Chemical Reactions Chapter 11 Study Guide (Unit 8)

- Understand and be able to explain all of the key concepts.
- Define and understand all of the survival words
- Memorize the names and symbols for these elements: (Ag, Al, Ar, As, Au, B, Ba, Be, Br, C, Ca, Cd, Cs, Cl, Co Cr, Cu, F, Fe, Fr, H, He, Hg, I, K, Kr, Li, Mg, Mn, N, Na, Ne, Ni, O, P, Pb, Rn, S, Sc, Si, Sn, Sr, Ti, U, Xe, Zn)
- Know the charges (oxidations numbers) of elements found in the s & p blocks.
- Know which elements are transition metals and therefore require the charge in parenthesis when being named. [ex Sn (II) or Co (III) ]
- Know the charges of Ag\(^{+1}\), Zn\(^{+2}\), Cd\(^{+2}\), Al\(^{+3}\), and Ga\(^{+3}\) (exceptions to the transition area)
- Know how to use the Activity Series of Metals and Halogens for single replacement reactions
- Know how to use the Solubility Rules
- Know how to predict the products of any reaction
- Know how to balance a chemical reaction
- Know how to determine the net ionic equation.
- Review all classwork (including your lab notebook) and quizzes.

Key Concepts

Hydrocarbons
- Because carbon has four valence electrons, carbon atoms always form four covalent bonds.
- Molecules of hydrocarbons are nonpolar
- Carbon atoms can form chains that are named using the following naming convention:
  - Prefix is determined by the number of carbons
    - 1 = meth
    - 2 = eth
    - 3 = prop
    - 4 = but
    - 5 = pent
    - 6 = hex
    - 7 = hept
    - 8 = oct
    - 9 = non
    - 10 = dec
  - Suffix is determined by the type of bond
    - Alkane C\(_n\)H\(_{2n+2}\) (all bonds are single)
    - Alkene C\(_n\)H\(_{2n}\) (one bond is a double)
    - Alkyne C\(_n\)H\(_{2n-2}\) (one bond is a triple)

11.1 Describing Chemical Reactions
- To write a word equation, write the names of the reactants to the left of the arrow separated by plus signs; write the names of the products to the right of the arrow, also separated by plus signs.
- To write a skeleton equation, write the formulas for the reactants (including their subscripts) for the reactants to the left of the yield sign and the formulas for the products to the right of the yield sign. All reactants should be separated by a plus sign and as should products.
- After writing the skeleton equation, use coefficients to balance the equation so that it obeys the law of conservation of mass.
The law of conservation of mass states that the mass of the reactants will always equal the mass of the products. In result the number of atoms of one element on the reactants side should be identical to the number of atoms of the same element on the products side.

11.2 Types of Chemical Reactions
- The five general types of reactions are combination (synthesis), decomposition, single-replacement, double-replacement, and combustion.
- The number of elements and/or compounds reacting is a good indicator of possible reaction type and thus possible products.
- In a combination (synthesis) reaction, there is always a single product.
- A decomposition reaction involves the breakdown of a single compound into two or more simple substances.
- In a single-replacement reaction, both the reactants and the products are an element and a compound. An element that will form an anion can only replace the anion in the compound whereas and element that will form a cation can only replace the cation in the compound. In order to predict the products in a single-replacement reaction, the reactivity of the elements must be considered. The Activity Series describes the reactivity of various elements.
- A double-replacement reaction generally takes place between two ionic compounds in aqueous solution.
- A combustion reaction always involves a hydrocarbon and Oxygen gas as reactants as well as carbon dioxide and water as products.

