Chemistry 105-Fundamental Chemistry
Exam 2-Tuesday, 3 November 1998

Name_________________________
Laboratory Section ______________
ID Number_____________________

PLEASE ANSWER IN THE SPACE PROVIDED. SHOW **ALL** WORK WHEREVER POSSIBLE-ESPECIALLY STOICHIOMETRIC FACTORS AND UNIT CONVERSIONS. THERE WILL BE ABSOLUTELY NO TALKING DURING THIS EXAM PERIOD. IF YOU HAVE A QUESTION, RAISE YOUR HAND. IF YOU FINISH EARLY, BRING YOUR EXAM TO ME AND LEAVE QUIETLY. DURING THE LAST TEN MINUTES OF THE EXAM PERIOD, DO NOT LEAVE YOUR SEAT AND DO NOT SPEAK TO OTHERS UNTIL ALL PAPERS HAVE BEEN COLLECTED. INITIAL EACH PAGE SO THAT IF THE PAGES BECOME SEPARATED I CAN PIECE YOUR EXAM BACK TOGETHER. USE A PEN. FILL YOUR STUDENT ID NUMBER IN THE SPACE PROVIDED. GOOD LUCK.

Selected equations, constants, and information:

$M_1V_1 = M_2V_2$, PV = nRT, 1J = 1 kg m^2 s^{-2}, 4 qts = 1 gal, 1.057 qts = 1L, 4.184 J = 1 cal, 2.54 cm = 1 in, 2000 lbs = 1 ton, 5280 ft = 1 mile, 453.6g = 1.00lb, 12 = dozen, 101.325 kps = 1 atm, 1.00 troy oz. = 1.10 avoirdupois [ordinary] oz., 16.0 avoirdupois oz. = 1.00 avoirdupois pound, R=0.08206L atm/K mol, 1atm=29.92 in=760torr=760mm Hg

Soluble compounds	**Insoluble compounds**
compounds of Group 1 elements	carbonates, chromates, and phosphates, **except** those of the Group 1 elements and NH_4^+
ammonium compounds	
chlorides, bromides, and iodides, **except** those of Ag^+, Hg_2^{2+}, and Pb^{2+}*	sulfides, **except** those of the Group 1 and 2 elements and NH_4^+
nitrates, acetates, chlorates, and perchlorates	hydroxides and oxides, **except** those of the Group 1 and 2 elements**
sulfates, **except** those of Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Hg_2^{2+}, and Ag^+***	

*$PbCl_2$ is slightly soluble.
**$Ca(OH)_2$ and $Sr(OH)_2$ are sparingly (slightly) soluble; $Mg(OH)_2$ is only very slightly soluble.
***Ag_2SO_4 is slightly soluble.

Part I. Vocabulary (10pts) Place the most appropriate term in the space provided.

In a typical acid-base ___________________________________, the base is slowly added from a ___________________ to an acidic solution. In this case, the base is termed the _______________________ and the acid the _______________________. Often an ____________________________ will be used to show the point at which a complete reaction has taken place. When the color of this compound changes, it signals the ______________________ of the titration. This point should not be confused with the ____________________________ point, the stage at which the volume of titrant added is exactly that required by the __________________________ relationship between the reactants. If too much base were added such that an excess of this reactant were present, no useful information could be gleaned from this procedure. Likewise, if the true concentration of the base were unknown, error would be introduced. One way to remedy this is to ____________________________ the base against a ____ such as potassium hydrogen phthalate, (KHP).

Part II. Problems (70pts)

1. (16 pts) Complete the following chemical reactions.

$HNO_{3(aq)}$ + $H_2O_{(l)}$

$Ca(OH)_{2(s)}$ + $H_2O_{(l)}$

$H_3PO_{4(aq)}$ + $KOH(aq)$

$Mg_{(s)}$ + $O_{2(g)}$

$NH_{3(l)}$ + $H_3O^+(aq)$

$LiOH_{(s)}$ + $CO_{2(g)}$

$SO_{3(g)}$ + $H_2O_{(l)}$

$HC_2H_3O_{2(aq)}$ + $H_2O_{(l)}$

2. (14pts) The surface atoms of aluminum metal corrode in air to form an impervious aluminum oxide coating that prevents further corrosion of the lower layers of atoms. The oxidation reaction is

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

(a) Calculate the mass of aluminum oxide formed from the corrosion of 10.0 g of aluminum. (b) In the reaction of 10.0 g of aluminum, what mass of oxygen is needed?

