SCH 3U Relative Reactivity Lab Questions (Loser/Gainer Questions)

Part 1: Reactions of Alkali Earth Metals and Alkaline Earth Metals in Water
Part 2: Reactions of Various Metals in HCl and H_2SO_4 Aqueous Solutions
Part 3: Reactions of Some Metals and Non-metals in Pure Oxygen

Part 1: Reactions of Alkali Earth Metals and Alkaline Earth Metals in Water

Questions #1,2 and 3 are to be done in conjunction. Make sure you leave enough space. One page for all five reactions is about right.

1. Write balanced chemical equations for all reactions in part 1. Note that the oxidation state of each alkali earth metal is 1+ and the oxidation state each alkaline earth metal is 2+ as shown on the periodic table. All of these metals react with water to produce a metal hydroxides plus hydrogen gas.

2. Add oxidation states to all atoms in your equations from question #1. Please note that the oxidation state is written **DIRECTLY ABOVE** the element symbol. Add ionic charges for the hydroxides. These ionic charges should be used to ensure that you have the correct formula for each hydroxide. Ionic charges are written **ABOVE AND TO THE RIGHT**

3. Using the oxidation states from question two, identify the:
   - losers (elements that lost electrons and hence have had an increase is oxidation state)
   - gainers (elements that gained electrons and hence have had a decrease is oxidation state)
   - the elements that have been oxidized
   - the elements that have been reduced

   You can use arrows above and below the reaction to help point out the change in oxidation states for the elements involved. What generalization could you make about metals based on this answer? Which element gained in all five reactions?

4. Rank all five metals using element symbols from part one in order of decreasing reactivity. This means that the most reactive metal is first and the least reactive is last. Separate the symbols by > signs. Your answers format should look like this:

   Hg > Ag > Au > etc.

5. Underneath of the element symbols you have written in question number four, write the ionization energy value for each element. Use this information to explain why the relative reactivity of these five metals is as observed.

Part 2: Reactions of Various Metals in HCl and H_2SO_4 Aqueous Solutions

6. Using the instructions in question #1, 2 and 3, write balanced chemical equations for all six metals with HCl. The product in each case is a chloride of the metal instead of a hydroxide. Hydrogen gas is produced as well. The oxidation states for the six metals achieved in these reactions are:

Al^{3+}	Ca^{2+}	Cu^{2+}	Fe^{3+}	Mg^{2+}	Zn^{2+}

The HCl molecule is frequently referred to as a covalent compound with a high degree of ionic character. This is particularly the case when HCl is dissolved in water to form hydrochloric acid. For the purposes of these reactions, it will be better to treat HCl as though it were fully ionic. Therefore use the following for oxidation states and ionic charges for HCl

$$\overset{1+}{H}\ \overset{1-}{Cl}$$

In the product chlorides, the oxidation state/ionic charge of the chlorine atom remains unchanged. Again one full page is about the right amount of space for these six reactions. If no reaction was visible, assume that a small undetectable amount of reaction did occur.

7. Repeat question #6 for the six reactions of all six metals with H_2SO_4. The products are now a sulphate and hydrogen gas. Use the following for H_2SO_4

$$\overset{1+}{H_2}\ \overset{6+}{S}\ \overset{2-}{O_4}$$

None of the oxidation states in the sulphate change during this reaction.

8. Based on your observations, create one combined list that shows the relative reactivity of all six metals in this lab. Most reactive first, least reactive last. You may need to compromise, given the difference in observations using HCl catalyst vs H_2SO_4 catalyst.

9. Underneath of the element symbols you have written in question number eight, write the ionization energy value for each element. Why does this not give perfect agreement to the reactivity you have observed? What additional factor must be considered? For two bonus marks present a good explanation that incorporates **ALL** relevant ionization energies that can more fully explain the observed relative reactivity.

Part 3: Reactions of Some Metals and Non-metals in Pure Oxygen

10. Write balance chemical equations for all reactions with oxygen. Be sure to use the diatomic form for oxygen. In each case, the metal reacts with oxygen to form a metal oxide. Use the following oxidation states to get the correct oxides:

C^{4+}	Mg^{2+}	Fe^{3+}	S^{4+}	O^{2-}

11. Note that the oxidation state of oxygen in diatomic elemental form is 0 and each metal in elemental form also has an oxidation state of 0. Use this information to add oxidation states for all elements in your reactions from #9 and use this to identify the losers and the gainer in each reaction.

12. Compare the electronegativities of all **five** elements involved. How does this help explain the reason for which element loses and which element gains from question #10.

13. How can the electronegativities (or related ionization energies) be used to explain the fact that the non-metals C and S react more slowly with oxygen than the metals Mg and Fe? Why are metals big losers?

Questions Related to pH Observation for All Parts:

14. Using the colour chart on the universal indicator bottle, state the pH for each hydroxide product in part 1 and each oxide product in part 3. Use a table to present your answers with the headings as follows:

Product Formula	Indicator Colour	pH

15. Do some of your own research on pH:
a) what does pH stand for
b) draw a common pH scale and label it to indicate acidic, basic and neutral
c) what is meant by the fact that the pH scale is logarithmic, give an example
d) what ion is most often associated with acidic solutions
e) what ion is most often associated with basic solutions

16. Is it possible that alkali earth metals and alkaline earth metals have received their names based on there reactions with water and the pH of the resulting solutions? (hint what is the linguistic origin of the terms alkali or alkaline?)

17. Are oxides of metals and non-metals acidic or basic based on your lab observations?

18. Why would testing the pH for the products in the second part of the lab be a waste of time?

For reference use chapter 10 in your textbook, in particular pg 385, 386 and 387