Acids Bases and Salts

Introduction

● Acids have sour taste .for example, vinegar, lemon juice (pure) taste sour due to the presence of acid in them.

● Bases are bitter in taste. Also they are soapy to touch .For example, baking soda is bitter in taste and feel soapy to touch.

When an acid and a base read together they form new compounds known as salt and water.

Acids

The term acid is derived from the Latin word acids meaning sour.

Substances with sour taste are regarded as acids. Lemon juice, vinegar, grape juice and spoilt milk etc. taste sour since they are acidic. Some of the acids like sulphuric acid have very strong action on the skin so that they are corrosive in nature.

According to Arrhenius an acid may be defined as a substance which releases one or more H^+ ions in aqueous solution.

(a) Methods of preparation:

Acids are prepared by first burning non metals in air and then dissolving the non –metal oxide in water.

For example silphurous acid can be prepared by burning sulphur in air and dissolving sulphur dioxide in water.

$$\underset{\text{Sulphur}}{S} + \underset{\text{Oxiygen}}{O_2} \rightarrow \underset{\text{Sulphur dioxide}}{SO_2}^{+} \xrightarrow{H_2O} \underset{\text{Sulphurous acid}}{H_2SO_3}$$

(b)Physical properties of Acid:

(i) Acids have sour taste.

(ii)Acids like conc. H_2SO_4 and conc. HNO_3 are corrosive In nature. They destroy organic matter like clothes, paper, wood and human skin.

(iii) Action with indicators – Acid change the colour of indicators.

Litmus	-	Blue to red
Methyl orange	-	Orange of red
Phenolphthalein	-	No change

(iv)Acids contain $[H^+]$ or $[H_3O^+]$ ions.

$$\underset{\text{Acid}}{HCl} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Chloride ion}}{Cl^-}$$

These ions are responsible for acidic nature.

(c) Chemical properties of Acids:

(i) Dilute acids like dilute HCl and dilute H_2SO_4 such react with certain metals to evolve hydrogen gas, Zn, Fe, Ca Mg etc.

$$2Na(s) + 2HCl(dilute) \longrightarrow 2NaCl(aq) + H_2(g)$$

$$Mg(s) + H_2SO_4(dilute) \longrightarrow MgSO_4(aq) + H_2(g)$$

(ii) ction with metal oxides: Acids react with metal oxides

(

$$ZnO(s) + 2HCl(dil.) \xrightarrow{\Delta} ZnCl_2(aq) + H_2O(\ell)$$

(iii) Action with metal carbonates and metal bicarbonates:

Metal carbonates and bicarbonates react with acids to evolve CO_2 gas and form salts.

$$\underset{\substack{\text{Calcium}\\ \text{carbonate}}}{CaCO3(s)} + 2HCl(dil.) \longrightarrow \underset{\substack{\text{Calcicum}\\ \text{chloride}}}{CaCl_2(aq)} + H_2O(\ell) + CO_2(g)$$

$$\underset{\substack{\text{Sodium}\\ \text{bicarbonat}}}{2NaHCO_3(s)} + H_2SO_4(dil.) \longrightarrow \underset{\text{SodiumSulphate}}{Na_2SO_4(aq)} + 2H_2O(aq) + 2CO_2(g)$$

(d) Types of acids:

All the acids can be classified into following categories-

(i) Organic acids and mineral acids.

(ii) Concentrated acids and dilute acids

(iii) Strong acids and weak acids

(i) Organic acids and mineral acids:

Organic acids are naturally occurring acids that are mostly found in plants and animals. These acids are the compounds of carbon. For example, acetic acid formic acid, citric acid etc. mineral acids are synthesized from minerals found on earth. For example, sulphuric acid, nitric acid and hydrochloric acid.

(ii) Concentrated acids and dilute acids:

Concentrated acids contain at large quantity of acid and very less or no water all.

Dilute acids contain large quantity or water and less quantity of acid.

(iii) Strong acids and weak acids:

Strong acid give a large number of hydrogen ions when dissolved in water. Mineral acids are generally strong acids.

