2 Acid, Base and Salts

The acidity of an aqueous solution depends on the concentration of hydrogen ions. The pH of pure water at 25ºC is 7 pH < 7.00 is an **acidic** solution pH = 7.00 is a **neutral** solution pH > 7.00 is a **basic** solution the smaller the pH value, the more acidic the solution.

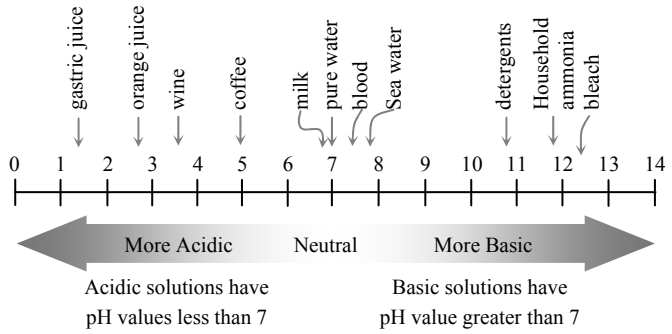


Table: 2.1 Colour of indicators in acidic and basic medium

Indicator	Colour in Acid	Colour in Base
Blue Litmus	Red	Blue
Red Litms	Red	Blue
Turmeric	Yellow	Reddish-brown
China Rose	Dark Pink	Green
Methyl Orange	Orange	Yellow
Phenolphthalein	Colourless	Pink

Acid derived from Latin *acidus* (meaning sour or tart) related to Latin *acetum* (meaning vinegar).

Characteristic properties associated with acid:

- Sour taste
- Change the colour of litmus from blue to red
- React with metal (such as Zn, Mg) to produce H_2 gas.

Hydroxide base to produce H_2O and salt, Carbonate to produce CO_2 H^+ released by acids in water solution.

Types of Acids: Acids are divided into two types on the basis of their occurrence– Natural acids and Mineral acids.

Natural Acid: Acids which are obtained from natural sources are called natural acid or organic acid.

Mineral Acids: Acids that prepare from mineral are known as mineral acids, inorganic acids, man-made acids or synthetic acid, such as hydrochloric acid, sulphuric acid, nitric acid, etc.

Base capable of liberating OH^- in water solution LiOH, NaOH, KOH, $Ca(OH)_2$, $Ba(OH)_2$.

Characteristic properties associated with base:

- Bitter or caustic taste.
- A slippery, soapy feeling.
- The ability to change litmus from red to blue.
- The ability to interact with acids.

Arrhenius Theory: An acid is a hydrogen-containing substance that dissociates to produce hydrogen ion, and a base is a hydroxide-containing substance that dissociates to produce hydroxide ion in aqueous solution.

$$HA \longrightarrow H^+(aq) + A^-(aq) \quad \text{acid}$$

$$MOH \longrightarrow M^+(aq) + OH^-(aq) \quad \text{base}$$

Note: Arrhenius acid solution contains an excess of H^+ ions, an Arrhenius base solution contains an excess of OH^- ions.

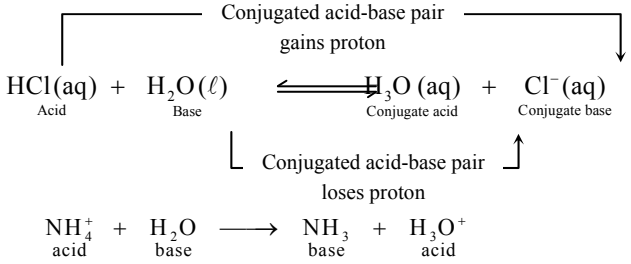
Brønsted–Lowry Theory: A Brønsted–Lowry acid is a proton (H^+) donor a and base is a proton (H^+) acceptor.

$$HCl(g) + H_2O(\ell) \longrightarrow H_3O^+(aq) + Cl^-(aq)$$

HCl: acid, H_2O: base

Hydronium ion: H_3O^+ $\left(H:\ddot{O}:H\right)^+$ (H)

Conjugated Acid and Base:



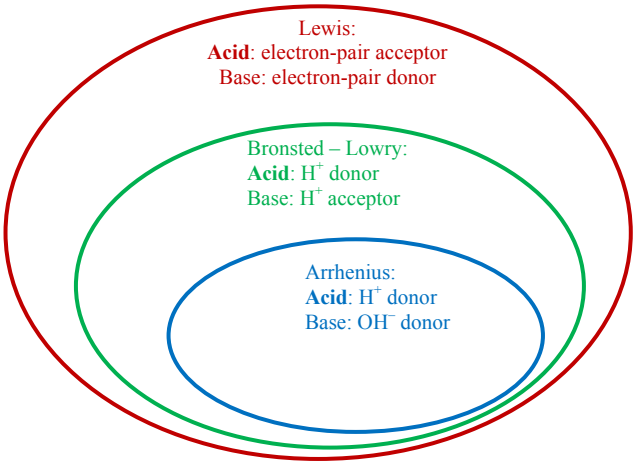
Example: The conjugated base of H_2O and of HNO_3

OH^- NO_3

The conjugated acid of SO_4^{2-} and $C_2H_3O_2$

HSO_4^- $HC_2H_3O_2$

Lewis Acid-base Theory



A base is any substance that has an unshared pair of electrons, ***an electron-pair donor*** and an acid is any substance that will attach itself to or a pair of electrons, ***an electron-pair acceptor***.

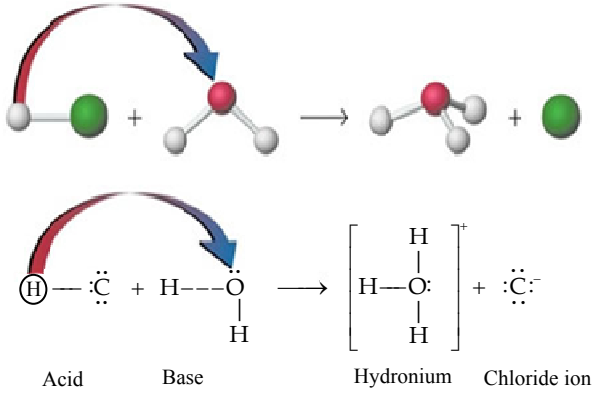


Table: 2.2 Reactions of acids

▪ **Reaction with metals** acid + metal ⟶ hydrogen + ionic compound nitric acid HNO_3 is oxidising agent, react with metals to produce water instead of H_2	$2HCl + Ca \longrightarrow H_2 + CaCl_2$ $H_2SO_4 + Mg \longrightarrow H_2 + MgSo_4$ $6HC_2H_3O_2 + 2Al \longrightarrow 3H_2 + Al(C_2H_3O_2)_3$ $3Zn + 8HNO_3 \longrightarrow \#Zn(NO_3)_2 + 2NO + 4H_2O$
▪ **Reaction with base** acid + base ⟶ salt + water	$HBr + KOH \longrightarrow KBr + H_2O$ $2HNO_3 + Ca(OH)_2 \longrightarrow Ca(NO_3)_2\_2H_2O$ $2H_3PO_4 + 3Ba(OH)_2 \longrightarrow Ba(PO_4)_2 + 6H_2O$
▪ **Reaction with metal oxides** acid + metal oxide ⟶ salt + water	$2HCl + Na_2O \longrightarrow 2NaCl + H_2O$ $H_2SO_4 + MgO \longrightarrow MgSO_4 + H_2O$ $6HCl + Fe_2O_3 \longrightarrow 2FeCl_3\_3H_2O$
▪ **Reaction with carbonates** acid + carbonate ⟶ salt + water + CO_2	$2HCl\_Na_2CO_3 \longrightarrow 2NaCl + H_2O + CO_2$ $H_2SO_4 + MgCO_3 \longrightarrow MgSO_4 + H_2O + CO_2$ $HCl + NaHCO_3 \longrightarrow NaCl + H_2O + CO_2$

Table: 2.3 Reactions of bases

1. Reaction with acids **2. Amphoteric hydroxides** hydroxide of certain metals – Zn, Al, Cr are amphoteric, they are capable of reacting with either an acid or a base.	$Zn(OH)_2 + 2HCl \longrightarrow ZnCl_2 + 2H_2O$ $Zn(OH)_2 + 2NaOH \longrightarrow Na_2Zn(OH)_4$
Reaction of NaOH and KOH with certain metals base + metal + water ⟶ salt + hydrogen	$2NaOH + Zn + H_2O \longrightarrow Na_2Zn(OH)_4 + H_2$ $2KOH + 2Al + 6H_2O \longrightarrow 2KAl(OH)_4 + 3H_2$

Indicators: Indicators are substances which indicate the acidic or basic nature of the solution by their colour change.