11.3 Reactions in Aqueous Solution
- A net ionic equation shows only those particles involved in the reaction and is balanced with respect to mass and charge.
- You can predict the formation of a precipitate by using the general rules for solubility of ionic compounds

Survival Words
- Activity series (333)
- Anion (172)
- Balanced equation (325)
- Catalyst (323)
- Cation (172)
- Chemical equation (353)
- Coefficients (325)
- Combination (Synthesis) reaction (330)
- Combustion reaction (336)
- Complete ionic equation (342)
- Decomposition reaction (332)
- Double-replacement reaction (334)
- Hydrocarbon (693)
- Insoluble (450-1)
- Net ionic equation (343)
- Product (53)
- Reactant (53)
- Single-replacement reaction (333)
- Skeleton equation (323)
- Soluble (450-1)
- Spectator ion (343)
- Yield (323)
You will be provided a clean copy of the following with your test:

### Activity Series for METALS

<table>
<thead>
<tr>
<th>Reactivity</th>
<th>Name</th>
<th>Symbol</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Reactive</td>
<td>Lithium</td>
<td>Li</td>
<td>Will replace H in acids (compounds starting with H) and Water.</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
<td>Ca</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sodium</td>
<td>Na</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
<td>Mg</td>
<td>Will replace H in acids only.</td>
</tr>
<tr>
<td></td>
<td>Aluminum</td>
<td>Al</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>Zn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iron</td>
<td>Fe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lead</td>
<td>Pb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydrogen</td>
<td>H⁺</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>Cu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mercury</td>
<td>Hg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silver</td>
<td>Ag</td>
<td></td>
</tr>
<tr>
<td>Least Reactive</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Activity Series for HALOGENS

<table>
<thead>
<tr>
<th>Reactivity</th>
<th>Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Reactive</td>
<td>Fluorine</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>Chlorine</td>
<td>Cl</td>
</tr>
<tr>
<td></td>
<td>Bromine</td>
<td>Br</td>
</tr>
<tr>
<td></td>
<td>Iodine</td>
<td>I</td>
</tr>
<tr>
<td>Least Reactive</td>
<td>Astatine</td>
<td>At</td>
</tr>
</tbody>
</table>

### Solubility Rules for Ionic Compounds

- **Salts of Alkali (Group I) metals and ammonium (NH₄⁺)**: Soluble (aq)
- **Nitrate (NO₃⁻) salts and Chlorate (ClO₃⁻) salts**: Soluble (aq)
- **Sulfate (SO₄²⁻) salts except compounds with Pb²⁺, Ag⁺⁺, Hg₂⁺², Ba²⁺, Sr²⁺, and Ca²⁺**: Soluble (aq)
- **Chloride (Cl⁻) salts except compounds with Ag⁺⁺, Pb²⁺, and Hg₂⁺²**: Soluble (aq)
- **Carbonates (CO₃⁻), Phosphates (PO₄³⁻), Chromate (CrO₄²⁻), Sulfides (S²⁻), and Hydroxide (OH⁻) except compounds with group I metals**: Insoluble (s)

