UNIT. NO 10 ACIDS, BASES AND SALTS

Arrhenius concept of Acids and Bases:

In 1887 a Swedish chemist Arrhenius proposed an acid, base theory. According to this theory. **"An acid is a substance that ionizes in water to produce H^+ ions and a base is a substance that ionizes in water to produce OH^- ions".**

Examples of Acid:

$$HCl_{(g)} \underset{}{\overset{H_2O}{\rightleftharpoons}} H^+_{(aq)} + Cl^-_{(aq)}$$

In above reaction HCl is an acid because it gives H^+ ions when dissolve in water.

Examples of Base:

$$NaOH \overset{H_2O}{\rightleftharpoons} Na^+ + OH^-$$

In above reaction NaOH is a base because it produce OH^- ions when dissolve in water.

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Question:

According to Arrhensius concept which substances in the following reaction are acids or bases.

1. $HNO_3 \overset{H_2O}{\rightleftharpoons} H^+ + NO^{-3}$

Sol:

In above reaction HNO_3 produces H^+ ions so HNO_3 is an acid.

2. $H_2SO_4 \overset{H_2O}{\rightleftharpoons} 2H^+ + SO_4^{-2}$

Sol:

In above reaction H_2SO_4 produces H^+ ions so it is an acid.

3. $KOH \overset{H_2O}{\rightleftharpoons} K^+ + OH^-$

Sol:

In above reaction KOH produces OH^- ions so it is a base.

4. $NH_4OH \xrightleftharpoons{H_2O} NH_4^+ + OH^-$

Sol:

In above reaction NH_4OH produces OH^- ions so it is a base.

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<u>The Bronsted-Lowery concept of Acids and Bases</u>:

In 1923 J.N Bronsted and T.M Lowery proposed an acid base theory and it is known as Bronsted-Lowery theory. According to this theory. **"An acid is a proton donor and a base is a proton acceptor".**

<u>Example-1</u>:

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

In above reaction HCl is converted in Cl^- ion. Therefore HCl donates a proton so according to Lowery- Bronsted theory HCl is an acid.

In the above reaction H_2O is converted into H_3O^+ ions. Therefore H_2O accepts (gains) a proton. So according to Bronsted - Lowery theory H_2O is a base.

<u>Example–2</u>:

$$NH_3 + H_2O \longrightarrow NH_4^+ + OH^-$$

In above reaction $\mathbf{NH_3}$ is converted into NH_4^+ ion. Therefore $\mathbf{NH_3}$ accepts (gains) a proton so according to Bronsted - Lowery theory $\mathbf{NH_3}$ is a base.

In the above reaction H_2O is converted into OH^- ions. Therefore H_2O donates a proton so according to Bronsted - Lowery theory H_2O is an acid.

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<u>Lewis concept of Acids and Bases</u>:

In 1923 G.N Lewis presented an acid base theory. According to this theory. **"An acid is a substance that can accept a pair of electrons to form a coordinate covalent bond**

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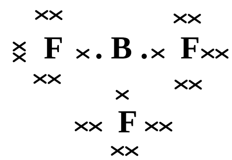
and base is a substance that can donate a pair of electrons to form a coordinate covalent bond".

Example of Lewis Acid:

BF_3 = 

In BF_3 Boron has six electrons (3 electron pairs) so it needs two more electrons to complete its octet. So BF_3 is an electrons pair acceptor. Hence according to Lewis concept BF_3 is Lewis acid.

Example of Lewis Base:

NH_3 = H 

In NH_3 nitrogen has free lone pair therefore it can donate an electron pair. Hence according to Lewis concept NH_3 is Lewis base.

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Some characteristics properties of acids and bases:

Sr.No	Property	Acid	Base
1	Taste	Sour	Bitter
2	Effect on blue litmus	Turns red	No effect
3	Effect on red litmus	No effect	Turns blue
4	Effect on skin	Corrosive	Harm skin tissue
5	Electrical conductivity	Aqueous solutions conduct electricity	Aqueous solutions conduct electricity

Question:

Write names, formula and use of some common acids?

