the molarity of *chloride ions* in solution C? Assume $MgCl_2$ is a strong electrolyte.

12. Dichlorodifluoromethane, once widely used as a refrigerant, can be prepared by the balanced reactions shown. How many moles of $Cl_2$ must be consumed to produce 2.25 kg $CCl_2F_2$? What volume would this $Cl_2$ gas occupy at STP? Assume all the $CCl_4$ produced in the first reaction is consumed in the second.

$$CH_4 + 2 Cl_2 \rightarrow CCl_4 + 4 HCl$$
$$CCl_4 + 2 HF \rightarrow CCl_2F_2 + 2 HCl$$
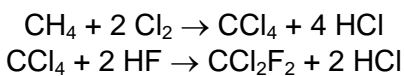
13. A NaOH solution cannot be made up to an exact concentration simply by weighing out the required mass of solid NaOH, because the NaOH is not pure.  Also, water vapor condenses on the solid as it is weighed.  To determine the concentration of such soutions, they must be standardized by titration.  For this purpose, a 25.00 mL sample of NaOH solution requires 33.61 mL of 0.1086 M HCl.  What is the molarity of the NaOH?  Include a balanced reaction in your solution.

14. A 2.89 g aluminum ore sample is reacted with excess HCl in the reaction below, and the liberated $H_2$ is collected over water at 25$^o$C at a barometric pressure of 744 mm Hg.  If 322 mL of hydrogen is collected, what is the percent aluminum (by mass) in the ore sample?
$$2 \ Al(s) + 6 \ HCl \ (aq) \rightarrow 2 \ AlCl_3(aq) + 3 \ H_2(g)$$
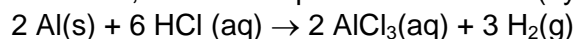
## Possibly Useful Information

| | |
|---|---|
| R = 0.08206 L atm mol$^{-1}$ K$^{-1}$ | STP = 1 atm, 0$^o$C |
| 1 atmosphere = 760 Torr | $\left(P + a\left(\dfrac{n}{V}\right)^2\right)(V - bn) = nRT$ |
| $P_{total} = n_{total}RT/V$ | $P_A = X_a P_{total}$ |
| $N_a = 6.02214 \times 10^{23}$ mol$^{-1}$ | $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ |

| Molar Masses ||
|---|---|
| Compound | Molar Mass (g/mol) |
| $AlCl_3$ | 133.3396 |
| $C_3H_8$ | 44.097 |
| $Ca(OH)_2$ | 74.093 |
| $CaCl_2$ | 110.983 |
| $CCl_2F_2$ | 120.913 |
| $CCl_4$ | 153.822 |
| $CH_4$ | 16.043 |
| $Cl_2$ | 70.9504 |
| CO | 28.010 |
| $H_2$ | 2.01588 |
| $H_2O$ | 18.0153 |
| HCl | 36.4606 |
| HF | 20.00634 |
| $MgCl_2$ | 94.2104 |
| NaOH | 39.9971 |
| $NH_3$ | 17.0356 |
| $NH_4Cl$ | 53.4912 |

**Vapor Pressure of Water at Various Temperatures**

| Temperature (°C) | Vapor Pressure (mmHg) |
|---|---|
| 15.0 | 12.79 |
| 17.0 | 14.53 |
| 19.0 | 16.48 |
| 21.0 | 18.65 |
| 23.0 | 21.07 |
| 25.0 | 23.76 |
| 30.0 | 31.82 |
| 50.0 | 92.51 |

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**TABLE 5.1   Solubility Guidelines for Common Ionic Solids**

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.
1. Salts of group 1 cations (with some exceptions for Li$^+$) and the $NH_4^+$ cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca$^{2+}$, Sr$^{2+}$, and Ba$^{2+}$ are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

# Periodic Table of the Elements

| Group 1 (1A) | 2 (2A) | 3 (3B) | 4 (4B) | 5 (5B) | 6 (6B) | 7 (7B) | 8 (8B) | 9 (8B) | 10 (8B) | 11 (1B) | 12 (2B) | 13 (3A) | 14 (4A) | 15 (5A) | 16 (6A) | 17 (7A) | 18 (8A) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.00794 | | | | | | | | | | | | | | | | | 2 He 4.00260 |
| 3 Li 6.941 | 4 Be 9.01218 | | | | | | | | | | | 5 B 10.811 | 6 C 12.011 | 7 N 14.0067 | 8 O 15.9994 | 9 F 18.9984 | 10 Ne 20.1797 |
| 11 Na 22.9898 | 12 Mg 24.3050 | | | | | | | | | | | 13 Al 26.9815 | 14 Si 28.0855 | 15 P 30.9738 | 16 S 32.066 | 17 Cl 35.4527 | 18 Ar 39.948 |
| 19 K 39.0983 | 20 Ca 40.078 | 21 Sc 44.9559 | 22 Ti 47.88 | 23 V 50.9415 | 24 Cr 51.9961 | 25 Mn 54.9381 | 26 Fe 55.847 | 27 Co 58.9332 | 28 Ni 58.693 | 29 Cu 63.546 | 30 Zn 65.39 | 31 Ga 69.723 | 32 Ge 72.61 | 33 As 74.9216 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.80 |
| 37 Rb 85.4678 | 38 Sr 87.62 | 39 Y 88.9059 | 40 Zr 91.224 | 41 Nb 92.9064 | 42 Mo 95.94 | 43 Tc (98) | 44 Ru 101.07 | 45 Rh 102.906 | 46 Pd 106.42 | 47 Ag 107.868 | 48 Cd 112.411 | 49 In 114.818 | 50 Sn 118.710 | 51 Sb 121.757 | 52 Te 127.60 | 53 I 126.904 | 54 Xe 131.29 |
| 55 Cs 132.905 | 56 Ba 137.327 | 57 *La 138.906 | 72 Hf 178.49 | 73 Ta 180.948 | 74 W 183.84 | 75 Re 186.207 | 76 Os 190.23 | 77 Ir 192.22 | 78 Pt 195.08 | 79 Au 196.967 | 80 Hg 200.59 | 81 Tl 204.383 | 82 Pb 207.2 | 83 Bi 208.980 | 84 Po (209) | 85 At (210) | 86 Rn (222) |
| 87 Fr (223) | 88 Ra 226.025 | 89 †Ac 227.028 | 104 Rf (261) | 105 Db (262) | 106 Sg (266) | 107 Bh (264) | 108 Hs (277) | 109 Mt (268) | 110 Ds (271) | 111 Rg (272) | | | | | | | |

*Lanthanide series

| 58 Ce 140.115 | 59 Pr 140.908 | 60 Nd 144.24 | 61 Pm (145) | 62 Sm 150.36 | 63 Eu 151.965 | 64 Gd 157.25 | 65 Tb 158.925 | 66 Dy 162.50 | 67 Ho 164.930 | 68 Er 167.26 | 69 Tm 168.934 | 70 Yb 173.04 | 71 Lu 174.967 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

†Actinide series

| 90 Th 232.038 | 91 Pa 231.036 | 92 U 238.029 | 93 Np 237.048 | 94 Pu (244) | 95 Am (243) | 96 Cm (247) | 97 Bk (247) | 98 Cf (251) | 99 Es (252) | 100 Fm (257) | 101 Md (258) | 102 No (259) | 103 Lr (262) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|