**SCH 3UI Unit 5 Outline**
**Chemical Reactions**

| Lesson | Topics Covered | Homework Questions and Assignments |
|---|---|---|
| 1 | **Note: Chemical Reactions and Chemical Equations**<br>• definition of chemical reaction<br>• four signs of chemical change<br>• the Law of Conservation of Mass<br>• balancing chemical equations | • complete handouts: Balancing Equations #1, #2, #3, #4 |
| 2 | **Note: Writing Chemical Equations**<br>• chemical formulas of compounds and elements<br>• indicating the states of reactants and products<br>• synthesis reactions<br>• decomposition reactions<br>• combustion reactions | • complete handout: Writing and Balancing Synthesis, Decomposition and Combustion Reactions |
| 3 | **Note: Writing Chemical Equations (continued)**<br>• double displacement reactions<br>• predicting the formation of precipitates using the solubility rules<br>• neutralization reactions | • complete handout: Writing and Balancing Double Displacement Reactions |
| 4 | **Note: Writing Chemical Equations (continued)**<br>• Single Displacement Reactions for Non-metals<br>• Pre-lab notes for Lab #5 | • complete handout: Writing Chemical Equations for Single Displacement Reactions of Non-metals<br>• set up lab report for Lab #5 |
| 5 | **Lab #5**<br>• perform lab<br>• carefully observe for any/all signs of chemical change<br>• take up errors | • begin lab report for Lab #5 |
| 6 | **Note: Writing Chemical Equations (continued)**<br>• Single Displacement Reactions for Metals<br>• Activity Series for metals | • complete handout: Writing Chemical Equations for Single Displacement Reactions of Metals<br>• complete lab report for Lab #5<br>• begin review for Unit 05 Chemical Reactions Unit Test |
| | **Unit Test** | |

# Chemical Reactions and Chemical Equations

A chemical reaction occurs when the _____ are _____ to form new elements or compounds with _____.

If a reaction takes place, there is evidence of _____, such as:

1. _____
2. _____
3. _____
4. _____

The **Law of Conservation of Mass** states that the _____ of the products of a reaction is equal to the _____of the reactants. This Law tells us that during a chemical reaction, the atoms of the reactants are _____ to form _____, but the _____and _____ of each atom _____.
During a chemical reaction, atoms are neither _____ nor _____.
Therefore, all chemical equations must be written in their _____.

**Hints for balancing chemical reactions:**

1. If there is an element by itself (not in a compound) _____.
2. Start with the element that has the _____.
3. If a chemical formula has a subscript that is an _____ number ( ), it may help to put a _____ in front of this compound before you begin.
4. For hydrocarbons ( ), if the number of carbon atoms is an _____, start by putting a "____" in front of the hydrocarbon. Balance _____ first, _____ second and _____ last.
5. When you are finished balancing, check to see if the coefficients can be _____ _____.

**Examples:**

$Pt + As \rightarrow Pt_3As_2$

$Li_3P + I_2 \rightarrow LiI + P_4$

$CoTe + Sn \rightarrow SnTe_2 + Co$

$Rb_3PO_4 + Cr_2(SO_4)_3 \rightarrow Rb_2SO_4 + CrPO_4$

$GeBr_4 + F_2 \rightarrow GeF_4 + Br_2$

$K_3N \rightarrow K + N_2$

$Sb_3(BO_3)_5 + Pd(ClO_3)_2 \rightarrow Sb(ClO_3)_5 + Pd_3(BO_3)_2$

$C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$

$C_9H_{20} + O_2 \rightarrow CO_2 + H_2O$

# Balancing Equations #1

1. $Al + S \rightarrow Al_2S_3$
2. $Sn + Cl_2 \rightarrow SnCl_4$
3. $ZnO \rightarrow Zn + O_2$
4. $H_2 + O_2 \rightarrow H_2O$
5. $Cu_2O \rightarrow Cu + O_2$
6. $Cu + S_8 \rightarrow Cu_2S$
7. $P_4 + O_2 \rightarrow P_4O_{10}$
8. $NO_2 \rightarrow N_2 + O_2$
9. $H_2 + I_2 \rightarrow HI$
10. $HgO \rightarrow Hg + O_2$
11. $H_2 + N_2 \rightarrow NH_3$
12. $NaCl + Br_2 \rightarrow NaBr + Cl_2$
13. $SiO_2 + HF \rightarrow SiF_4 + H_2O$
14. $Fe_2O_3 \rightarrow Fe + O_2$
15. $K + Br_2 \rightarrow KBr$
16. $Ca + HI \rightarrow CaI_2 + H_2$
17. $Na + O_2 \rightarrow Na_2O$
18. $BiCl_3 \rightarrow Bi + Cl_2$
19. $CO + O_2 \rightarrow CO_2$
20. $Mg + HCl \rightarrow H_2 + MgCl_2$
21. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
22. $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
23. $C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$
24. $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$

