Chemical Reactions – Synthesis & Decomposition

**Reminder: you are expected to read your textbook and try the practice exercises on your own.

Chemical Reactions – 6 clues

1. Change in colour
2. Formation of a NEW gas
3. Formation of a new solid (precipitate)
4. Change in temperature
5. Production of light
6. Production of electricity

Chemical Equations

Word equation

lead (II) nitrate solution + potassium iodide solution => lead (II) iodide + potassium nitrate solution

Skeletal Equation

Convert each word to its chemical formula

$Pb + 2(NO3)_{2\,(aq)} + KI_{\,(aq)} \rightarrow PbI_{2\,(s)} + KNO_{3\,(aq)}$

Balanced

$Pb + 2(NO3)_{2\,(aq)} + 2KI_{\,(aq)} \rightarrow PbI_{2\,(s)} + 2\,KNO_{3\,(aq)}$

$4Fe + 3O_2 \rightarrow 2Fe_2O_{3(s)}$

Types of Chemical Reactions

Synthesis (combination)

- Two or more reacting substances (elements or compounds) combine to form one product
- Vast majority are exothermic (give off energy)
- General Equation: A + B = AB (give off energy to increase disorder to compensate for AB forming a compound which increases order and disobeys entropy)

$2Mg_{(S)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

$N_2 + 3H_{2\,(g)} \rightarrow 2NH_{3\,(g)}$

$CO_{2\,(g)} + H_2O_{(l)} \rightarrow H_2CO_{3\,(aq)}$

Decomposition

- One product produces two or more substances

- Most are endothermic
- Chemical Formula: AB -> A + B

$2NaCl_{(s)} \rightarrow 2Na_{(s)} + Cl_{2(g)}$

$CuSO_4$ (dot) $5H_2O \rightarrow CuSO_{4\,(s)} + 5\ H_2O_{(l)}$

$H_2CO_{3\,(aq)} \rightarrow CO_2 + H_2O$ (Important)

$NH_4OH_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)}$ (Important)

$2NaHCO_{3\,(s)} \rightarrow Na_2CO_3 + CO_{2\,(g)} + H_2O_{(l)}$

Combustion

Occurs with C,H, O (sometimes) and O_2

Very exothermic

$2C_8H_{18(l)}$ (octane) + $25O_{2(g)} \Rightarrow 16CO_{2(g)} + 18H_2O_{(l)}$

Single Displacement

A single-displacement reaction is when one element moves out of one compound and into another. This is usually written as

A + BX -> AX + B

This will occur if A is more reactive than B. You can refer to the activity series to be sure of this.

Metal Activity Series

Metal	**Metal Ion**
Lithium	Li+
Potassium	K+
Barium	Ba2+
Calcium	Ca2+
Sodium	Na+
Magnesium	Mg2+
Aluminum	Al3+
Manganese	Mn2+
Zinc	Zn2+
Chromium	Cr2+, Cr3+
Iron	Fe2+, Fe3+
Lead	Pb2+
Copper	Cu2+
Mercury	Hg2+
Silver	Ag+
Platinum	Pt2+
Gold	Au+, Au3+

Reactivity

Most Reactive

Least Reactive

Notes on the Metal Reactivity Series:

By studying replacement reactions we can arrange the metals in decreasi
of reactivity. The reactivity series list the different metals (and hydrogen) in order of their decreasing tendency to lose electrons in water solutions at specified temperatures. Hydrogen is on the list because it behaves as though it were a metal in certain reactions. Metals found above hydrogen will replace hydrogen in acid solutions, while those below will not.

As we know the tendency of metals to lose electrons depends chiefly on the

nuclear charge and on the atomic radius of the metal atom. The reactivity series may be used to make reasonable predictions concerning the reactivity of different metals. According to the table, for example, aluminum will replace mercury in an aqueous solution of a mercury compound. Silver will not replace iron.

