**ACIDS BASES AND SALTS**

Theories on acids and bases

1. Lavoisier’s Theory: Lavoisier defined an acid as a substance which contains oxygen. He defined it as an oxide of a non-metal which when dissolved in water, produces a solution which turns litmus paper from blue to red.

The problem with this theory is that there are many acids without oxygen. E.g.

Lavoisier died in 1816 and he also discovered oxygen

2. Arrhenius’ Theory: Arrhenius defined an acid as a substance that when dissolved in aqueous solution produces hydrogen ion () as the only positive ion.

He defined a base as a substance which when dissolved in aqueous solution produces () as the only negative ion.

His theory is still accepted today.

The above are bases

3. Bronsted – Lowry Theory: J.N. Bronsted and J.M. Lowry simultaneously but independently put forward their theory based on protons.

They defined an acid as a proton (positive charge) donor

They defined a base as a proton acceptor.

Bronsted-Lowry reaction is a reversible reaction in which the products are also capable of donating and accepting a proton. They are generally known as conjugate acids or bases.

In the reactions above is capable of donating and accepting a proton. Hence, is an example of amphoteric specie

4. Lewis Theory: G.M. Lewis’ theory is based on electronic configuration.

He defined an acid as a substance that is capable of accepting an electron pair.

He defined a base as a substance capable of donating an electron pair.

For a substance to act as a Lewis’ base, it must be deficient of electrons. These are known as **Electrophiles (Electron loving species)**.

For a substance to behave as a Lewis’ base, it must possess a lone pair electron. These are generally known as **Nucleophiles (Nucleus loving species)**.

**ACIDS**

An acid is defined as a substance which when dissolved in an aqueous solution (such as water), produces hydrogen ion (H+) or hydroxonium ion (H3O+) as the only positive ions.

**CLASSES OF ACIDS**

Acids can be classified into two based on their sources namely

1. Organic acids: These are acids that can be obtained from plant and animal sources (organic sources). These acids are usually weak acids. The table below shows a few.

|  |  |  |
| --- | --- | --- |
| Acid Name | Acid source (or other name) | Acid Formula |
| Ethanoic acid (formerly called Acetic acid) | Vinegar | CH3COOH |
| Amino acids | Proteins |  |
| Fatty acids | Fats and oils |  |
| Ascorbic acid (Vitamin-C) | Orange |  |
| Citric acid | Lemon and Lime (more pronounced in lemon and lime than in orange) |  |
| Lactic acid | Milk |  |
| Tartaric acid | Grape |  |
| Boric acid | Soda |  |
| Formic acid | Ant |  |
|  |  |  |

2. Inorganic acids: These are also called mineral acids. They are acids that can be obtained from mineral elements or inorganic sources.

**STRENGTH OF AN ACID**

This is defined as the degree of dissociation of acid molecules into ions when put in an aqueous solution. This is called **ionisation**.

There are two types of ionisation namely:

a. Complete ionisation: This is the type of dissociation that is **irreversible**. **Strong acids ionise completely** in aqueous solutions.

The major strong acids are: , and

b. Incomplete (or partial) ionisation: This is the type of dissociation that is **reversible**. Weak acids ionise partially in solution. Examples are H2CO3, H2SO3, H2S and all organic acids etc.

**CONCENTRATION OF AN ACID**

This is defined as the relative proportion of acid to water in a solution.

A concentrated acid has a higher proportion (amount) of acid to water.

A dilute acid has a higher proportion of water to acid.

**NB**: Acids are diluted in order to reduce their concentration.

Acids can be diluted by adding them to water.

In diluting acids, water should not be poured into the flask containing the acid but rather, the acid should be poured into the flask containing the water while the test tube is in a slanting position. This is because acids have affinity for water and they release a large amount of heat when they come in contact with water.

**BASISCITY OF AN ACID**

This is defined as the number of replaceable hydrogen ions in one molecule of the acid.

**GENERAL PHYSICAL CHARACTERISTICS OF ACIDS**

1. Dilute acids have sour tastes
2. Acids (liquid, gases or molten) turn blue litmus paper red
3. Concentrated acids are corrosive. That is they cause severe burns on the skin.

**GENERAL CHEMICAL PROPERTIES (REACTIONS) OF ACIDS**

1. Reaction with metals: Acids react with active metals to liberate hydrogen gas (except HNO\_3)
2. Reaction with Bases or Alkali: This reaction is called a neutralisation reaction. Acids react with bases or alkalis to produce salt and/or water only.
3. Reaction with carbonates: Acids react with carbonated substances to liberate carbon (IV) oxide (CO\_2)

GENERAL USES OF ACIDS

Acids are useful chemicals used to produce other useful chemicals such as fertilizers

Acids are also used in the laboratory as catalysts

BASES

These are oxides and hydroxides of metals. Most bases are insoluble in water but the ones that are soluble form Alkalis. Like an acid, strong alkalis ionize completely in solution while weak alkalis ionize partially in solution

Examples of Bases:

For the alkalis, we have:

KOH (Strong base)

NaOH (Strong base)

NH\_4OH (weak base)

Ca(OH)\_2 (weak base)

For other bases,

Al(OH)\_3

ZnO

CuO

MgO

From the above, we can see that all alkalis are bases but not all bases are alkalis.