# Balancing Equations #2

1. $CaS + KCl \rightarrow CaCl_2 + K_2S$
2. $Na + Cl_2 \rightarrow NaCl$
3. $Al + O_2 \rightarrow Al_2O_3$
4. $AlN + CaO \rightarrow Al_2O_3 + Ca_3N_2$
5. $AlCl_3 \rightarrow Al + Cl_2$
6. $N_2 + NH_4Cl \rightarrow (NH_4)_3N + Cl_2$
7. $AlN \rightarrow Al + N_2$
8. $Na_2CO_3 + Ca \rightarrow CaCO_3 + Na$
9. $Al(NO_3)_3 + Na_2CO_3 \rightarrow NaNO_3 + Al_2(CO_3)_3$
10. $(NH_4)_2O + Ca(NO_3)_2 \rightarrow NH_4NO_3 + CaO$
11. $AgNO_3 + K_2S \rightarrow KNO_3 + Ag_2S$
12. $BaCl_2 + Na_2CO_3 \rightarrow BaCO_3 + NaCl$
13. $Ca(NO_3)_2 + Li_3PO_4 \rightarrow Ca_3(PO_4)_2 + LiNO_3$
14. $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$
15. $NH_4Br + Cl_2 \rightarrow NH_4Cl + Br_2$
16. $Zn + HCl \rightarrow ZnCl_2 + H_2$
17. $I_2 + KF \rightarrow KI + F_2$
18. $Ag + Cl_2 \rightarrow AgCl$
19. $Ba + S \rightarrow BaS_4$
20. $Li_2O + SO_2 \rightarrow Li_2SO_3$
21. $C_2H_2 + O_2 \rightarrow CO_2 + H_2O$
22. $Al + FeO \rightarrow Al_2O_3 + Fe$
23. $H_2O_2 \rightarrow H_2O + O_2$
24. $N_2 + H_2 \rightarrow NH_3$
25. $Na + H_2O \rightarrow NaOH + H_2$

**Balancing Equations #3**

1. $XeF_6 + H_2O \rightarrow XeO_3 + HF$
2. $KClO_3 \rightarrow KCl + O_2$
3. $CaC_2 + O_2 \rightarrow Ca + CO_2$
4. $Fe_3O_4 + H_2 \rightarrow Fe + H_2O$
5. $BN + F_2 \rightarrow BF_3 + N_2$
6. $H_2O \rightarrow H_2 + O_2$
7. $Zn + HCl \rightarrow H_2 + ZnCl_2$
8. $Fe + O_2 \rightarrow Fe_2O_3$
9. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
10. $H_2S \rightarrow H_2 + S_2$
11. $Al + HCl \rightarrow AlCl_3 + H_2$
12. $NI_3 \rightarrow N_2 + I_2$
13. $FeCl_3 + NaOH \rightarrow Fe(OH)_3 + NaCl$
14. $Br_2 + CaI_2 \rightarrow CaBr_2 + I_2$
15. $Mg + O_2 \rightarrow MgO$
16. $TiO_2 + B_4C + C \rightarrow TiB_2 + CO$
17. $Pb(NO_3)_2 + KI \rightarrow PbI_2 + KNO_3$
18. $Cr_2(SO_4)_3 + NaOH \rightarrow Cr(OH)_3 + Na_2SO_4$
19. $Fe_2O_3 + C \rightarrow Fe + CO_2$
20. $Cu + AgNO_3 \rightarrow Ag + Cu(NO_3)_2$
21. $C_4H_8 + O_2 \rightarrow CO_2 + H_2O$
22. $NaN_3 \rightarrow Na + N_2$
23. $NH_4Cl + Na_3PO_4 \rightarrow (NH_4)_3PO_4 + NaCl$
24. $NpF_3 + O_2 + HF \rightarrow NpF_4 + H_2O$
25. $Sb_2S_3 + HCl \rightarrow H_3SbCl_6 + H_2S$