Sr.No	Name	Formula	Common use
1	Hydrochloric acid	HCl	Cleaning of metals, bricks and removing scale from boilers.
2	Nitric acid	HNO_3	Manfacture of fertilizers, explosives

3	Sulphuric acid	H_2SO_4	Manufacture of many chemicals, drugs, dyes, paints & explosive
4	Phosphoric acid	H_3PO_4	Manufacture of fertilizers, acidulant for food

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Question:

Write names, formula and use of some common bases?

Sr.No	Name	Formula	Common use
1	Sodium Hydroxide	NaOH	Soap making, drain cleaners
2	Potassium Hydroxide	KOH	Making liquid soap, shaving cream
3	Calcium Hydroxide	$Ca(OH)_2$	Making mortar, plasters, cement
4	Magnesium Hydroxide	$Mg(OH)_2$	Antacid, Laxative

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Question:

Write the main factors that causes certain diseases in smokers.

Ans. Sulphuric dioxide and oxides of nitrogen are also produced by the smoking of cigarettes. Smokers breath in a lot of sulphur dioxide. Over long period of time, they have an increased risk of suffering from cold, bronchitis and asthma.

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Acid Rain & Acid Snow:

Causes of Acid Rain & Acid Snow;

Fossils fuels contain small amount of sulphur and nitrogen. Fossils fuels produce sulphur dioxide and oxides of nitrogen when the fuel is burn. Large amount of these oxides are released from burning of coal in factories and power stations. These oxides chemically react with water vapours in clouds and oxygen in air forming.

$$SO_2 + \frac{1}{2}O_2 + H_2O \longrightarrow H_2SO_4 \text{ (Acid)}$$

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3 \text{ (Acid)}$$

These acids mix up with rain drops and fall as acid rain or acid snow.

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Question:

Write some effects (disadvantages) of acid rain?

Ans. Acid rain can damage trees and it kills huge areas of forest. If washes out aluminium ions from the soil. These aluminium ions run into rivers, lakes and ponds. Aluminium is very toxic to fish and other aquatic life. Therefore fish and other aquatic animals cannot survive and they may be killed.

Acid rain can also damage buildings and statues. The acid rain react with carbonates present in the stones of buildings and damage the buildings. The acid rain also dissolves in the statues as a result the statue crumbles away. The acid rain is an important environmental issue.

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Self Ionization of Water:

Water molecules are highly polar in nature. Sometimes the collision b/w water molecules becomes strong enough that a proton is transferred from one water molecule to another water molecule. This process is called self ionization of water.

Hydroxide Ion:

A water molecule that denotes or loses a proton becomes a negatively charged ion. This negatively charged ion is called hydroxide ion. It is represented by "OH^-".

$$H_2O + H_2O \longrightarrow H_3O^+ + OH^-$$

(Hydroxide Ion)

Hydronium Ion:

A water molecule that accepts or gain a proton becomes positively charged ion. This positively charged ion is called hydronium ion. It is represent by "H_3O".

$$H_2O + H_2O \longrightarrow H_3O^+ + OH^-$$

(Hydronium Ion)

Self Ionization:

The reaction in which two water molecule produce ions is called self ionization or auto ionization of water. This reaction can also be written as simple ionization of water.

$$H_2O \longrightarrow H^+ + OH^-$$

Water is a weak electrolyte. Therefore the self ionization of water occurs to a very small extent. At 25°C temperature the concentration of H^+ ions and OH^- ions are given as:

$$[H^+] = [OH^-] = 1\ x\ 10^{-7} M$$

Equilibrium Constant For Self Ionization of Water:

$$H_2O \longrightarrow H^+ + OH^-$$

We know equilibrium constant expression is

$$Equilibrium\ constant = \frac{Product\ \ of\ concentration\ \ of\ products}{Product\ \ of\ concentration\ \ of\ reactants}$$

$$\mathbf{Kc} = \frac{[H^+][OH^-]}{[H_2O]}$$

$$\mathbf{Kc[H_2O]} = [H^+][OH^-]$$

Since water is a weak electrolyte. Therefore the concentration of $\mathbf{H_2O}$ will remain the same

So $$\mathbf{Kc[H_2O] = Kw}$$

Where "Kw" is called ionization constant for water.

$$\mathbf{Kw} = [H^+][OH^-]$$

At 25°C temperature

$$\mathbf{Kw = [1x10^{-7}]\,[1x10^{-7}]}$$

$$\mathbf{Kw = 1x10^{-7-7}}$$

$$\mathbf{Kw = 1x10^{-14}}$$

Q. Write a note on pH scale?

Ans. In 1909 the Danish biochemist Soren Sorenson proposed a convenient method to express a small concentration of H^+ ions and OH^- ions by pH or pOH.