An alkali can also be defined as the basic hydroxide which is soluble in water

PHYSICAL PROPERTIES OF BASES

They have bitter taste

They are soapy when touched

They turn red litmus paper blue

Concentrated Alkalis are also corrosive

CHEMICAL PROPERTIES OF BASES

Neutralization: This is the process in which an acid reacts with an appropriate amount of base or alkali to produce salt and water only. It can also be defined as the combination of and to produce .

Ammonolysis: This is the process where by base or alkali react with ammonium salt to liberate ammonia gas

GENERAL USES OF BASES OR ALKALIS

Bases and alkalis are useful chemicals used to produce dyes, perfumes, crayon and glasses etc.

They are used in the purification of Bauxite

SALTS

A salt is a compound formed when the ionisable, from an acid is replaced by a metallic or ammonium ion.

TYPES OF SALTS

Normal salts: These are formed when strong acids react with strong bases. They are formed chemically when the from an acid is completely replaced by a metal.

Normal salts are neutral to litmus paper. Examples of normal salts are:

Acid salt: This is formed when strong acid reacts with weak base. They are produced chemically when the from an acid is partially replaced with a metal. This means dibasic acids form one acid salt, tribasic acids form two acid salts while monobasic acids do not form acidic salts. Acid salts are acidic to litmus paper and they usually contain hydrogen

Examples of acidic salts are

Basic salts: This is formed when strong bases react with weak acids. They can also be produced when there is insufficient supply of acid needed for the complete neutralization. Basic salts usually contain OH^- and they are alkaline to litmus paper.

Examples include:

Double salts; These contain different types of ions in which two are positively charged and the other is negatively charged. Double salts contain water of crystallization and they are very soluble in water. Alum is a typical example of a double salt.

Examples include:

Complex salts: These contain complex ions and they are usually coloured. They are known as the salts of transition metals

PHENOMENA ASSOCIATED WITH SALT

Efflorescence: This is the process whereby some salts when exposed to the atmosphere lose part or all of their water of crystallization to form an anhydrous or a lower hydrate. Such salts are called efflorescent. Examples include

Deliquescence: This is the process whereby some salts when exposed to the atmosphere absorb water (or moisture) and turn into solution. Such salts are called deliquescent. Examples of such compounds include

Hygroscopy: These hygroscopic substances also absorb water when exposed to the atmosphere. If they are solids, they become sticky or moist. Examples include

PREPARATION OF SALTS

The method used in preparing salts depends on the solubility of the salt in water and its stability to hear. A salt is said to be heat resistant if it does not decompose on heating e.g. Na\_2CO\_3, K\_2CO\_3

All sodium, potassium and ammonium salts are soluble in water

All nitrate salts (NO3^-) are also soluble in water

All chloride salts are soluble in water except AgCl and PbCl\_2. However PbCl\_2 is soluble when hot but reappears when cold. CuCl is insoluble in water but CuCl\_2 is soluble, FeCl\_3 is insoluble but FeCl\_2 is soluble

All sulphate (SO\_4^2-) salts are soluble in water except CaSO\_4 and PbSO\_4. However, CaSO\_4 is slightly soluble in water.

Only sodium, potassium and ammonium carbonates (CO\_3^2-) are soluble in water. Other carbonates are insoluble in water

PREPARATION OF SOLUBLE SALTS

Dilute acids on metals

Dilute acid and alkalis

Dilute acid and insoluble base

Dilute Acid and Carbonates

PREPARATION OF INSOLUBLE SALTS

Double decomposition

Combination Reaction

USES OF AMMONIUM SALTS

NH\_4Cl is used as an electrolyte in dry cell.

NH\_4Cl is also used as flux for soldering

(NH\_4)\_2SO\_4 is used as a fertilizer.

(NH\_4)\_2SO\_4 in a more concentrated form is used as a weed killer

(NH\_4)\_2CO\_3 is used as a nose inhaler to prevent dizziness in the laboratory. In a lower concentration, it is used to manufacture crackers

NH\_4NO\_3 is used in making explosive

DECOMPOSITION OF AMMONIUM SALTS

PH-SCALE

This is a scale that is numbered from 1 – 14 used to measure the acidity and/or alkalinity of a substance. A solution with PH less than 7 is acidic while the one with a PH greater than 7 is alkaline. A solution with a PH of 7 Is neutral (i.e. neither acidic nor basic)

Acidity increases with a decrease in PH while alkalinity increases with an increase in PH

In 1909 Sorensen defined the logarithmic equation of PH. He defined Ph as the negative logarithm of the hydrogen ion concentration to base 10.

Adding log to both sides,

Multiplying through by -1

Take note of this too:

Taking as a constant

Calculate the pH of 0.005moldm^-3 H\_2SO\_4. Answer: 2

Calculate the pOH of 2.5X10^-3moldm^-3 of H\_3PO\_4.