**Balancing Equations #4**

1. $C_6H_{12} + O_2 \rightarrow H_2O + CO_2$
2. $K_2SO_4 + BaCl_2 \rightarrow KCl + BaSO_4$
3. $KOH + H_2SO_4 \rightarrow K_2SO_4 + H_2O$
4. $Ca(OH)_2 + NH_4Cl \rightarrow NH_4OH + CaCl_2$
5. $C + SO_2 \rightarrow CS_2 + CO$
6. $Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$
7. $V_2O_5 + Ca \rightarrow CaO + V$
8. $Na_2O_2 + H_2O \rightarrow NaOH + O_2$
9. $Fe_3O_4 + H_2 \rightarrow Fe + H_2O$
10. $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2O + SO_2$
11. $Al + H_2SO_4 \rightarrow H_2 + Al_2(SO_4)_3$
12. $Si_4H_{10} + O_2 \rightarrow SiO_2 + H_2O$
13. $NH_3 + O_2 \rightarrow N_2H_4 + H_2O$
14. $C_{15}H_{30} + O_2 \rightarrow H_2O + CO_2$
15. $BN + F_2 \rightarrow BF_3 + N_2$
16. $C_{12}H_{26} + O_2 \rightarrow H_2O + CO_2$
17. $C_7H_6O_3 + O_2 \rightarrow H_2O + CO_2$
18. $Na + ZnI_2 \rightarrow NaI + NaZn_4$
19. $HBrO_3 + HBr \rightarrow H_2O + Br_2$
20. $Al_4C_3 + H_2O \rightarrow Al(OH)_3 + CH_4$
21. $CH_3NO_2 + Cl_2 \rightarrow CCl_3NO_2 + HCl$
22. $C_6H_{12} + O_2 \rightarrow CO_2 + H_2O$
23. $Ca_3(PO_4)_2 + SiO_2 + C \rightarrow CaSiO_3 + CO + P$
24. $NH_3 + O_2 \rightarrow NO + H_2O$
25. $NaPb + C_2H_5Cl \rightarrow Pb(C_2H_5)_4 + Pb + NaCl$

# Writing Chemical Equations and Types of Reactions

Writing chemical equations from a description of a reaction:

1. Write the word equation for the reaction using the name of each substance involved.
2. From each substance's name, determine its chemical formula using the criss-cross rule.
   a) Metals are written as their chemical symbol. They DO NOT have a subscript or charge.
   b) Write the diatomic elements (_____) with the subscript ___.
3. Balance the reaction by putting a coefficient in front of the compounds as needed. DO NOT change the chemical formula of substances by adding subscripts.
4. Indicate the state of each substance at SATP in brackets after its formula:
   (s) means _____ (all pure ionic compounds are _____ at SATP)
   (l) means _____ (g) means _____
   (aq) means _____ (all acids are aqueous solutions)
   (v) means _____

A **<u>vapour</u>** refers to a substance that is usually _____ or _____ at SATP, but has been converted to the _____ by the addition of energy.

- water is _____ at SATP, so in the gas state, it is called _____
- iodine is _____ at SATP, so in the gas state, it is _____

Write the word equations and balanced chemical equations for these reactions:

1. Sodium metal reacts with pure chlorine to form sodium chloride.

2. When a solution of aluminum bromide is mixed with pure iodine, pure bromine is formed in a solution of aluminum iodide.

You may be asked to write the chemical equations for reactions if you are told what **TYPE** of reaction takes place. There are five main types of chemical reactions. We will start with _____, _____ and _____.

1. **<u>Synthesis Reactions</u>** occur when two or more reactants combine to form a _____ _____.

   The general form of the equation is:

eg. 2 Na (s) + $Br_2$ (l) → 2 NaBr (s)

eg. Write the balanced chemical equation for the reaction of gaseous nitrogen monoxide with oxygen gas to form gaseous dinitrogen tetroxide.

eg. Write the chemical reaction for the synthesis of iron (II) sulfide from its elements.

2. **<u>Decomposition Reactions</u>** occur when a _____ breaks down to form two or more products. They are the "reverse" of synthesis reactions.

   The general form of the equation is:

eg. $2\ H_2O\ (l) \rightarrow 2\ H_2\ (g) + O_2\ (g)$

eg. Write the balanced chemical equation to show the decomposition of carbonic acid to form carbon dioxide gas and liquid water.

eg. Write the balanced chemical reaction in which mercury (II) oxide breaks down into its elements.

3. **<u>Combustion Reactions</u> (burning)** occurs when a substance reacts rapidly with oxygen producing an oxide, and heat and light.

eg. Write the balanced chemical equation for the combustion of sodium metal.

eg. Sulfur burns to form sulfur trioxide gas.

When fuels such as hydrocarbons ( ) burn in air (oxygen), they produce carbon dioxide and water vapour.

eg. $C_4H_8\ (l) + O_2\ (g) \rightarrow$

eg. Write the balanced chemical equation for the combustion of liquid octane, $C_8H_{18}$.