Halogen series

(most reactive) F => Cl => Br => I (least reactive)

- always an element and a compound, if the element is higher on the activity series than the one in the compound they switch places.

eg. Silver nitrate solution + copper => Silver + Copper(II) Nitrate Solution

$2AgNO_{3\,(aq)} + Cu_{(s)} \rightarrow 2Ag_{(s)} + Cu(NO_3)_{2\,(aq)}$ (Cu is most stable in 2+ state)

General Formula

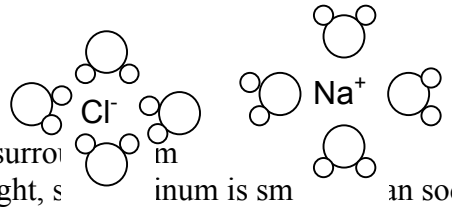
A (element)	+	BC (compound) (generally aqueous)	->	AC (compound) (aqueous)	+	B (element)

Double Displacement Reactions

Always occur in solution Background on Solubility:

- Ionic compounds dissociate in water. The ionic bond gets separated.
- It is a physical change, NOT chemical
- $NaCl_{(s)} + H_2O \Rightarrow NaCl_{(aq)} \Rightarrow Na^{+1}_{(aq)} + Cl^{-1}_{(aq)}$

O Na^{+1} O (surrounded by water molecules on ALL sides in three dimensions to isolate it, likewise the Cl anions would be surrounded by water molecules with the hydrogen ends pointing in.



- There MUST be enough water to completely surro m
- With metals size decreases as you go left to right, s inum is sm an sodium, and it forms a +3 not a +1 charge so it is much smaller, there dium is the oluble because it is larger and can be surrounded by more water molecu ch isolate it effectively than a few surrounding the aluminum. This is why group one VAYS solu group one compounds are assumed to have high solubility.
- It is easiest to dissolve large ions or polyatomic ior a low charg (eg Nitrate is large but only has a –1 charge so it is ver le, but Carl has a higher –2 charge so it is less soluble).
- Small size and low charge are still hard to dissolve
- Hg^{+1} (exist as Hg_2^{2+}) Cl is insoluble but Hg^{+2} Cl is soluble

- All nitrates and group one compounds are soluble

Precipitation Reactions

$Ba(NO_3)_2 + 2KCl_{(aq)} \rightarrow BaCl_{2(aq)} + 2KNO_{3(aq)}$

Therefore NO REACTION because no solid formed

$Ba^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2K^{+1}_{(aq)} + 2Cl^-_{(aq)} \rightarrow Ba^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2K^{+1}_{(aq)} + 2Cl^-_{(aq)}$

Therefore NO REACTION nothing has happened…

$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow \mathbf{AgCl_{(s)}} + NaNO_{3(aq)}$

$PB(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow \mathbf{PbI_{2(s)}} + 2KNO_{3(aq)}$

SOLUBILITY OF IONIC COMPOUNDS AT SATP
SATP or STP = Standard Air Temperature and Pressure

		Anions						
		Cl^-, Br^-, I^-	**S^{-2}**	**OH^-**	**SO_4^{2-}**	**CO_3^{2-}, PO_4^{3-}, SO_3^{2-}**	**$C_2H_3O_2^-$**	**NO_3^-**
Cations	High solubility (aq) ≥0.1 mol/L	most	Group 1, Group 2, NH_4^+	Group 1, NH_4^{+1}, Sr^{2+}, Ba^{2+}, Tl^+	most	Group 1, NH_4^{+1}	Most	all
	Low Solubility (s) <0.1 mol/L	Ag^+, Pb^{2+}, Tl^+, Hg_2^{2+}, Cu^+	most	most	Ag^+, Pb^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Ra^{2+}	most	Ag^+	none

Gas Production

$Na_2S_{(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + \mathbf{H_2S_{(g)}}$

Neutralization

$H_2SO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(l)}$

Use an indicator such as phenolphthalein to discover if a pH change has occurred indicating a neutralization reaction.

Law of Conservation of Matter

Matter cannot be created or destroyed; you must have the same number of atoms on the left side as there are on the right of your equations

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A. Synthesis (Combination) Reactions
    - Occurs when two or more simple substances combine