**NOTE:** You are responsible for memorizing the polyatomic ion list and the diatomic elements!
Review Questions

1. What are the symbols for solid, liquid, gas, and aqueous in a chemical reaction? (s), (l), (g), (aq)
2. What changes during a chemical reaction? The arrangement of the atoms
3. What remains the same during a chemical reaction? The type of atoms, number of atoms, and mass
4. Label the following reactions as Synthesis (S), Decomposition (D), Single-Replacement (SR), Double Replacement (DR), or Combustion.
   a. D PbO₂ → PbO + O₂
   b. S A + Z → AZ
   c. D Fe(OH)₃ → Fe₂O₃ + H₂O
   d. Combustion C₃H₄ + O₂ → H₂O + CO₂
   e. DR H₂SO₄ + BaCl₂ → BaSO₄ + HCl
   f. SR MQ + R → RQ + M
   g. S Hf + N₂ → Hf₃N₄
   h. SR Mg + H₂CO₃ → MgCO₃ + H₂
   i. D UT₃ → U₂ + T
   j. Combustion C₁₂H₂₂O₁₁ + O₂ → CO₂ + H₂O
5. Balance the following equations
   a. _1__Mg + _1__H₂SO₄ → _1__MgSO₄ + _1__H₂
   b. _2__C₂H₆ + _7__O₂ → _4__CO₂ + _6__H₂O
   c. _1__Pb(NO₃)₂ + _2__NaI → _1__Pbl₂ + _2__NaNO₃
   d. _3__Fe + _2__O₂ → _1__Fe₃O₄
   e. _2__H₂ + _1__O₂ → _2__H₂O
   f. _1__C₃H₈ + _5__O₂ → _3__CO₂ + _4__H₂O
6. Write the balanced chemical equations for the following reactions. Write NR if there is no reaction.
   a. Bubbling chlorine gas through a solution of potassium iodide gives elemental iodine and a solution of potassium chloride.
      Cl₂ (g) + KI (aq) → I₂ + KCl(aq)
   b. Solid tetraphosphorus decoxide reacts with water to produce phosphoric acid.
      P₄O₁₀ (s) + 3 H₂O (l) → 4 H₃PO₄ (aq)
   c. Octane gas reactions with oxygen gas in a combustion reaction.
      2 C₈H₁₈ (g) + 25 O₂ (g) → 18 H₂O(l) + 16 CO₂ (g)
   d. Zinc sulfide is added to sulfuric acid in an aqueous solution.
      ZnS (aq) + H₂SO₄ (aq) → ZnSO₄ (aq) + H₂S(aq)
e. Solutions of potassium fluoride and calcium nitrate are mixed.
   \[ 2 \text{KF}(aq) + \text{Ca(NO}_3\text{)}_2(aq) \rightarrow 2 \text{KNO}_3(aq) + \text{CaF}_2(aq) \]

f. A piece of steel wool (iron) is placed in sulfuric acid (H\text{SO}_4).
   \[ \text{Fe}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{H}_2(g) + \text{FeSO}_4 \quad \text{[I used iron (II)]} \]

g. Mercury is poured into an aqueous solution of zinc nitrate.
   \[ \text{Hg}(l) + \text{Zn(NO}_3\text{)}_2(aq) \rightarrow \text{no reaction} \]

h. Bromine reacts with aqueous barium iodide.
   \[ \text{Br}_2 + \text{BaI}_2 \rightarrow \text{I}_2 + \text{BaBr}_2 \]

i. Aluminum is obtained from aluminum oxide with the addition of a large amount of electrical energy.
   \[ 2 \text{Al}_2\text{O}_3 \rightarrow 4 \text{Al} + 3 \text{O}_2 \]

j. Heating tin (IV) hydroxide gives tin (IV) oxide and water.
   \[ \text{Sn(OH)}_4 \rightarrow \text{SnO}_2 + 2 \text{H}_2\text{O} \]

7. Predict the products and then balance the equations:
   a. \(_1\)\text{Ca} (s) + \(_1\)\text{S} (s) \rightarrow 1 \text{CaS} (s)
   b. \(_1\)\text{Zn} (s) + \(_2\)\text{AgNO}_3 (aq) \rightarrow 2 \text{Ag} (s) + 1 \text{Zn(NO}_3\text{)}_2(aq)
   c. \(_2\)\text{Al} (s) + \(_3\)\text{H}_2\text{SO}_4 (aq) \rightarrow 3 \text{H}_2(g) + 1 \text{Al}_2\text{(SO}_4\text{)}_3(aq)
   d. \(_\text{Al} (s) + \_\text{H}_2\text{O (l)} \rightarrow \text{no reaction}
   e. \(_1\)\text{CdBr}_2 (aq) + \(_1\)\text{Na}_2\text{S} (aq) \rightarrow 2 \text{NaBr} (aq) + 1 \text{CdS} (s)
   f. \(_\text{Cl}_2 + \_\text{NaF} \rightarrow \text{no reaction}
   g. \(_1\)\text{Cl}_2 + \(_2\)\text{NaBr} \rightarrow 1 \text{Br}_2 + 2 \text{NaCl}
   h. \(_2\)\text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2
   i. \(_2\)\text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2

