Class 9 – Easy Notes - Chemistry

CHAPTER 7 – ACID BASE CHEMISTRY

یہ کتاب / نوٹس خاص طور پر ان طلباء کے لیے تیار کی گئی ہے جو تعلیمی لحاظ سے کمزور ہیں۔ اس کے مطالعے سے نہ صرف آپ کے لیے پڑھائی آسان ہو جائے گی بلکہ آپ اعلیٰ نمبرز حاصل کرنے کے قابل بھی ہو جائیں گے۔ اگر آپ اس کتاب سے بھرپور فائدہ اٹھائیں اور دلجمعی سے مطالعہ کریں، تو ممکن ہے کہ آپ بھی پوزیشن ہولڈرز کی فہرست میں شامل ہو جائیں۔ محنت کریں، کامیابی حاصل کریں — اور اگر دورانِ مطالعہ آپ کو کسی قسم کی دشواری کا سامنا ہو تو فوراً سر عمیس سے رابطہ کریں۔ آپ کی ہر ممکن رہنمائی کی جائے گی۔

7.1 Acids and Bases

Acids and Bases have been known to mankind since centuries.

Acids

Definition: A substance that has sour taste is called acid. It turns blue litmus paper red.

Sources: Many substances contain acids such as lemon, curd, lime and tamarind etc.

Examples: acetic acid (CH_3COOH), hydrochloric acid (HCl), nitric acid (HNO_3), sulphuric acid (H_2SO_4) and tartaric acid ($C_4H_6O_6$).

Most of these acids can be easily dissolved in water that is why they are available in the form of aqueous solution.

Classification: Acids are divided into two types on the basis of their occurrence.

(a) Natural or Organic acids: Acids obtained from natural sources are called natural or organic acids. For example: acetic acid (CH_3COOH), tartaric acid ($C_4H_6O_6$) and formic acid (HCOOH).

(b) Mineral acids or man-made: Acids prepared from mineral (sodium chloride, sodium nitrate etc) are called mineral or man-made acids. For example: hydrochloric acid (HCl), nitric acid (HNO_3) and sulphuric acid (H_2SO_4).

Organic acid	Natural Sources
Acetic acid	Vinegar
Ascorbic acid	Amla, Guava
Citric acid	Lemon, Orange
Lactic acid	Sour milk, curd
Formic acid	Ant sting
Oxalic acid	Tomato
Tartaric acid	Tamarind

Base

Definition: A substance that has bitter taste is called base. It turns red litmus paper blue. It has slippery touch.

Alkali: It is a base that dissolves in water.

Examples of alkali or base: Sodium hydroxide or caustic soda (NaOH), potassium hydroxide or caustic potash (KOH) , calcium hydroxide or lime water $Ca(OH)_2$ and aqueous ammonia (NH_4OH).

Corrosive: Sodium hydroxide or caustic soda (NaOH) and potassium hydroxide or caustic potash (KOH) are corrosive and can burn the skin.

Metal oxides: Metal oxides are also basic in nature because they react with acid to form salt and water.

Explanation: In actual metal oxides such as Na_2O itself is not a base but its O^{-2} ion react with water to give alkali (base).

$$Na_2O + H_2O \rightarrow 2NaOH$$

After that, this alkali react with acid to form salt and water

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Examples of metal oxides: sodium oxide (Na_2O), calcium oxide (CaO), zinc oxide (ZnO), magnesium oxide (MgO).

★ Few other things to discuss about acid and base

Acids and bases cancel the properties of each other when mixed in equal amounts.

Neutralization: Acid and base react to form salt and water.

7.2 Different Concepts of Acids and Bases

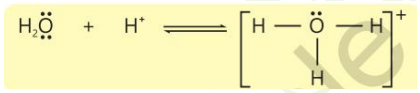
Arrhenius Acids and Bases

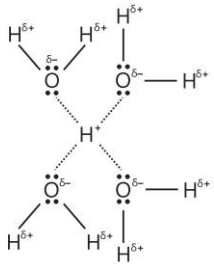
Scientist: In 1884, Svante Arrhenius is a Swedish chemist (1859 − 1927). He suggested that acids and bases may be classified in terms of their behavior in water.

Arrhenius Acid:

Definition: Acid is a substance which dissociates in water to give proton (H^+) or hydroxonium ion (H_3O^+).