(b) For the reaction shown above, assign the oxidation numbers, give the formula of the reactant that is reduced, the formula of the reactant that is oxidized, the formula of the reducing agent and the formula of the oxidizing reagent.

3. (15pts) If a magnesium hydroxide solution (200.0 mL, 0.563 M) were added to a solution of ammonium carbonate (255 mL, 0.713 M) what would be the result? For full credit, give (a) the complete, balanced chemical equation; (b) the net ionic equation; (c) the mass of all products formed; (d) the amount of excess reactant remaining; and (e) identify the limiting reactant.

4. (15pts) Hydrogen can be made in the "water gas reaction."

$$C_{(s)} + H_2O_{(g)} \longrightarrow H_{2(g)} + CO_{(g)}$$

If you begin with 250 L of gaseous water at 120 ˚C and 2.00 atm pressure, and 150.6754g of carbon, how many liters of H_2 can be made?

5. (10 pts) Assuming you could see at the molecular level (ie., you are a *tiiiiiiiiiiny* little person) draw a representation for what one would see for each of the following solutions.

a) NH_3 added to water:

b) $Pb(NO_3)_2$ added to water:

Part III. Laboratory (20pts)

PROCEDURE

1. Check out an evaporating dish from the stockroom. Clean the evaporating dish (perhaps using a mild abrasive such as washing/baking soda). Weigh and record the weight (± 0.001 g) of the evaporating dish. Weigh and record the weight of a clean, dry 100 mL beaker. Obtain an unknown (which should contain about 5 grams of mixture), dump the entire contents of the test tube into the weighed beaker and weigh the beaker and sample (See #1). Record the combined weight and unknown number on the Report Sheet.
2. Add approximately 50 mL of distilled water to the beaker and stir with a stirring rod for 5-6 minutes. Allow the mixture to settle and decant (pour) the liquid into a second, clean beaker. Wash* the residue (solid remaining in the 100 mL beaker) by adding 25 mL of distilled water to the solid, stir several minutes, and decant the "wash water" into the beaker containing the first liquid (more correctly called a decantate). (Save the decantate and water wash for step 5 below.) (See #2) Repeat the addition of 25 mL quantities of distilled water (combining them with previous water washings) until the blue color of copper sulfate no longer appears in the beaker with the sand and $CaCO_3$.

   You should perform steps 3-4 and 5-6 simultaneously.
3. SLOWLY (dropwise at first) add 5 mL of 6M HCl to the remaining SiO_2 / $CaCO_3$ mixture in the beaker. A vigorous evolution of CO_2 gas (as well as the formation of water) accompanies the addition of HCl. When the CO_2 is no longer evolving (no more bubbling) transfer the liquid **(BUT NOT THE SOLID)** into the evaporating dish. Add distilled water to wash* the solid in the beaker using four 5 mL portions of distilled water. Combine these washes with the solution in the evaporating dish (which should NOT have any sand in it). (See #3) Place the evaporating dish on a wire gauze in the hood at your station, and, using a bunsen burner, heat slowly thus preventing vigorous boiling. Realize that some HCl fumes are being given off and that is why it is imperative that the hood be utilized. Continue heating until most of the water has been evaporated. At this point, reduce the flame to avoid spattering. When the salt in the evaporating dish appears dry, heat it strongly for several minutes (about 3 minutes). Allow the dish to cool on a wire gauze. Weigh the evaporating dish as soon as it cools to avoid reabsorption of water.
4. Wash* the solid (SiO_2) remaining in the beaker with three 5 mL portions of acetone. (See #4) All of the used acetone should be placed in the waste acetone bottle Place the beaker containing the sand on the hot plate for a few minutes or dry the sand as directed by your instructor. When the acetone has completely evaporated, weigh the beaker and sand.