Weak acids give very few hydrogen ions when dissolved in water. For example, citric acid, acetic acid, formic acid, carbonic acid etc.

	Type	Chemical Formula	Where found or used
Carbonic acid	Mineral acid	H_2SO_3	In soft drinks, In stomach as gastric juice, used in tanning industry.
Nitric acid	Mineral acid	HNO_3	Used in the manufacture of explosives (TNT, Nitroglycerine) and fertilizers (Ammonium nitrate, calcium nitrate, Purification of Au, Ag.
Hydrochloric acid	Mineral acid	HCl	In purification of common salt, in textile industry as bleaching agent to make aqua regia.
Sulphuric acid	Mineral acid	H_2SO_4	Commonly used in car batteries, in the manufacture of fertilizers (Ammonium phosphate, Super phosphate) detergent etc. in paints, plastics, drugs, in manufacture of artificial silk, in petroleum refining
Phosphoric acid	Mineral acid	H_3PO_4	Used in antirust paints and in fertilizers
Formic acid	Organic acid	HCOOH	Found in the stings of ants and bees, used in tanning leather, in medicines for treating gout.
Acetic acid	Organic acid	CH_3COOH	Found in vinegar, used as solvent in the manufacture of dyes and perfumes.
Lactic acid	Organic acid	$CH_3CH(OH)COOH$	Responsible for souring of milk in curd
Benzoic	Organic acid	C_6H_5COOH	Used as a food preservative
Citric acid	Organic acid	C_6H_8O7	Present in lemons, oranges and citrus fruits.
Tartaric acid	Organic acid	C_4H_6O6	Present in tamarind

Bases

Bases are hydroxides of metals.
A base is a compound which contains one or more hydroxyl ions and on reacting with an acid produces a salt.
e.g.

Sodium hydroxide	NaOH
Calcium hydroxide	$Ca(OH)_2$
Aluminium hydroxide	$Al(OH)_3$

Alkalies: Base which dissolve in water are called alkalies. e.g. KOH, NaOH

(a) Methods of Preparation:

Base are prepared by first burning metals in air and then dissolving the metal oxide in water. For example magnesium hydroxide can be prepared by burning magnesium in air and dissolving magnesium oxide in water.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Oxygen}}{O_2} \rightarrow \underset{\text{Magnesium oxide}}{MgO} \xrightarrow{H_2O} \underset{\text{Magnesium hydroxide}}{Mg(OH)_2}$$

(b) Physical Properties:

(i) Bases have bitter taste
(ii) Bases and alkalies are soapy in touch e.g. KOH, NaOH etc.

(iii) Action with indicators- Bases change the colour of indicators

Litmus	-	Red to blue
Methyl orange	-	No change in colour
Phenolphthalein	-	Colourless to pink

(c) Chemical Properties:

(i) Action with metals: Metals like zinc, tin and aluminium react with strong alkalies like NaOH (caustic soda), KOH (caustic potash) to evolve hydrogen gas.

$$Zn(s) + 2NaOH(aq) \longrightarrow \underset{Sodiumzincate}{Na_2ZnO_2(aq)} + H_2(g)$$

(ii) Action with non-metal oxides: Acids react with metal oxides but bases react with non-metal oxides to from salt and water.

$$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(\ell)$$

(d) Strong and Weak Bases:

Bases which are almost completely ionized in water, are known as strong bases. e.g. Sodium hydroxide (NaOH), potassium hydroxide (KOH), barium hydroxide $Ba(OH)_2$ etc.
Base which dissolve in water only slightly and produce a low concentration of hydroxide ions are called weak base. e.g. NH_4OH, AgOH etc.