Role of water: Water has an essential role in Arrhenius concept of acids and bases. When acid dissociates in water, four water molecules surrounds the proton (H^+) of an acid. Proton (H^+) reacts with lone pair of water molecule to give hydronium ion (H_3O^+) because H^+ is small in size with high charge density.





Mineral Acids:

Mineral acids are generally very strong acids. The acid which ionizes more in water is considered as strong acid.

For example, hydrochloric acid ionizes completely in water in single step and gives large amount of hydronium ion.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

Nitric also ionizes in single step:

$$HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$$

Diprotic acid: Acids which ionizes in two steps by donating two protons (H^+) are called diprotic acids. For example sulphuric acid.

$$H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$$

$$HSO^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$$

Organic acids:

Organic acids ionizes to very limited extent, so, they are weak acids.

For example: Acetic acid (CH_3COOH) ionizes only 0.132%. It means that only 1.32 molecules ionizes out of 1000.

$$CH_3OOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

Formic acid (HCOOH) ionizes only 1.06%. It means that only 11 molecules ionizes out of 1000.

Arrhenius Base:

Definition: Base is a substance which dissociates in water to give hydroxyl ion (OH^-).

Role of water: Water has an essential role in Arrhenius concept of acids and bases. When base dissociates in water, water molecules surrounds the hydroxyl ion (OH^-) of a base and stabilize them (hydrate).

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Sodium hydroxide (NaOH) and Potassium hydroxide (KOH) are strong bases because they ionize completely in water.

$$NaOH + H_2O \rightleftharpoons Na^+ + OH^-$$

$$NH_4OH + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Neutralization:

When a strong acid and strong base are dissolved in water, they completely dissociate ions.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$NaOH + H_2O \rightleftharpoons Na^+ + OH^-$$

From above reactions hydronium ion (H_3O^+) and hydroxyl (OH^-) react to form water and heat is evolved.

$$H_3O^+ + OH^- \rightarrow 2H_2O + heat$$

Salt (NaCl) formed during this process is not present in the form of solid crystals. It is present in the solution in the form of hydrated spectator sodium ions (Na^+) and chloride ions (Cl^-).

Limitations/ demerits/ defects:

- This concept is applicable only in aqueous mediums. It does not work for non-aqueous mediums.
- Na_2CO_3, K_2CO_3 and NH_3 are bases but they do not contain hydroxyl ion (OH^-) and do not directly yield hydroxyl ion (OH^-) in water.
- CO_2 is an acid but it does not contain proton (H^+) and does not directly yield proton (H^+) in water.

7.3 Bronsted – Lowry concepts of Acids and Bases

Scientists: In 1923, Danish chemist Johannes N. Bronsted (1879-1947) and English chemist Thomas M. Lowry (1874-1936) independently presented their theories known as Bornsted-Lowry concepts of acid and base.

Bronsted-Lowry Acid:

An acid is a substance that donates a proton (H^+).

For example: HCl

Bronsted-Lowry Base:

A base is a substance that accepts a proton (H^+).

Example: $OH^-, CN^-, NH_3 \; and \; Cl^-$

In this concept of acid and base, presence of water is not essential.

Note that:

- Every Arrhenius acid is Bronsted-Lowry acid.
- Every Arrhenius base is Bronsted-Lowry base.
- Every Bronsted-Lowry acid is not Arrhenius acid. For example: ${NH_4}^+$
- Every Bronsted-Lowry base is not Arrhenius base. For example: NH_3
- OH^- is base for Arrhenius and Bronsted-Lowry both.

Explanation:

Consider a reaction between hydrogen chloride gas (hydrochloric acid) and water.

$$\underset{\text{Acid}}{HCl} + \underset{\text{Base}}{H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+} + \underset{\text{Conjugate base}}{Cl^-} \quad \text{------ (1)}$$

$$\underset{\text{Base}}{NH_3} + \underset{\text{Acid}}{H_2O} \rightleftharpoons \underset{\text{Conjugate base}}{OH^-} + \underset{\text{Conjugate acid}}{{NH_4}^+} \quad \text{------ (2)}$$

Acid: Acid is the specie that donates a proton (H^+). In reaction (1) HCl and in reaction (2) water (H_2O) donated proton (H^+), so, they are acids.

Base: Base is the specie that accepts a proton (H^+). In reaction (1) water (H_2O) and in reaction (2) ammonia (NH_3) accepted proton (H^+), so, they are bases.

Conjugate acid: In reverse reaction (1) H_3O^+ and in reverse reaction (2) ${NH_4}^+$ are conjugate acids because they are donating a proton.