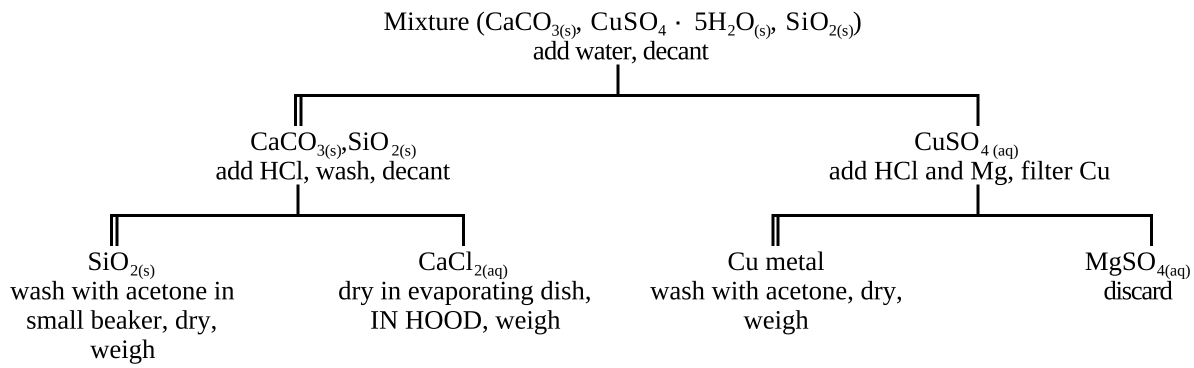
   Caution! Acetone is flammable. All Bunsen burners on the bench should be extinguished.
5. Add 10 mL of 6M HCl to the blue $CuSO_4$ solution and warm on a hot plate while adding small pieces of magnesium (Mg) a few at a time. (See #5) Do not add more Mg until the previous addition disssolves or you may spend a considerable amount of time waiting for **excess** magnesium to react. (Typically, a total of approximately 0.3 g of Mg is sufficient to react with the Cu.) Stir the mixture occasionally and break up the large clumps. Add more Mg until the blue color of Cu^2 has disappeared and a deposit of red copper is produced. You may wish to use a beaker of water as a side-by-side reference for a colorless liquid. However, if the copper has been stirred too vigorously, the liquid may appear pink. All of the blue color should have disappeared.

   TIP: Excess Mg typically floats whereas Cu sinks in the solution.

   If excess Mg remains in the beaker, concentrated HCl (12M) may be added dropwise to dissolve the Mg. Typically, the excess Mg floats. Remove from the hot plate and filter.
6. Weigh a piece of Whatman #1 filter paper and your watch glass. Filter the mixture using the Buchner funnel, an empty filter flask, and the weighed piece of filter paper. Dampen the filter paper with water. (See #6) Refer to the Reference Section for proper usage of a Buchner funnel. The copper can be washed out of the beaker into the funnel with distilled water. When the copper has been transferred onto the filter paper, wash the copper with four 5 mL portions of distilled water and two 15 mL portions of acetone. Draw air through the filter paper and copper until no liquid is present. Transfer the copper and filter paper to a preweighed watch glass, label and place in the oven until dry (15 minutes).

A simplified flow diagram (such as will be used in qualitative analysis in Chemistry 106) is given here to show the overall procedure. Note that a double line indicates a precipitate; a single line a decantate (liquid decanted off).

Experimental Flow Chart



Unknown Number ______

1. Weight of beaker..____________

2. Weight of beaker and sample..____________

3. Weight of sample ....____________

$CaCO_3$

4. Weight of evaporating dish...____________

5. Weight of evaporating dish and dry $CaCl_2$..............................____________

6. Weight of $CaCl_2$..____________

7. Weight of $CaCO_3$ in original sample...................................____________

   Show calculations:

SiO_2

8. Weight of beaker and remaining dry solid (SiO_2) ....____________

9. Weight of beaker..____________

10. Weight of SiO_2 in original sample ....____________

$CuSO_4 \cdot 5\ H_2O$

11. Weight of watch glass and filter paper ....____________

12. Weight of watch glass, filter paper and Cu metal......................____________

13. Weight of Cu metal...____________

14. Weight of $CuSO_4 \cdot 5 H_2O$ in original sample..........................____________

Show calculations:

[Remember: $Mg_{(s)} + CuSO_{4(aq)} \longrightarrow MgSO_{4(aq)} + Cu_{(s)}$]

CALCULATIONS

1. Weight of original sample...____________
2. Percent SiO_2 in original sample ....____________
3. Percent $CaCO_3$ in the sample...____________
4. Percent $CuSO_4 \cdot 5 H_2O$ in the sample..................................____________
5. Sum of the individual percentages......................................____________

QUESTIONS

1. How would the percent copper sulfate pentahydrate ($CuSO_4 \cdot 5 H_2O$) be affected if there was some unreacted magnesium (Mg) metal left after all the copper had reacted?

2. If the total weight of a mixture was 5.85 grams, and it was found to be 45.0% silicon dioxide, 28.6% calcium carbonate and 26.4% copper sulfate pentahydrate, what weight of each substance is present in the mixture?