Chemical	Commercial Name	Chemical Formula	Uses
Sodium hydroxide	Caustic soda	NaOH	In manufacture of soap, paper pulp, rayon, refining of petroleum etc.
Potassium hydroxide	Caustic potash	KOH	In alkaline storage batteries, manufacture of soap, absorbing CO_2 gas etc.
Calcium hydroxide	Slaked lime	$Ca(OH)_2$	In manufacture of bleaching powder, softening of hard water etc.
Magnesium hydroxide	Milk of magnesia	$Mg(OH)_2$	As an antacid to remove acidity from stomach
Aluminium hydroxide	-	$Al(OH)_3$	As foaming agent in fire extinguishers
Ammonium hydroxide	-	NH_4OH	In removing grease stains from clothes and in cleaning window panes.

Indicators

An indicator is a substance which indicated the nature of particular solution whether acidic, basic or neutral.

(i) Litmus: Litmus is a purple dye which is extracted from a plant lichen A blue litmus strip when dipped in an acid solution acquires red colour. similarly a red strip when dipped in a base solution becomes blue.

(ii) Phenolphthalein: It is also an organic dye. In neutral or acidic solution, it remains colourlees while in the basic solution, the colour of the indicator change to pink.

(iii) Methyl orange: Methyl orange is an orange coloured dye and keeps this colour in the neutral or basic medium. In the acidic medium the colour of the indicator becomes red.

(iv) Red Cabbage juice : It is purple in colour in neutral medium and turns red or pink in the acidic medium . in the basic or alkaline medium, its colour change to green ,

(v) Turmeric juice: It is yellow in colour and remains as such in the neutral and acidic medium. In the basic medium its colour becomes reddish or deep brown.

(vi) China Rose: Extract of china rose (Gudhal) pe6tals is of pink colour. It will change into dark pink (magenta)in acidic solution and green in basic solution.

Indicator	Colour in acidic medium	Colour basic medium
Blue litmus	Red	Blue
Red litmus	Red	Blue
Turmeric	Yellow	Reddish-brown
China rose	Dark pink (magenta)	Green
Methyl orange	Red	Orange
Phenolphthalein	Colourless	Pink

Neutralization

The reaction between an acid and a base in known as neutralization. Salt and water are produced in this process with the evolution of heat. Evolved heat is known as heat of neutralisation.
e.g.

$$\underset{\text{Hydrochloric acid}}{HCl} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium chloride}}{Nacl} + \underset{\text{Water}}{H_2O} + 57.1\,kJ$$

(i) Neutralisation in everyday life:

Indigestion: People particularly of old age suffer from acidity problems in the stomach which s caused mainly due to release of excessive gastric juice containing HCl. The acidity is neutralized by antacid tablets which contain sodium hydrogen carbonate (baking soda), magnesium hydroxide etc.

Ant bite: The stings of bees and ants contain formic acid. Its corrosive and poisonous effect can be neutralized by rubbing soap which contains NaOH (an alkali) or by rubbing baking soda ($NaHCO_3$) or by calamine solution ($ZnCO_3$). The stings of wasps contain an alkali and its poisonous effect can be neutralised by an acid like acetic acid (present in vinegar).

- **Soil treatment:** Farmers generally neutralize the effect of acidity in the soil caused by acid rain by adding slaked lime (calcium hydroxide) to the soil.

- **Factory wastes:** The wastes of many factories contain acids. If they are allowed to flow into the water bodies, the acids will kill fish and other organisms. The factory wastes are, therefore, neutralized by adding basic substances.

Theories of Acids & Bases

(i) Arrhenius Theory:

This concept was presented in 1884

According to this theory all substances which give H^+ ions when dissolved in water are called acids, while those which ionize in water to give OH^- ions are called bases.

e.g.

$$\underset{Base}{HA} + H_2O \rightleftharpoons H_3O^+ + A^-$$

$$\underset{Acid}{H_2SO_4} + 2H_2O \rightleftharpoons 2H_3O^+ + SO4^{-2}$$

$$\underset{Base}{BOH} + H_2O \rightleftharpoons B^+ + OH^-$$

$$NaOH + H_2O \xrightarrow[Water]{} Na^+ + OH^-$$

$$\underset{Base}{NH_4OH} \rightleftharpoons NH_4^+ + OH^-$$

(ii) Acid Base Concept of Bronsted and Lowry:

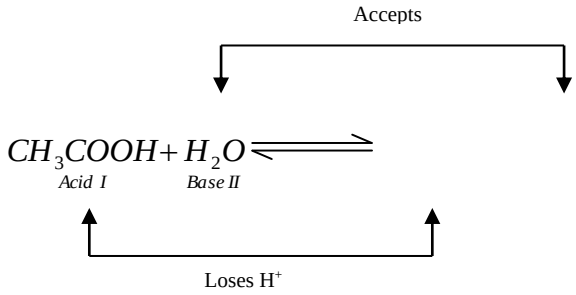
This theory was given by Bronsted, a Dainsh chemist and Lowry, an English chemist independently in 1923. According to it an acid is a substance, molecule or ion which has a tendency to release the proton (photogenic) and similarly a base has a tendency to accept the proton (protophillic).

e.g.

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

In this reaction, HCl acts as an acid because it donates a proton to the water molecule. Water, on the other hand, behaves as a base by accepting a proton.

According to the theory, an acid on losing a proton becomes a base, called conjugate base, while the base by accepting proton changes to acid called conjugate acid.



Here CH_3COO^- ion is conjugate base of CH_3COOH, while H_3O^+ions is conjugate acid of H_2O.

(iii) Lewis theory:

The theory was given by G.N. Lewis in 1938. According to it, an acid is a species which can accept a pair of electrons, while the base is one which can donate a pair of electrons.

e.g.

Lewis acids:- CH_3^+, H^+, BF_3, $AlCl_3$, $FeCl_3$ etc.

Lewis base:- NH_3, H_2O, R-O-R, R-OH, CN^-, OH^- etc.

pH Scale

A scale for measuring hydrogen ion concentration in a solution called pH scale, has been developed by S.P.L. Sorrense.

Negative logarithm of hydrogen ion concentration is known as pH.

$$pH = -\log[H^+] = \log\left[\frac{1}{H^+}\right]$$

(i) For acidic solution, pH < 7

(ii) For alkaline solution, pH > 7

(iii) For neutral solution, pH = 7

Solution	Approximate	Solution	Approximate
Gastric juice	1.0-3.0	Pure water	7.0
Lemon juice	2.2-2.4	Blood	7.36-7.42
Vinegar	3.0	Baking soda solution	8.4
Beer	4.0-5.0	Sea water	9.0
Tomato juice	4.1	Washing soda solution	10.5
Coffee	4.5-5.5	Lime water	12.0
Acid rain	5.6	House hold ammonia	11.9
Milk	6.5	Sodium hydroxide	14.0
Saliva	6.5-7.5		

Salts

A substance formed by neutralization of an acid with a base is called a salt.

e.g.

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

$$Cu(OH)_2 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O$$

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

(i) Preparation of salts:

- By neutralization of an acid by base:

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

- By reaction of an acid with a metal:

$$Zn + dil.2HCl \longrightarrow ZnCl_2 + H_2$$

- By the action of acid on carbonates:

$$Na_2CO_3 + dil.2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

By the action of acid on metal oxides:

$$Na_2O + dil.2HCl \longrightarrow 2NaCl + H_2O$$

(ii) Naming of salts:

- Salts obtained from sulphuric acid are known as sulphates e.g. $CaSO_4$, Na_2SO_4 etc.
- Salts obtained from nitric acid are known as nitrates e.g. KNO_3, $NaNO_3$ etc.
- Salts obtained from hydrochloric acid are known as chlorides e.g. $CaCl_2$, KCl etc.
- Salts obtained from phosphoric acid are known as phosphates e.g. $Ca_3(PO_4)_2$, Na_3PO_4 etc.
- Salts obtained from carbonic acid are known as carbonates e.g. $CaCO_3$, $BaCO_3$ etc.

(iii) Properties of salts

- Salts are mostly solids with high melting point and high boiling point.
- Salts are usually souble in water.
- Solutions of salts in water conduct electricity.