Conjugate base: In reverse reaction (1) Cl^- and in reverse reaction (2) OH^- are conjugate bases because they are accepting a proton.

Amphoteric compound: Amphoteric compounds are those who behave as both acids and bases. For example water. In reaction (1) water is a base and in reaction (2) water is an acid.

More examples:

$$\underset{\text{Acid}}{HCN} + \underset{\text{Base}}{H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+} + \underset{\text{Conjugate base}}{CN^-}$$

$$\underset{\text{Acid}}{HI} + \underset{\text{Base}}{H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+} + \underset{\text{Conjugate base}}{I^-}$$

Limitations/ demerits/ defects:

- It works only for those reactions in which proton (H^+) is involved.
- It does not explain acid base reactions in non-protonic system.

7.4 Properties of Acids and Bases

Properties of acids and bases depend on the substance they react with. For example acids react with metals and produce hydrogen gas but bases do not react with metals.

Acids give the following three types of reactions:

1. Acids react with alkalis or metal oxides and form salt and water.

$$2HNO_3 + CaO \rightarrow Ca(NO_3)_2 + H_2O$$
$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

2. Acids react with metals (Mg, Zn) and form salts and hydrogen gas is evolved.

$$2HCl + Mg \rightarrow MgCl_2 + H_2$$
$$H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$$

   Remember, less reactive metals like Cu, Ag, Au and Pt do not evolve hydrogen gas when react with acids.

3. Acids react with metal carbonates and metal hydrogen carbonates and evolve carbon dioxide gas.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$
$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

Properties of bases:

- NaOH, KOH are completely soluble in water and $Ca(OH)_2$ is sparingly soluble in water that is why they are known as alkalis.
- $Cu(OH)_2$ is not soluble in water that is why it is not an alkali.

1. Alkali/base react with acid to form salt and water.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$$

2. Alkalies react with ammonium salt and liberate ammonia gas

$$NaOH + NH_4NO_3 \rightarrow NaNO_3 + H_2O + NH_3$$
$$Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2H_2O + 2NH_3$$

7.5 Acid Rain and its Effects

Definition: When rain water has pH between 4.2 and 4.4, it is called acid rain.

Causes: Burning of fossil fuels release harmful gases in air like SO_2, SO_3 and NO_2 etc. These gases react with water and form acid droplets. These droplets fall on the ground as acid rain.

Effects of Acid Rain:

- It effect soil, plants, aquatic life and man-made structures.
- It makes soil acidic.
- It washed away nutrients present in the soil.
- Many plants cannot live and grow in acidic soil.
- It damages vegetation and plants.
- It makes water bodies acidic and thus, harm aquatic life.
- It is the reason due to which many lakes, rivers, ponds and streams do not have fish.
- Acid rain and dry deposition of acid particles damage buildings, statues, automobiles and other structures of stone and metal.

Interesting information

Use of oxalic acid ($H_2C_2O_4$):

It is used commercially for bleaching straw and leather, to remove rust stains from metals and fabrics and for removing ink stains from fabrics.

Stomach acidity or hyperacidity:

Definition: Cells within the lining of stomach produce acid. If they produce more acid than usual, a person will face stomach acidity or hyperacidity.

Causes: If a person takes fatty and spicy food.

Acid: Hydrochloric acid (HCl)

Indication/ symptoms: Feeling burning sensation right below our breast bone, sour taste in mouth, heart burn or pain near the heart area.

Treatment: A person can take weak bases like calcium hydroxide $Ca(OH)_2$ and magnesium hydroxide commonly known as antacids. These bases neutralize the stomach. They do not cause harm because concentration of OH^- is very low.

Exercise Within Chapter

1. Name some fruits which contain citric acid?
   Ans: Lemon, lime, oranges and grapefruits etc.
2. How do chloride ions exist in water?
   Ans: Chloride ions $(Cl)^-$ exist free in water. Water molecules surrounds them in hydrated shell.
3. Why does ammonium hydroxide (NH_4OH) only partially ionize in water?
   Ans: In actual, ammonium hydroxide (NH_4OH) is the ammonia gas (NH_3) dissolved in water. NH_3 is weak base that is why it has low tendency to accept a proton. That is why it is partially ionized.
4. Give two examples of Bronsted-Lowry bases which are not bases by Arrhenius definition.

Ans: Ammonia (NH_3) and hydroxyl ion $(OH)^-$ are Bronsted-Lowry bases but they are not bases by Arrhenius definition.