**Writing and Balancing Synthesis, Decomposition and Combustion Reactions**

For each of the following reactions, use the information that is given to write balanced chemical equations. Include the states of all reactants and products. Classify each reaction by its type.

1. Silver oxide is formed from its elements.

2. Magnesium metal burns in air.

3. When pure sodium hydrogen carbonate is heated, it decomposes into pure sodium oxide, carbon dioxide gas and water vapour.

4. Write the equation for the combustion of liquid pentane ($C_5H_{12}$) in air.

5. Liquid ethanol ($C_2H_6O$) is "burned" by an alcoholic's body.

6. Write the chemical equation that shows ammonia gas ($NH_3$) decomposing into its elements.

7. Write the decomposition reaction for powdered lead (II) sulfide into it elements.

8. Write the combustion reaction that occurs when acetylene gas ($C_2H_2$) is burned in a welder's torch.

9. Write the equation showing the formation of sulfurous acid from sulfur dioxide gas and water.

10. Lead (IV) nitride is formed from its elements.

11. Sodium azide ($NaN_3$) decomposes into its elements in a car's airbag.

# SOLUBILITY RULES

These "rules" (generalizations) are a compilation of the findings from many precipitation reactions.

| Rule | Exceptions |
|---|---|
| All compounds containing:<br>sodium ion $Na^{1+}$<br>potassium ion $K^{1+}$<br>lithium ion $Li^{1+}$<br>ammonium ion $NH_4^{1+}$<br>are **soluble**. | None |
| All compounds containing:<br>nitrate ion $NO_3^{1-}$<br>acetate ion $CH_3COO^{1-}$<br>chlorate ion $ClO_3^{1-}$<br>are **soluble**. | None |
| Compounds containing:<br>chloride ion $Cl^{1-}$<br>bromide ion $Br^{1-}$<br>iodide ion $I^{1-}$<br>are **soluble**. | $Ag^{1+}$, $Pb^{2+}$, $Hg^{1+}$ |
| Compounds containing:<br>sulfate ion $SO_4^{2-}$<br>are **soluble**. | $Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$, $Pb^{2+}$, $Hg^{1+}$ |
| Compounds containing:<br>carbonate ion $CO_3^{2-}$<br>phosphate ion $PO_4^{3-}$<br>are **insoluble**. | $Na^{1+}$, $K^{1+}$, $Li^{1+}$, $NH_4^{1+}$ |
| Compounds containing:<br>hydroxide ion $OH^{1-}$<br>are **insoluble**. | $Na^{1+}$, $K^{1+}$, $Li^{1+}$, $NH_4^{1+}$, $Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$ |
| Compounds containing:<br>sulfide ion $S^{2-}$<br>are **insoluble**. | $Na^{1+}$, $K^{1+}$, $Li^{1+}$, $NH_4^{1+}$, $Ca^{2+}$, $Mg^{2+}$, $Ba^{2+}$, $Sr^{2+}$ |

# Writing Chemical Equations for Double Displacement Reactions

**Double Displacement Reactions** are chemical reactions that take place when the negative and positive ions from two compounds rearrange to form two new compounds. The cation (positive ion) from one compound replaces the cation from the second compound.

The general form of the equation is:

If one of the products of a double displacement reaction is insoluble in water, it will come out of solution as a _____, so its state is _____.

A set of rules called the "solubility rules" can be used to determine whether a substance will dissolve in water or form a precipitate. You will be given a copy of these rules for tests.

eg. Classify each substance as soluble (aq) or an insoluble precipitate (s) in water.

| | | |
|---|---|---|
| sodium carbonate | mercury (I) sulfate | lead (II) chlorate |
| aluminum chloride | potassium phosphate | tin (II) hydroxide |
| calcium sulfide | cadmium acetate | chromium (III) iodide |
| iron (II) nitrate | silver bromide | calcium carbonate |
| ammonium hydroxide | zinc sulfide | lithium oxalate |

eg. Solutions of silver nitrate and sodium chloride are mixed. Write the balanced chemical equation for the reaction and use the solubility rules to identify any precipitates.

eg. A solution of sodium sulfide is added to a solution of copper (II) acetate. Write the chemical equation for the reaction and use the solubility rules to identify any precipitates.

**Neutralization reactions** (the reaction of an _____ with a _____) are also double displacement reactions. The products are always _____ and a "_____".
A **salt** is the ionic compound that forms from the positive (metal) ion of a _____ and the negative ion from an _____. If the salt is insoluble, it will form a _____.

The general equation is:

eg. Nitric acid reacts with pure magnesium hydroxide. Write the balanced chemical equation.

eg. Powdered barium hydroxide is added to sulfuric acid.