PH:

The negative logarithm of the molar concentration of H^+ions in aqueous solutions is called pH.

$$pH = -\,Log\,[H^+]$$

For pure water at 25^oC

$$[H^+] = 1x10^{-7}M \quad put\ in\ \ (i)$$

$$pH = -log[H^+]$$

$$= -log[1x10^{-7}]$$

$$= -log[10^{-7}]$$

$$= -(-7)log10$$

$$pH = +7(1)$$

$$pH = 7$$

The above result shows that pH of pure water is 7. Therefore all aqueous solutions with pH = 7 at 25°C are called neutral solution.

Acidic Solution:

All such solutions whose pH is less than 7 are called acidic solution.

Basic Solution:

All such solutions whose pH is greater than 7 are called basic solutions.

POH:

The negative logarithm of the molar concentration of OH^- ions in aqueous solutions is called POH.

$$pH = -log[OH^-] \quad put\ in \quad (i)$$

For pure water at 25°C

$$[OH^-] = 1\ x\ 10^{-7}M \quad Put\ in \quad (i)$$

$$pOH = -log[OH^-]$$

$$= -log[1\ x\ 10^{-7}]$$

$$= -log[10^{-7}]$$

$$pOH = -(-7)log10$$

$$pOH = +7(1)$$

$$pOH = 7$$

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Prove that pH + pOH = 14

Solution:

L.H.S = pH + pOH

$= (-log[H^+]) + (-log[OH^-]) \quad (i)$

At 25°C

$[H^+] = 1 \, x \, 10^{-7} M$

$[OH^-] = 1 \, x \, 10^{-7} M$

Putting values in (i)

$$pH + pOH = (-log[H^+]) + (-log[OH^-])$$
$$= \left(-log(1 \, x \, 10^{-7})\right) + \left(-log(1 \, x \, 10^{-7})\right)$$
$$= (-log10^{-7}) + (-log10^{-7})$$
$$= (-(-7)log10) + (-(-7)log10)$$
$$= 7 \log 10 + 7 \log 10$$
$$= 7(1) + 7(1)$$
$$= 7 + 7$$
$$= 14 = R.H.S$$

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Question:

What is the importance of Kw (Ionization constant for water).

Ans. Kw is used to indicate the acidic solution, basic solution and neutral solution. It depends upon temperature. In any aqueous solution at 25°C temperature the product of concentration of H^+ ions and OH^- ions is always equal to 1 x 10^{-14}. It means that if $[H^+]$ increases then $[OH^-]$ decreases in such away that their product always remain 1 x 10^{-14}.

For neutral solution $[H^+] = [OH^-] = 1x10^{-7}$

For acidic solution $[H^+] > 1x10^{-7}$

For basic solution $[OH^-] < 1x10^{-7}$

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<u>The pH Scale</u>:

Chemists used a number scale from 0 to 14 to describe the concentration of H^+ ions in a solution. This number scale is known as pH scale. pH scale help us to indicate a neutral solution, acidic solution or basic solution.

1. A pH of 7 indicates a neutral solution.
2. A pH of less than 7 indicates an acidic solution.
3. A pH of greater than 7 indicates a basic solution.

Measurement of pH:

Scientists used different methods to measure pH of a solution. Normally pH paper or universal indicator paper is used to measure pH of a solution. This pH paper is dipped in the solution after sometime some colour appears on the pH paper. This colour is compared to the colour chart. From colour chart we get the exact pH value.

Use for Litmus Paper:

A very common method used in chemistry to find the pH value of acids or basis in the use of litmus paper. In this method the litmus paper may be red or blue. The colour red or blue is of special importance because an acid turns blue litmus paper red and a base turns red litmus paper blue.

