THE CLASSIFICATION OF INORGANIC COMPOUNDS

Introduction

- Combination of elements by chemical reactions yield compounds.
- There are two main group of compounds; organic and inorganic.
- Organic compounds mainly contain carbon and hydrogen and obtained from living organisms.

All compounds other than organic ones named inorganic

1. Acids

Compounds dissolving in water by producing H^+ ion are called acids. Many of the fruits and vegetable contain acids; in lemon, apple, tomatoes, orange, as well as in car batteries, and in cleaning materials.

$HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$

$H_2SO_4 \rightarrow 2H^+(aq) + SO_4^{-2}(aq)$

$HNO_3 \rightarrow H^+(aq) + NO_3^-(aq)$

$CH_3COOH \rightarrow H^+(aq) + CH_3COO^-(aq)$

- They have sour taste.
- They change the color of litmus paper to red.
- Their aqueous solutions conduct electricity.
- They are corrosive substances.
- Most of them are soluble in water.

Example 1

Which of the following substances are acids? Explain.

A. CH_4 B. HF C. NH_3 D. $HClO_4$

Example 2

Show the ionization of following acids in water.

A. HCOOH B. H_2SO_3 C. H_2S D. H_3PO_4

1. Naming of Acids

- Acids containing two types of atoms are called binary acids.
- Their names follow the form *hydro + nonmetal name + acid*.

HCl : Hydrochloric acid

HI : Hydroiodic acid

H_2S : Hydrosulfuric acid

HF : Hydrofluoric acid

Acids containing oxygen atoms are called oxy acids.

Their names follow the form –ic + acid, or –ous + acid.

H_3BO_3 : Boric acid

H_3PO_4 : Phosphoric acid

H_2SO_4 : Sulfuric acid

H_2SO_3 : Sulfurous acid

HNO_3 : Nitric acid

HNO_2 : Nitrous acid

2. Classification of Acids

According to Strength

If an acid ionizes completely, it is an strong acid, and if it ionizes partially it is a weak acid.

Strong acids

HCl, H_2SO_4, HNO_3, HI, HBr, $HClO_4$

Weak acids

HF, H_2SO_3, HNO_2, H_2S, H_3PO_4, CH_3COOH, HCN, H_2CO_3

According to Number of Hydrogen Atoms

According to number of H^+ ion produced acids are classified as monoprotic, diprotic or triprotic.

Monoprotic acids

HCl, HNO_3, HI, HBr, $HClO_4$

$HCl(g) + H_2O \rightarrow H^+(aq) + Cl^-(aq)$

$CH_3COOH(l) + H_2O \rightarrow H^+(aq) + CH_3COO^-(aq)$

Diprotic acids

H_2SO_3, H_2S, H_2CO_3, H_2SO_4

$H_2CO_3(l) + H_2O \rightarrow 2H^+(aq) + CO_3^{-2}(aq)$

Triprotic acids

H_3PO_4, H_3AsO_4

$H_3AsO_4(s) + H_2O \rightarrow 3H^+(aq) + AsO_4^{-3}(aq)$

Example 3

Classify the following acids as strong or weak.

A. HCOOH B. H_2SO_3 C. HNO_3 D. H_3PO_4

3. Chemical Properties of Acids

- Acids ionize in water and conduct electricity, during the ionization heat is released.
- They change the color of indicators.
- They react with bases and produce salt and water, it is called neutralization reaction.
- They react with some metals and produce hydrogen gas.

$HNO_3(l) + KOH(s) \rightarrow KNO_3(aq) + H_2O(l)$

$2HCl(aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$

Example 4

What is the volume at STP of hydrogen gas produced by the reaction of 2.4 g of Mg with enough HCl? (Mg:24)

Example 5

How many grams of NaOH is required to neutralize completely 19.6 g of H_2SO_4? (S:32, H:1. O:1, Na:23)

2. Bases

- Compounds dissolving in water by producing OH^- ion are called bases.
- They are opposite of acids.
- They have slippery feeling.
- Water soluble bases are called alkalis.
- Many cleaning products contain bases, KOH, NH_3, $Al(OH)_3$.

