Exam #3 Chem151 03 Dec 2015
(35 points)

Name:

Question 1 (6 points)

The compound diborane (B_2H_6) can be prepared by reacting lithium hydride (LiH) with boron trifluoride (BF_3). A side product formed is lithium borotetrafluorate ($LiBF_4$). If the chemist starts with 6.00 g of LiH and 12.00 g of BF_3, calculate the mass of B_2H_6 formed and the masses of all leftover reactants.

Question 2 (5 points)

Adamantane is the simplest *hydrocarbon* containing the same basic structural feature as diamond. (Do not confuse it with "adamantium", a fictional substance found in Marvel comics.) When adamantane is completely burned in air, 1.7909 g of CO_2 and 0.5855 g of H_2O was collected. The mass spectrum of adamantane shows a large peak at 136.2 g/mol. Calculate the empirical and molecular formulae of adamantane.

Question 3 (5 points)
Hydrogen gas is evolved when calcium metal reacts with water to produce a basic solution.
(a) The *unbalanced* chemical equation is

$$Ca + H_2O \rightarrow Ca(OH)_2 + H_2$$

Balance the equation and label the physical states of the reactants and products.

(b) Find the change in oxidation numbers for each element in this redox reaction.

(c) Identify the oxidizing and reducing agents in this reaction.

(d) Why is the final solution basic?

Question 4 (9 points)
The basic solution $Ca(OH)_2$ can react with sulfuric acid, H_2SO_4, to produce the insoluble salt $CaSO_4$ and water.
(a) Write a balanced chemical equation for this reaction.

(b) What volume of 0.600 M H_2SO_4 is required to exactly neutralize a 2.0 L solution of 0.250 M $Ca(OH)_2$?

(c) If the yield of $CaSO_4$ precipitate is only 65%, calculate (i) the mass of the solid formed and (ii) the concentration of calcium and sulfate ions remaining in solution.

(d) $MgSO_4$ is much more soluble than $CaSO_4$, while $BaSO_4$ is much less soluble than $CaSO_4$. Explain.

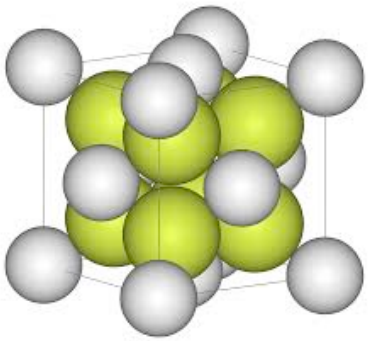
Question 5 (5 points)
When magnesium metal is placed in a blue solution of copper(II) sulfate, the blue color entirely disappears, and a red metal precipitates out of solution.
(a) Write the *net ionic* equation for this reaction.

(b) List any spectator ions present in the solution.

(c) If one of the reactants was in excess and you still observed everything above, would you expect any magnesium to be left unreacted? Give a reason to support your answer.

(d) If aluminum nitrate solution was added to copper(II) sulfate solution, would you expect to see a precipitate? Why or why not? [This has to do with solubility rules and is unrelated to the activity series.]

Question 6 (2 points)
In the "fluorite" unit cell shown on the right, the X atoms form a face-centered cube with Y atoms in the tetrahedral holes. What is the formula of fluorite? Show your work.



Question 7 (3 points)
Balance the following redox equation under *acidic* conditions.

$$Zn_{(s)} + VO^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + V^{3+}_{(aq)}$$

Extra Credit (2 points – all or nothing)
Draw the Lewis structure of the adamantane molecule (see question 2).