LAD G3 (pg 1 of 2) **Single Replacement Reactions**

Oxidation-Reduction Reactions (aka Redox) *ANSWERS*

1. Zinc nitrate is put into water and then combined with copper. [if a Rx occurs, assume copper(II)]
   a. Observations:
   No Reaction, nothing appears to be happening.

   The element that is more reactive is the one that will exist as an ion, rather than as an element.
   b. Which element must be more reactive: copper or zinc?
   This means that zinc must be more reactive because Zn is already in the reacted state (it has already been "active") as an ion having reacted with nitrate. Since there is no reaction, that means that the more active Zn stays reacted, and the less active copper can not take zinc's place and copper remains unreacted as an element, with an oxidation state (charge of zero).

   c. Check the activity series and confirm your conclusion. Which element is above – copper or zinc?
   On the activity series, on the back of your periodic table, zinc is above copper confirming that zinc is more active than copper.

   d. Equations (overall and net ionic):
   No reaction

2. Copper sulfate is put into water and is then combined with solid zinc.
   a. Observations: (color of solid product? changing color of the solution?)
   The zinc starts to change color - black at first (this is a side reaction caused by the zinc oxide "rust" on the outside of the zinc), and eventually develops a copper-colored solid "stuff" forming on it. The blue color of the solution begins to fade, eventually turning colorless the next day. Some of the solutions did not turn completely colorless indicating that not all of their copper ions were gone from the solution. This may have occurred if that group did not put in enough zinc to replace all of the copper ions.

   Copper, in ion form is blue (or blue-green), yet in its elemental form it is its distinctive "copper" color.
   b. What color is the solid product that forms? What element is the solid product?
   The solid product forming is copper-colored. It makes sense that it would be copper.

   c. What is causing the starting solution to be blue?
   Copper ions in the presence of water are blue in color. They were blue in the original compound which is a hydrate, and when dissolved in water, they remain blue in the presence of water.

   d. Why does the blue color of the solution fade as the reaction proceeds? Where does the blue color go?
   The color fades of the solution to colorless because the copper ions leave the solution (taking their electrons back) and turning into solid copper metal atoms (with no charge, oxidation number = 0).

   e. Equations (overall and net ionic):
   Overall: $Cu(NO_3)_{2(aq)} + Zn \rightarrow Cu + Zn(NO_3)_{2(aq)}$
   Net ionic: $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$

3. Solid copper(II) sulfate is combined with solid zinc.
   a. Observations: (dissociation issues?)
   No changes seem to occur.

   b. For a single replacement reaction to occur, the reacting compound must be dissociated. Why?
   If a replacement is going to happen − if the metal ion (the one attached to nitrate) is going to be replaced and turn into a neutral metal atom, that metal cation must be separated from its anion which occurs when it dissociates when it dissolves into an aqueous solution.

   c. Equations (overall and net ionic):
   No reaction since no replacement could occur.

4. Iron(III) sulfide is put into water (solution?) and is combined with zinc.

   a. Observations & Explanations: (solubility issues?)
   The iron(II) sulfide appears not to dissolve

   b. Equations (overall and net ionic):
   No reaction because iron(II) sulfide is insoluble. If no dissolving occurs, then no dissociation occurs, and no replacement can happen.

5. Zinc is dropped into water.
   a. Observations:
   No changes seem to occur.

   b. Check the activity series to see what it says about hydrogen and zinc.
   Zinc is above hydrogen in the activity series, however it is only able to replace hydrogen from acids, not from water. This is because the H−O bond in water is too strong for zinc to replace it, only when H is part of an acid, and the bond is "looser" can it be replaced by zinc.

6. Zinc is dropped into hydrochloric acid.
   a. Observations: (rate of reaction in different concentrations or different temperatures? exo- or endothermic?)

3 M concentration at room temperature	3 M concentration heated up	12 M concentration at room temp
slow bubbling	faster bubbling	very rapid bubbling
tube gets warm	tube gets warmer	tube gets very hot (EXOTHERMIC)

   b. Locate hydrogen and zinc in the activity series. Do their positions in the activity series confirm the results? (Remember in this reaction, the hydrogen is in an acid not in water.)
   As mentioned in #5b, zinc can replace hydrogen out of acids.

   c. Equations (overall and net ionic): (This is the reaction that happened when we reacted the core of a post-1982 penny in LAD 11.6)
   Overall: $Zn + 2\,HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_2$
   Net ionic: $Zn + 2\,H^{+}_{(aq)} \rightarrow Zn^{2+} + H_2$

   d. What can you conclude about the effect of temperature on reaction rate? Write a statement that correlates temperature and reaction rate.
   As temperature increases, the reaction rate increases. This is because at increased temperature, the molecules are moving faster and will collide more often, as well as colliding with more force, causing the reaction to happen faster.

   e. What can you conclude about the effect of concentration on reaction rate? Write a statement that correlates concentration and reaction rate.
   As concentration increases, the reaction rate increases. This is because at increased concentration, the molecules are more crowded and will collide more often causing a faster reaction.

7. Sodium is dropped in water, as seen in LAD 11.5 – Reactivity of the Alkali Metals
   a. Observations:
   The metal floats on the surface of water (less dense) and bubbles, and then it bursts into an orangy−yellow flame. You saw this same color when we were doing flame tests in chapter 11.
   From chapter 3 when we dropped potassium in water (and from our potassium flame tests) may recall that the potassium flame was purple!
   The temperature of the water increases. If an acid/base indicator is put in the water, color changes indicate that a base (hydroxide solution) is formed during the reaction.
   b. Which metals on the activity series can replace hydrogen from water?
   Li, K, Ba, Ca, Na
   c. Although water is a molecular compound, with covalent bond, you can predict the single replacement reaction best if you think of water as hydrogen hydroxide. Write the formula for water written as hydrogen hydroxide.
   HOH
   d. Equation (overall):
   $2Na + 2H_2O \rightarrow 2NaOH_{(aq)} + H_2$
   e. You see flames with this reaction. It is not actually the sodium that is "on fire." It is the product gas, hydrogen that burns because the temperature increases enough to cause it to ignite. Write a reaction for the combustion of hydrogen gas.
   $2H_2 + O_2 \rightarrow 2H_2O$