Q. What is acidity of stomach?

Ans. The main component of digestive or gastric juice in the stomach is hydrochloric acid. Almost two liter of this acid is secreted each day by gastric glands. Sometimes too much acid is secreted in the stomach which causes indigestion. This is called acidity of the stomach.

Q. Write some valuable applications of pH measurement.

Ans. Analytical chemist measures pH value of solutions. pH measurement has valuable applications.

1. It helps to create soil conditions ideal for plant growth.
2. It helps in medical diagnosis.
3. It helps to maintain correct acid base balance in swimming pools.

Q. How etching is used to crave patterns into metals. .

Ans. Etching is an art that uses acid to crave patterns into metal, glass and other materials. In this process a piece of metal or glass is covered with wax. After this a design is etched on the plate. The plate is then dipped into a tank of acid. The acid eats away the exposed portion. As a result a design is left behind and then the plate is taken out of the acid tank and cleaned. If we want to get colourful design then some ink is applied on etching.

Q. What happens when we put lemon juice on fish?

Ans. The unpleasant fishy odour is due to amines. The citric acid present in lemon juice converts amines into non-volatile salts. As a result the unpleasant fishy odour reduces(decreases).

<u>Salts</u>:-

An acid contain replaceable hydrogen atoms. When these hydrogen atoms are completely or partially replaced by a metal atom then a new compound is formed which is called salt.

HCl ⟶ NaCl

↓ Acid ↓ Salt

HCl ⟶ NaCl

↓ Replaceable 'H' atom ↓ Metal atom has replaced 'H' atom

Salts are ionic compounds. The first part of the name of salt is the name of metal ion and second part of the name is negative part of the acid.

NaCl

↙ The name of metal ion (sodium) ↘ Negative part of acid (chloride)

<u>Neutralization Reaction</u>:-

The reaction of an acid with a base in which salt and water are formed is called neutralization reaction. It is basically a reaction b/w H^+ ions of acid and OH^- ions of a base.

$$Acid + Base \longrightarrow salt + water$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Also

$$H^+ + OH^- \longrightarrow H_2O$$

Methods for Making Salts:-

First Method:-

Reaction of an acid with a base produce salt and water.

$$Acid + Base \longrightarrow salt + water$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Second Method:-

Reaction of an acid with metal oxide produce salt and water.

$$Acid + Metal\ oxide \longrightarrow salt + water$$

$$H_2SO_4 + CuO \longrightarrow CuSO_4 + H_2O$$

Third Method:-

Reaction of an acid with a metal produce salt and water.

$$Acid + Metal \longrightarrow salt + hydrogen$$

$$2HCl + Mg \longrightarrow MgCl_2 + H_2$$

Fourth Method:-

Reaction of an acid with metal carbonate produce salt, carbon dioxide and water.

$$Acid + \ Metal\ carbonate \longrightarrow salt + carbondioxide + water$$

$$2HCl + CaCO_3 \longrightarrow CaCl_2 + CO_2 + H_2O$$

Fifth Method:-

Addition of a salt in a salt produces a new salt.

$$salt + salt \longrightarrow salt$$

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

Uses of Salts:- OR **Food Preservation:-**

Food preservation keeps food from spoiling and allows it to be stored for along time. Ancient methods for preserving food include boiling, salting, drying fruits and vegetables etc. In modern world many preservatives are used to preserve food without these preservatives food would spoil long time before it is used. Many salts such as sulphites and benzoates are being used as preservatives to preserve food.

Types of Salts:-

There are three main types of salts.

i) Acid Salt
ii) Basic Salt
iii) Normal Salt

i) Acid Salt:-

A salt which is formed by partial neutralization of an acid is called acid salt.

OR

A salt which is formed by partial neutralization of replaceable H^+ ions of an acid by a positive metal ion are called acid salts.

Example:-

$$H_2SO_4 + KOH \longrightarrow KHSO_4 + H_2O$$

ii) Basic Salt:-

A salt which is formed by the partial neutralization of a polyhydroxy base is called

basic salt.