Calculate the pH of 2X10^-4moldm^-3 NaOH

Given that the pH of zobo is 3.4, calculate its OH^- concentration

HYDROLYSIS OF SALTS

This can be defined as the chemical reaction between salt and water. It is also known as the reverse reaction of neutralization. The pH of a salt depends on the strength of the acid and base that combine to produce the salt.

The strong acids are

The strong bases are

DRYING AGENTS

These are the substances that have strong affinity for water and/or moisture. They are used for drying gases in the laboratory. They are also used in a desiccator i.e. a device used for drying gases. They may be deliquescent or hygroscopic.

It should be noted that a drying agent should not be used to dry a gas that it can react with e.g. conc. H\_2SO\_4 should never be used to dry NH\_3 because it can react with NH\_3 to produce fertilizers. The table below shows some common drying agents and the gases they can dry

|  |  |
| --- | --- |
| DRYING AGENT | GASES |
| Conc. H\_2SO\_4 | All gases except NH\_3 and H\_2S |
| Fused CaCl\_2 | All gases except NH\_3 |
| P\_2O\_5 | All gases except NH\_3 |
| CaO (Quicklime) | Suitable for NH\_3 only |
| Silica gel (SiO\_2) | All gases |

VOLUMETRIC ANALYSIS

One of the most important aspects of chemistry is to analyse chemical substances qualitatively or quantitatively.

Qualitative analysis involves the determination of the ions present in a given salt.

Quantitative analysis involves the determination of the molar (or concentration) present in a given substance. Quantitative analysis can be volumetric or gravimetric.

Volumetric analysis involves the volume measurement of the substance

Gravimetric analysis involves the direct mass measurement of a substance.

Volumetric analysis is more used because it is more convenient but it is less accurate than the gravimetric analysis.

TITRATION

This is the process of running an acid from the burette into the base in the conical flask until the acid has been completely neutralized by the base. An indicator is usually added to the base so as to detect the colour change. It should be noted that titration is an aspect of volumetric analysis

INDICATORS

These are weak organic acids or bases that change colour in solution according to the hydrogen concentration (pH)

|  |  |  |
| --- | --- | --- |
| Indicator | Colour in acidic solution | Colour in basic solution |
| Litmus paper | Red | Blue |
| Methyl Orange | Red/Pink | Yellow |
| Phenolphthalein | Colourless | Red |

The choice of an indicator depends on the strength of the acids and bases that combine

|  |  |  |
| --- | --- | --- |
| Strength of acid | Strength of base | Suitable indicator |
| Strong Acid | Strong base | Any indicator |
| Strong Acid | Weak Base | Methyl Orange |
| Weak Acid | Strong Base | Phenolphthalein |
| Weak Acid | Weak Base | No suitable indicator |

The concentration of a solution is directly proportional to the number of moles and inversely proportional to the volume of the substance

For acid base titration

C\_a = molar conc. (concentration in moldm^-3) of Acid

C\_b = molar concentration of Base

V\_a = Volume of Acid (End point)

V\_b = Volume of Base (in pipette)

n\_a = stoichiometric ratio of acid (number of moles of acid in equation)

n\_b = stoichiometric ratio of base (number of moles of base in equation)

PRINCIPLE OF DILUTION

The number of moles of acid or base before dilution is equal to the number of moles of the solute after dilution

But,

C\_i = initial concentration at V\_i

C\_f = final concentration at V\_f

Volume of water added to the solution is given as,

SOLUBILITY

The solubility of a solute in a given solvent is the amount of solute in gdm^-3 or moldm^-3 that will dissolve in 1000cm^3 or 1dm^3 of the solvent to form a saturated solution

Volume in cm^3

Volume in dm^3

SOLUBILITY PRODUCT

We represent each ion or radical by the same letter

BUFFERED SOLUTION

A buffered solution is one that does not bring about a change in pH on the addition or dilution of small amount of alkali.

Buffered solution principle is widely employed in the manufacture of drugs. Buffered solution is prepared by mixing a weak acid and its salt or a weak base and its salt e.g.

Take note of the following

The value of can be used to calculate its pH

So given an equation

is just a modified equilibrium constant

Normally, the equilibrium constant is given as:

For a model basic acid, the molecule splits to form and which are made in equimolar amounts. This is because one mole of each is gotten in the end.

Given that the concentrations of the Hydrogen ions and the A minus ions are the same.

In weak acids like ethanoic acid, only about 1 molecule in several 100 is dissociated at any time. The concentration of the acid therefore remains almost the same

When experiments are carried out, it will be seen that the less the hydrogen concentration, the less the dissociation constant. Or the less the weak acid dissociates the lower, the concentration of hydrogen ions and the lower the value

Given that the dissociation constant of ethanoic acid is at 25C. Find

I. The concentration of the hydrogen ion I

II. The pH of the acid

III. The fraction of ethanoic acid dissociated