## Writing and Balancing Double Displacement Reactions

1. Classify each of the substances as being soluble (aq) or insoluble precipitates (s) in water.

a) potassium bromide _____
b) lead(II) carbonate _____
c) barium sulfate _____
d) zinc hydroxide _____
e) sodium acetate _____
f) silver iodide _____
g) cadmium sulfide _____
h) zinc carbonate _____
i) silver acetate _____
j) copper (II) sulfide _____
k) $Mg_3(PO_4)_2$ _____
l) $K_2Cr_2O_7$ _____
m) $NiCl_2$ _____
n) $NH_4OH$ _____
o) $Hg_2SO_4$ _____

2. The following aqueous solutions were mixed.
a) Complete the **word equation** to show the products of the double displacement reactions that occurs.
b) Underneath the word equation, write the chemical formulas for the reactants and products.
c) Balance the reaction.
d) Use the solubility rules to determine whether the products are soluble (aq) or insoluble precipitates (s).

a) magnesium hydroxide + zinc nitrate →

b) strontium hydroxide + silver sulfate →

c) ammonium chloride + lead (II) chlorate →

d) calcium acetate + sodium sulfide →

e) lithium phosphate + mercury (I) nitrate →

f) potassium carbonate + tin (IV) bromide →

3. Write the neutralization reaction that occurs when hydrobromic acid is mixed with pure iron (III) hydroxide.

4. Write the reaction that occurs when powdered barium hydroxide is added to sulfuric acid.

5. Write the reaction that occurs when phosphoric acid is added to a solution of sodium hydroxide.

## Writing Chemical Equations for Single Displacement Reactions of Non-metals

**Single Displacement Reactions** are chemical reactions in which the atoms of a pure element replace similar atoms from a compound to form two new products.

**For non-metals**: more reactive pure non-metals will replace less reactive non-metals from a compound. If the pure non-metal is less reactive than the non-metal in the compound, no reaction will occur. The reactivity of non-metals can be predicted from the Periodic Table.

The general form of single displacement reactions of **non-metals** is:

eg. Pure bromine is added to a solution of potassium iodide. If a reaction will take place, write the balanced chemical equation. If no reaction will occur, write "NR".

eg. Pure sulfur is added to a solution of aluminum fluoride. If a reaction will take place, write the balanced chemical equation. If no reaction will occur, write "NR".

eg. Pure argon is bubbled through a solution of sodium iodide. If a reaction will take place, write the balanced chemical equation. If no reaction will occur, write "NR".

**Homework:** For the following combinations, predict if a reaction will occur. If a reaction will occur, write and balance the chemical equation. If there is no reaction, write "NR".

1. Pure fluorine mixed with a solution of potassium sulfide.

2. Chlorine is bubbled through a solution of copper (II) bromide.

3. Pure iodine is added to a solution of scandium chloride.

4. Pure phosphorus is added to a solution of lithium sulfide.

5. Pure oxygen is bubbled into a solution of sodium phosphide.

## Writing Chemical Equations for Single Displacement Reactions of Metals

**Single Displacement Reactions** are chemical reactions in which the atoms of a pure element replace similar atoms from a compound to form two new products.

**For metals**: more reactive pure metal atoms will replace less reactive metal ions from a compound. If the pure metal atoms are less reactive than the metal ions in the compound, no reaction (NR) will occur. You will be given the activity series for metals.

| |
|---|
| Lithium |
| Potassium |
| Barium |
| Calcium |
| Sodium |
| Magnesium |
| Aluminum |
| Zinc |
| Iron |
| Nickel |
| Tin |
| Lead |
| Hydrogen |
| Copper |
| Silver |
| Gold |

The general form of single displacement reactions of **metals** is:

eg. Use the activity series of metals to predict if a reaction will occur when copper metal is added to aqueous silver nitrate. If a reaction will occur, write the balanced chemical equation. If no reaction will occur, write NR.

eg. Iron metal is added to a solution of aluminum chlorate.

**Homework:** For the following combinations, predict if a reaction will occur. If a reaction will occur, write and balance the chemical equation. If there is no reaction, write "NR". Include the states of all reactants and products. Use the solubility rules to determine the solubility of any new compounds that form.

1. Magnesium metal is placed in a solution of copper (I) acetate.

2. Copper metal is placed in a solution of lead (II) chlorate.

3. A piece of aluminum is dipped into aqueous silver nitrate.

4. Pure sodium is added to a solution of calcium chloride.

5. Pure zinc is placed in a beaker of aqueous nickel (II) bromide.