Example:-

$$Zn(OH)_2 + HCl \longrightarrow Zn(OH)Cl + H_2O$$

$$Al(OH)_3 + HCl \longrightarrow Al(OH)_2 + H_2O$$

Normal Salt:-

A salt which is formed by complete neutralization of an acid is called normal acid.

Example:-

$$HCl + KOH \longrightarrow KCl + H_2O$$

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

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Self Assessment Exercise 10.5:-

1) **Hydroxides such as $Mg(OH)_2$ called milk of magnesia is used as antacid. It neutralizes excess stomach acid (HCl). Write complete and balanced chemical equation for this neutralization reaction.**

Ans. $2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + H_2O$

2) **HCl and KOH react and produce potassium chloride. Write complete and balanced chemical equation for this neutralization reaction.**

Ans. $HCl + KOH \longrightarrow KCl + H_2O$

3) **Balance the following neutralization reaction.**

Ans. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

$H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$

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Self Assessment Exercise 10.6:-

Q. Classify following salts as normal or acid salts.

1. $NaHSO_4$

Ans. $NaHSO_4$ is an acid salt.

2. Na_2SO_4

Ans. Na_2SO_4 is a normal salt.

3. $KHCO_3$

Ans. $KHCO_3$ is an acid salt.

4. K_2CO_3

Ans. K_2CO_3 is an normal salt.

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Exercise Question

Page-No-51 **QNo-2(i):-**

Write the equation for the self-ionization of water

Ans:- **Self- Ionization of Water:-**

The reaction in which two water molecules produce ions is called as the self ionization or auto-ionization of water.

$$H_2O \rightleftharpoons H^+ + OH^-$$

A water molecule that donate or lose a proton becomes a negatively charged hydroxide ion (OH^-).and the water molecule which gains or accepts the protons becomes positively charged hydronium ion (H_3O^+)

$$H_2O + H_2O \longrightarrow H_3O^+ + OH^-$$

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Q-No-2(ii)

Define and give example of Arrhenius acids.

Ans:- Arrhenius Acids:-

According to Arrhenius concept an acid is a substance that ionizes in water to produce H^+ ions.

Examples:-

i. HCl $\xrightleftharpoons{H_2O}$ $H^+ + Cl^-$

i. HNO_3 $\xrightleftharpoons{H_2O}$ $H^+ + NO_3^-$

H2O3

ii. CH_3COOH $\xrightleftharpoons{H_2O_3}$ $CH_3COO^- + H^+$

Q-No-2(iii)

Why H^+ acts as a Lewis acid?

Ans:- According to Lewis concept an acid is a substance that can accept a pair of electrons to from a coordinate covalent bond. Since H^+ ion has no electrons so it can easily accept a pair of electron from another atom. That is why H^+ ion acts as a Lewis acid.

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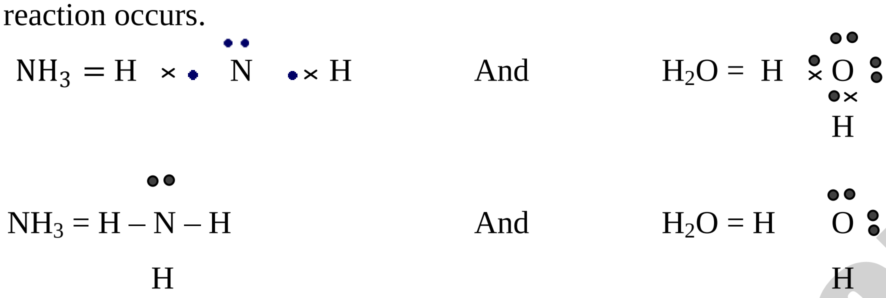
Q-No-2(iv)

Why NH_3 acts as Bronsted-Lowery base?

Ans:- According to Bronsted- Lowery concept an acid is a proton donor and a base is a proton acceptor. Ammonia (NH_3) is a gas at room temperature when it is dissolved in water then following reaction occurs.



Overall reaction is:

In this water (H_2O) is proton donor and ammonia (NH_3) proton acceptor. Therefore according to Bronsted-Lowry concept water acts as an acid and ammonia acts as base.