$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$

$KOH(s) \rightarrow K^+(aq) + OH^-(aq)$

$NH_3 + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$

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$Ca(OH)_2(s) \rightarrow Ca^{+2}(aq) + 2OH^-(aq)$

1. Naming of Bases

- The word "hydroxide" is added after the name of metal ion in the naming of bases.

$Mg(OH)_2$: Magnesium hydroxide
KOH : Potassium hydroxide
NaOH : Sodium hydroxide
$Ba(OH)_2$: Barium hydroxide
$Cu(OH)_2$: Copper (II) hydroxide
NH_3 : Ammonia

2. Classification of Bases

According to Strength

- Bases that ionize in water completely are said to be strong base. NaOH, KOH and LiOH are strong bases.
- Bases that ionize in water partially are called weak bases. NH_3, $Mg(OH)_2$, $Fe(OH)_2$, $Al(OH)_3$ are example for weak bases.

3. Chemical Properties of Bases

- According to solubility bases conduct electricity.
- They change the color of litmus paper to blue.
- They react with acids and produce salt and water.
- Water insoluble bases decompose on heating to give metal oxides and water.

$2KOH(s) + H_2SO_4(l) \rightarrow K_2SO_4(aq) + 2H_2O(l)$
$NH_3(g) + HCl(aq) \rightarrow NH_4Cl(aq)$
$Mg(OH)_2 \rightarrow MgO + H_2O$

Example 6

Write the reaction equations of the phosphoric acids with the following bases.

A. Potassium hydroxide
B. Aluminum hydroxide
C. Ammonia
D. Iron (III) hydroxide

3. Oxides

- Compounds of oxygen with other elements are called oxides. There are only two kinds of atoms in oxides.
- NO_2, SO_2, H_2O, CO_2, N_2O_5, NO, N_2O are common non metal oxides, they have covalent bond structure.
- Na_2O, FeO, Al_2O_3, CaO, SiO_2, MgO, CuO, PbO are some common metal oxides they have ionic structure.

1. Naming of Oxides

- They are named like binary compounds.

MgO : Magnesium oxide
FeO : Iron (II) oxide
Na_2O : Sodium oxide
SO_2 : Sulfur dioxide
CO_2 : Carbon dioxide
P_2O_5 : Diphosphorus pentoxide
SnO_2 : Tin(IV) oxide
NO : Nitrogen monoxide

2. Classification of Oxides

A. Neutral Oxides

- They are oxygen poor compounds of non metals .
- They have neither acidic nor basic properties.
- They do not react with acids, bases and water. They are slightly soluble in water.
- CO, NO and N_2O are neutral oxides

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B. Acidic Oxides

- Oxygen rich compounds of non metals are called acidic oxides. SO_2, NO_2, P_2O_5, Cl_2O_7, CO_2 are examples.
- Their solutions are acidic.
- They are known as acidic anhydrides.

Acidic oxide + water → Acid
$CO_2 + H_2O \rightarrow H_2CO_3$
$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$
$N_2O_5 + H_2O \rightarrow 2HNO_3$

C. Basic Oxides

- Generally metal oxides are called basic oxides. Na_2O, CaO, Li_2O, MgO, K_2O are examples.
- Their solutions are basic.
- They are known as basic anhydrides.

Basic oxide + water → Base
$Na_2O + H_2O \rightarrow 2NaOH$
$MgO + H_2O \rightarrow Mg(OH)_2$
$K_2O + H_2O \rightarrow 2KOH$

D. Mixed Oxides

- Compounds that contain two oxides of the same metal are called mixed oxides. Fe_3O_4, Mn_3O_4, Pb_3O_4 are examples.
- They behave as if they are two separate oxides in chemical reactions.

Fe_3O_4 : $FeO.Fe_2O_3$: Iron (II, III) oxide
Mn_3O_4 : $MnO.Mn_2O_3$: Manganese(II, III) oxide
Pb_3O_4 : $2PbO.PbO_2$: Lead (II, IV) oxide

E. Peroxides

Compounds that contain O_2^{-2} ion are called peroxides. H_2O_2, K_2O_2, Li_2O_2, CaO_2, MgO_2 are examples.