8. Write a balanced net ionic equation for the following reactions:
   a. \(_2\)\text{HCl (aq) + } \_\text{Ca(OH)}_2 (aq) \rightarrow 2 \text{H(OH)} (l) + \text{CaCl}_2 (aq)
      Net ionic equation: 2 \text{H}^{+1} + 2 \text{OH}^{-1} \rightarrow 2 \text{H}_2\text{O}
   b. \(_3\)\text{AgNO}_3 (aq) + \_\text{AlCl}_3 (aq) \rightarrow \text{Al(NO}_3\text{)}_3(aq) + 3 \text{AgCl} (s)
      Net ionic equation: 3 \text{Ag}^{+1} (aq) + 3 \text{Cl}^{-1} (aq) \rightarrow 3 \text{AgCl}(s)

9. Mr. Ross broke into the lab last night and started mixing the chemicals in the prep room. He stirred together aqueous solutions of sodium sulfide and cadmium nitrate in a beaker. Much to his surprise a bright yellow precipitate formed.
   a. Write the formula of the yellow precipitate that Mr. Ross formed.
   b. Identify the spectator ions in the solution
   c. Write the net ionic equation for the reaction.
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a. $\text{Na}_2\text{S} (\text{aq}) + \text{Cd(NO}_3\text{)}_2 (\text{aq}) \rightarrow 2\text{NaNO}_3 (\text{aq}) + \text{CdS} (\text{s})$  The CdS is the precipitate

b. $\text{Na}^{+1} (\text{aq})$ and $\text{NO}_3^{-1} (\text{aq})$

c. $\text{Cd}^{+2} (\text{aq}) + \text{S}^{-2} (\text{aq}) \rightarrow \text{CdS} (\text{s})$

10. When pale yellow chlorine gas is bubbled through a clear, colorless solution of sodium iodide, the solution turns brown.

   a. What type of reaction is taking place? Single Replacement
   b. Write the balanced chemical equation.

   $$\text{Cl}_2 + 2\text{NaI} \rightarrow \text{I}_2 + 2\text{NaCl}$$

11. A laboratory investigation was done in the BHS chemistry lab. During the laboratory investigation, Isaac “the Weatherman” Polanski heated a small amount of magnesium in a crucible with a Bunsen burner to its ignition temperature, forcing it to react with the oxygen in the surrounding air. As a result of the reaction, an intense white light was given off and a white powder appeared to take the place of the magnesium in the crucible.

   Write the balanced chemical equation for the reaction that occurred.

   $$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$$

   Identify the type of reaction that occurred. Synthesis

12. Emily “Dorothy” Bailey was performing a double replacement reaction by mixing aqueous sodium hydroxide with aqueous lead(II) nitrate. Emily noticed that a dark brown precipitate formed upon mixing the two solutions. In the spaces below, write the balanced chemical equation for the reaction. Identify which product is the precipitate. Identify the spectator ions in the equation. Finally, write the net ionic equation for the reaction that Emily performed.

**Balanced Equation:**

$$2\text{NaOH} (\text{aq}) + \text{Pb(NO}_3\text{)}_2 (\text{aq}) \rightarrow 2\text{NaNO}_3 (\text{aq}) + \text{Pb(OH)}_2 (\text{s})$$

**Complete ionic equation:**

$$\text{Na}^{+1} (\text{aq}) + \text{OH}^{-1} (\text{aq}) + \text{Pb}^{+2} (\text{aq}) + \text{NO}_3^{-1} (\text{aq}) \rightarrow \text{Na}^{+1} (\text{aq}) + \text{NO}_3^{-1} (\text{aq}) + \text{Pb(OH)}_2 (\text{s})$$

**Precipitate:** Pb(OH)$_2$ (s)

**Spectator Ions:** Na$^{+1}$ (aq) & NO$_3^{-1}$ (aq)

**Net Ionic Equation:**

$$2\text{OH}^{-1} (\text{aq}) + \text{Pb}^{+2} (\text{aq}) \rightarrow \text{Pb(OH)}_2 (\text{s})$$