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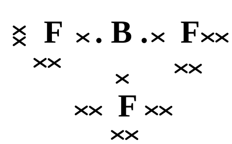
Q-No-2(v)

Why BF_3 acts as Lewis acid?

Ans:- According to Lewis concept an acid is a substance that can accept a pair of electrons to form a coordinate covalent bond and base is a substance that can donate a pair of electrons to form a coordinate covalent bond.

BF_3 = 

Boron is BF_3 has six electrons (3 electron pair). So it needs two more electrons (an electron pair) to complete its Octet. Therefore BF_3 is an electron pair acceptor. Hence according to Lewis concept BF_3 is Lewis acid.

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Q-No-3

$$NH_4OH + HNO_3 \longrightarrow NH_4NO_3 + H_2O$$

Q-No-4

i. $H_2SO_4 + Mg(OH)_2 \longrightarrow MgSO_4 + 2H_2O$

ii. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

iii. $2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$

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Q-No-5

i. $HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

According to Bronsted – Lowry concept an acid is a proton donor and base is a proton acceptor. In the above reaction HNO_3 is converted into NO_3 by donating a proton therefore HNO_3 is an acid and H_2O accepts the proton so it is a base.

ii. $NH_3 + HNO_3 \longrightarrow NH_4NO_3$

In this reaction HNO_3 donates a proton to NH_3 so HNO_3 is an acid and NH_3 accepts this proton so NH_3 is a base.

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Q-No-6

i. $F + BF_3 \longrightarrow [BF_4]$

According to Lewis concept an acid is a substance that can accept a pair of electrons to form a coordinate covalent bond and base is a substance that can donate a pair of electrons to form a coordinate covalent bond.

In this above reaction F has a lone pair so it can donate a lone pair of electrons. Therefore it is Lewis base. Whereas in BF_3 Boron has six electrons and it needs two more electrons to complete its octet. Therefore BF_3 is an electron pair acceptor. Hence according to Lewis concept BF_3 is lewis acid.

ii. $H + NH_3 \longrightarrow [NH_4]$

H^+ ion has no electrons so it can accept a lone pair of electrons from another atom. Therefore according to Lewis concept H^+ ion acts as Lewis acid. Whereas NH_3 has a lone pair of Nitrogen atom so it can donate an electron pair. Therefore NH_3 is Lewis base.

iii. $NH_3 + AlCl_3 \longrightarrow [H_3N - AlCl_3]$

In the above reaction Aluminium (Al) in $AlCl_3$ has six electrons and it needs two more electrons to complete its octet. Therefore $AlCl_3$ is an electron pair of acceptor so it is Lewis acid and NH_3contains a lone pair so it can donate this lone pair. Hence NH_3 is Lewis base.

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Q-No-7

i. $[H^+] = 1.0 \times 10^{-3}$ M

Here $[H^+] = 1.0 \times 10^{-3}$ M > 1.0×10^{-7} M

Therefore given solution is acidic.

ii. $[H^+] = 1.0 \times 10^{-10}$ M

Here $[H^+] = 1.0 \times 10^{-10}$ M < 1.0×10^{-7} M

Therefore given solution is basic.

iii. $[OH^-] = 1.0 \times 10^{-3}$ M

First all we will find concentration of H^+ ion

$[H^+] = ?$

We know that

$K_w = [H^+] [OH^-]$ Here $K_w = 1.0 \times 10^{-14}$ M

$1.0 \times 10^{-14} = [H^+] [1.0 \times 10^{-3}]$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10-3} = [H^+]$$

$[H^+] = 1.0 \times 10^{-11}$ M

Here

$[H^+] = 1.0 \times 10^{-11}$ M < 1.0×10^{-7} M

Therefore given solution is basic.

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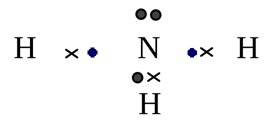
Q -No -8

i. NH_3

NH_3 =



Ammonia NH_3 has a lone pair on Nitrogen atom so it can donate an electron pair. Therefore
according to Lewis concept NH_3 base.

ii. F

F has a lone pair on Flourine atom so it can donate an electron pair. Therefore according to Lewis concept F is Lewis base.