(iv) Classification on salts:

Salts have been classified on two basis:

Classification based on chemical formulae of salts:

- **Normal salts:** A normal salt is the one which does not contain any ionisable hydrogen atom or hydroxyl group.

e.g. NaCl, KCl, $NaNO_3$, K_2SO_4 etc.

- **Acidic salts:** An acidic salt still contains some replaceable hydrogen atoms.

e.g. Sodium hydrogen sulphate ($NaHSO_4$), sodium hydrogen carbonate ($NaHCO_3$) etc.

- **Basic salts:** A basic salt still contains some replaceable hydroxyl groups.

e.g. Basic lead nitrate Pb(OH) NO_3, basic lead chloride, Pb(OH)Cl etc.

Classification based on nature of salt solution:

- **Neutral salt solutions:** The solution of a salt formed by neutralization of a strong acid with a strong base in neutral in nature. Such solutions do not change the colour of litmus solution and the salts which produce such type of solutions are known as neutral salts.

e.g. NaCl, KCl, $NaNO_3$, Na_2SO_4 etc.

- **Acidic salt solutions:**

The solution of a salt formed by neutralization of a strong acid with a weak base is acidic in nature. Such solutions change the colour of blue litmus solution to red and the salts which produce such type of solutions are known as acidic salts.

e.g. $(NH_4)_2SO_4$, NH_4Cl etc.

- **Basic salt solutions:**

The solution of a salt formed by neutralization of a weak acid with a strong base is basic in nature. Such solutions change the colour of red litmus solution to blue and the salts which produce such type of solutions are known as basic salts.

e.g. Na_2CO_3, K_3PO_4 etc.

Important points

1. All alkalies are based but all bases are not alkalies. e.g. $Al(OH)_3$ is a base, but not an alkali.

2. The atmosphere of Venus is made up of thick white and yellow clouds of Oil of Vitriol (H_2SO_4).

3. Vitamin C which is very important for our body is also an organic acid known as ascorbic acid.

4. Some substances have the tendency to absorb water from air and turn into a solution, such substances are called deliquescent. Both NaOH and KOH are deliquescent in nature which means that they absorb moisture from air.

5. the crystals of some substances have some water molecules associated with them. These water molecules are known as water of crystallization. Such salts are called hydrated salts.
e.g. $CuSO_4.5H_2O$, $FeSO_4.7H_2O$, $Na_2CO_3.10H_2O$
The crystals which have lost their water of crystallization are called anhydrous

6. A 30% cold and concentrated solution of sodium chloride is called brine.

EXERCISE

1. Match the following

(i) Grapes	(A) Acetric acid
(ii) Vinegar	(B) Lactic acid
(iii) Lemon	(C) Tartaric acid
(iv) Sour milk	(D) Citric acid

(A) (i)-(C), (ii)-(A), (iii)-(D), (iv)-(B)
(B) (i)-(B), (ii)-(A), (iii)-(D), (iv)-(C)
(C) (i)-(D), (ii)-(A), (iii)-(B), (iv)-(C)
(D) (i)-(B), (ii)-(C), (iii)-(D), (iv)-(A)

2. Which of the following acid is used in the manufacture of explosives like TNT (trinitron toluene).
(A) CH_3COOH (B) HNO_3
(C) HCl (D) D_3PO_4

3. Aqua-regia dissolves noble metals by producing-
(A) Cl_2 (B) N_2
(C) NOCl (D) NCl_3

4. 10 mL of a solution of NaOH is found to be completely neutralized by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralize will be –
(A) 4 mL (B) 8 mL
(C) 12 ML (D) 16 mL

5. Match the following-

(i) Hydrochloric acid	(a) Organic acid
(ii) Phosphoric acid	(b) Strong acid
(iii) Citric acid	(c) Vinegar
(iv) Acetic acid	(d) Weak acid

	(i)	(ii)	(iii)	(iv)
(A)	a,	c,	b,	d
(B)	b,	d,	a,	c
(C)	a,	d,	b,	c
(D)	d,	b,	a,	c

6. Aqueous solution of CH_3COOH contains:
(A) CH_3COO-, H^+
(B) CH_3COO^-, H_2O, CH_3COOH
(C) CH_3COO-, H_3O^+, H^+
(D) CH_3COOH, CH_3COO^-, H^+

7. When a strong acid is slowly added to water-
(A) it releases heat
(B) it absorbs heat
(C) there is no heat change
(D) none

8. The strength of the acid depends on the-
(A) number of hydrogen atoms present in the molecule.
(B) oxygen content.
(C) density
(D) concentration of hydrogen ions furnished by ionisation.