Example 7

Classify the following oxides below.
CaO, NO, N_2O, Li_2O, Cl_2O_7, CO, Mn_2O_4, BaO_2, SrO

Example 8

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What mass of phosphoric acid can be obtained from the reaction of 14.2 g of P_2O_5 with excess water?

Example 9

Perform the following conversions

A. Li → LiO → LiOH → LiCl
B. Zn → ZnO → $ZnCl_2$

4. Amphoteric Compounds

- Most of the compounds of Zn, Al, Cr, Sn, Pb, and Be are amphoteric compounds.
- Oxides and hydroxides of these metals have both acidic and basic characters.
- They are in soluble in water and do not react with it.
- ZnO, Al_2O_3, SnO, BeO, Cr_2O_3, PbO are oxides, and $Zn(OH)_2$, $Al(OH)_3$, $Be(OH)_2$, $Sn(OH)_2$, $Pb(OH)_2$, $Cr(OH)_3$ are hydroxides.

  $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

  $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$

5. Salts

- Salts are ionic compounds of anions and cations.
- NaCl, $CaCO_3$, $ZnBr_2$, $FeSO_4$, NH_4Cl, $Mg(NO_3)_2$, LiF, $AlPO_4$ …etc are examples.
- They are all crystalline solids.
- They have very high melting and boiling points.
- Many of them are soluble in water and their aqueous solutions conduct electricity.

1. Naming of Salts

- In the naming of salts first metal ion (positive ion) then name of negative ion is read.

NaCl: Sodium chloride BaC_2O_4: Barium oxalate

$FeCl_2$: Iron(II) chloride $KMnO_4$: Potassium permanganate

NH_4Br: Ammonium bromide PbI_2: Lead (II) iodide

2. Classification of Salts

A. Neutral Salts

- They are formed from the reactions of strong acids with strong bases.
- They have neither acidic nor basic character.
- Their solutions are neutral.
- NaCl, $LiNO_3$, KNO_3, NaBr, Li_2SO_4 …etc are examples.

B. Acidic Salts

- They are formed from the reactions of strong acids with weak bases.
- They have acidic character.
- Their solutions are acidic.
- $FeCl_2$, $CuNO_3$, $Zn(NO_3)_2$, NH_4Cl, Li_2SO_4 …etc are examples.

C. Basic Salts

- They are formed from the reactions of weak acids with strong bases.
- They have basic character.
- Their solutions are basic.
- NaCN, LiF, K_2CO_3, Li_3PO_4, $K_2C_2O_4$ …etc are examples.

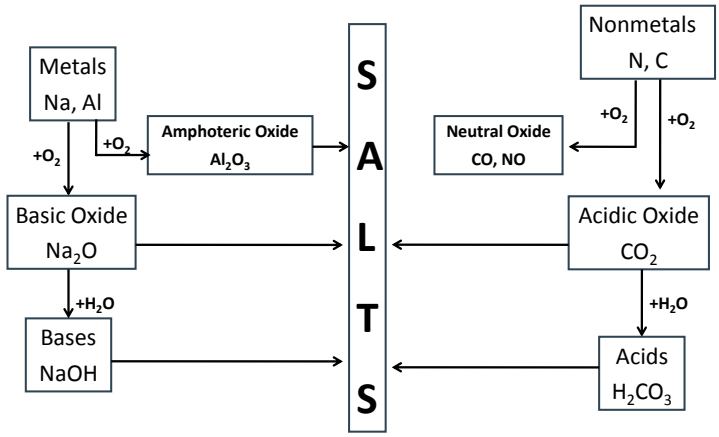
3. Chemical Properties of Salts

- Salts can react with metals according to activity strength.

  $Zn(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Zn(NO_3)_2(aq)$
- Water soluble salts undergo displacement reaction.

  $KCl(aq) + AgNO_3(aq) \rightarrow 2AgCl(s) + KNO_3(aq)$
- They may also react with acids under certain conditions.

Transformation of inorganic compounds with salts



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