Natural indicators – Litmus solution, turmeric.

Synthetic indicators – Methyl Orange, Phenolphthalein, Methylene blue, etc.

Olfactory Indicators: Those substances whose smell changes in acidic or basic solution are called olfactory indicators e.g. onion and vanilla extract. The colour of some acid– base indicators in acidic and basic medium are given below:

Table: 2.4

Sr. No	Indicators	Colour in acidic medium	Colour in basic medium
1.	Litmus solution	Red	Blue
2.	Methyl Orange	Pink	Orange
3.	Phenolphthalein	Colourless	Pink
4.	Methyl red	Yellow	Red

Salts: Most of the rocks and minerals of Earth's mantle are salts of one kind or another huge quantity of dissolved salts exist in the ocean salts can be considered compounds derived from acids and bases.

$$NaOH_{(base)} + HCI_{(acid)} \longrightarrow NaCI_{(salt)}$$

Salts are usually crystalline and have high melting point and boiling point.

- **Neutral Salts:** Strong Acid + Strong base pH value is 7, e.g. $NaCl, CaSO_4, KNO_3$.
- **Acidic Salts:** Strong Acid + weak base pH value is less than 7, e.g. NH_4Cl, NH_4, NO_3.
- **Basic Salts:** Strong base + weak acid pH value is more than 7, e.g. $CaCO_3$, CH_3COONa.

Electrolytes: Substances whose aqueous solutions are conductors of electricity; all electrolytes divided into two groups; Strong and Weak electrolytes. Strong electrolytes are

essentially 100% ionised in solution, *weak electrolytes* are much less ionised most salts are strong electrolytes acids and bases that are strong electrolytes are called strong acids and strong bases acids and bases that are weak electrolytes are called weak acids and weak bases for equivalent concentrations, solutions of strong electrolytes contain many more ions than do solutions of weak electrolytes.

Example: 1 M HCl and 1 M $HC_2H_3O_2$. Strong base NaOH and weak base NH_3 can be distinguished in a similar fashion.

Strong Base and Weak Base

The strength of a base is determined by the amount of hydroxide ions (OH^-) that the base provides when dissolved in water. Some of the bases, when dissolved in water, get almost completely dissociated to provide hydroxide ions. These bases are called strong bases. (Bases soluble in water are also called alkalis.) For example, sodium hydroxide and potassium hydroxide are strong bases. But there are bases which, when dissolved in water get only partially dissociated to give hydroxide ions. These are weak bases. For example, magnesium hydroxide and ammonium hydroxide are weak bases.

- **Strong acids:** $(H_2SO_4, HNO_3, HCl, HClO_4)$,
- **Strong base:** $KOH, NaOH, Ba(OH)_2$
- **Weak acids:** $(CH_3COOH, HCOOH, HF)$,
- **Weak base:** $NH_4OH, Ca(OH)_2$.

A double arrow $(\rightleftarrows)$ is used in the ionisation equation of soluble weak electrolyte to indicate that the solution contains a considerable amount of the un-ionised compound in equilibrium with its ions in the solution a single arrow $(\longrightarrow)$ is used to indicate that the electrolyte is essentially all in the ionic form in the solution.