9. …….. is known as ascorbic acid which is present in citrus fruits.
(A) Vitamin D (B) Vitamin C
(C) Vitamin A (D) Vitamin K

10. Which is a base and not an alkali?
(A) NaOH (B) KOH
(B) $Fe(OH)_3$ (D) none is true

11. Which of the following metals can displace hydrogen from the aqueous solution of sodium hydroxide?
(A) Mg (B) Cu
(C) Al (D) Ag

12. Which of the following is a conjugate acid-base pair?
(A) H_3O^+ & OH^- (B) H_2CO_3 & HCO_3^-
(C) H^+ & OH^- (D) NH_4^+ & NH_2^-

13. CO_2 reacts with _____ to form Na_2CO_3.
(A) H_2O (B) NaOH
(C) NaCl (D) Na_2O

14. The solution of a substance is water is slippery. It combines with an acid to produce a salt. The substance is-
(A) an acid (B) a salt
(C) a base (D) none of these

15. Fear and excitement generally cause one to breathe rapidly and it results in the decrease of carbon dioxide in the blood. In what way will it change the pH of the blood?
(A) pH will decrease (B) pH will increase
(C) no change (D) pH will adjust to 7

16. When a drop of phenolphthalein is introduced in lime water, the solution turns-
(A) blue (B) milky
(C) red (D) pink

17. An indicator that urns reddish brown when dissolved in soap solution is-
(A) litmus (B) china rose
(C) turmeric powder (D) None of these

18. Natural indicator litmus is extracted from-
(A) lichens (B) earthworm
(C) ants (D) algae

19. Which of the following indicators is colourless in acidic medium?
(A) Methyl orange
(B) Turmeric powder
(C) Litmus
(D) Phenolphthalein

20. Which of the following is not an indicator?
(A) Methyl orange (B) Litmus
(C) China rose (D) Sunflower

21. Which of the following compounds is a base?
(NTSE-Stage-I/Raj/2007)
(A) Salt
(B) Hydrochloric acid
(C) Copper sulphate
(D) Sodium hydroxide

22. Which one of the following acids has two replaceable hydrogen atoms?
(NTSE-Stage-II/2008)
(A) Formic acid (B) Acetic acid
(C) Sulphuric acid (D) Phosphoric acid

23. Examine the following statements
(a) Temporary hardness of water is due to the presence of soluble bicarbonates of calcium and magnesium.
(NTSE-Stage-II/2008)
(b) Permanent hardness of water is caused by the presence of the chlorides and sulphates of calcium and magnesium.
(c) Rain water is the purest form of water collected after a heavy shower.
(d) Ion exchange of permutit process is the modern and most effective method of removing both temporary and permanent hardness of water.
Which statements are correct?
(A) (a) and (c)
(B) (b) and (d)
(C) (a), (b) and (c)
(D) (a), (b), (c) and (d)

24. Some substances are given below-
(NTSE-Stage-II/2008)
(a) magnesium oxide (b) carbon dioxide
(c) sulphur dioxide (d) calcium oxide
Which of the above substances, when dissolved in water, turn blue litmus to red? Select the correct alternative.
(A) (a) and (b) (B) (b) and (c)
(C) (b) and (d) (D) (a) and (d)

ANSWER – KEY

ACIDS, BASES AND SALTS

Q.	1	2	3	4	5	6	7	8	9	10
A.	A	B	C	D	B	D	A	D	B	C
Q.	11	12	13	14	15	16	17	18	19	20
A.	C	B	B	C	B	D	C	A	D	D
Q.	21	22	23	24						
A.	D	C	D	B						