Example: nitric acid a strong acid nitrous acid a weak acid

$$HNO_3(aq) \longrightarrow H^+(aq) + NO^{3-}(aq)$$

$$HNO_2 + (aq) \rightleftarrows H + (aq) + NO^{2-}(aq)$$

Pure water is a very weak electrolyte; ionization of water

$$H_2O + H_2O \rightleftarrows H_3O^+ + OH$$

acid base acid base

$$H_2O \rightleftarrows H^+ + OH$$

At 25ºC, the concentration of H^+ and OH^- is 1.0 × 10–7 M

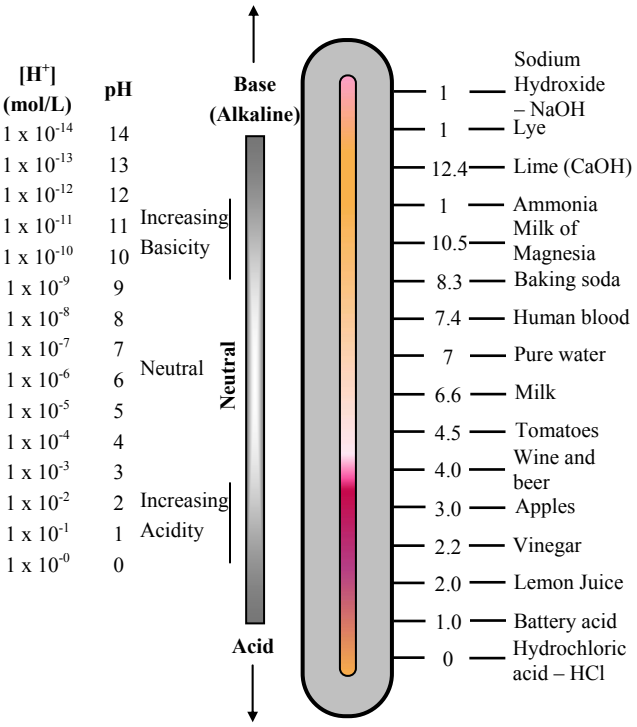
$$[H^+] = 1.0 \times 10 - 7M$$

$$[OH^-] = 1.0 \times 10 - 7M$$

Introduction to pH: The acidity of an aqueous solution depends on the concentration of hydrogen ions. The pH of pure water at 25ºC is 7 pH < 7.00 is an **acidic** solution pH = 7.00 is a **neutral** solution pH > 7.00 is a **basic** solution the smaller the pH value, the more acidic the solution. The pH scale of acidity (–) negative logarithm of the H^+ concentration in moles per litre.

$$pH = -\log\left[H^+\right]$$

pH Scale for Expressing Acidity



Some Important Chemical Compounds:

- **Common Salt (NaCl):** *Sodium chloride* is known as common salt. Its main source is sea water. It is also exists in the form of rocks and is called rock salt. Common salt is an important component of our food. It is also used for preparing sodium hydroxide, baking soda, washing soda, etc.
- **Sodium Hydroxide or Caustic Soda (NaOH)** is prepared by passing electricity through an aqueous solution of sodium chloride also known as ***brine.***

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

This process is known as **chlor-alkali** process because of the product formed (Chlor; chlorine and Alkali; NaOH)

Properties:

- It is white translucent solid.
- Crystals of sodium hydroxide are deliquescent.
- It is readily soluble in water and gives strong alkaline solution.
- **Bleaching Powder** $(CaOCl_2)$: Its chemical name is calcium oxychloride. It is prepared by passing chlorine gas through dry slaked lime.

$$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$$

Uses:

- For bleaching cotton and linen in textile industry and wood pulp in paper industry. Using for disinfecting drinking water.
- **Baking Soda** $(NaHCO_3)$: Chemical name is sodium hydrogen carbonate. It is prepared by passing CO_2 gas through brine solution saturated with ammonia.

$$NaCl + H_2O + CO_2 + NH_3 \longrightarrow NH_3Cl + NaHCO_3$$

Properties:

- It is white crystalline solid and sparingly soluble in water at room temperature.
- On heating it decomposes to give sodium carbonate and carbon dioxide.
- It reacts with acids to give carbon dioxide gas.
- It aqueous solution is weak alkaline due to hydrolysis.

Uses:

- It is used in soda–acid fire extinguisher.
- It acts as mild antiseptic and antacid.

Washing Soda $(Na_2CO_3.10H_2O)$:

Its chemical name is sodium carbonate decahydrate. It is prepared by heating baking soda. Re-crystallisation of sodium carbonate gives washing soda.

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

$$Na_2CO_3 + 10H_2O \longrightarrow Na_2CO_3 \cdot 10H_2O$$

Uses:

- It is used for removing permanent hardness of water and used in glass, soap and paper industries.
- It can be used as a cleaning agent for domestic purposes.

Plaster of Paris $\left(CaSO_4 \cdot \frac{1}{2}H_2O\right)$**:**

Its chemical name is calcium sulphate hemihydrates. It is obtained by heating gypsum up to 373 K.

$$CaSO_4 \cdot 2H_2O \longrightarrow CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O$$

On treatment with water it is again converted into gypsum and sets as a hard mass.

$$CaSO_4\,\frac{1}{2}H_2O + 1\frac{1}{2}H_2O \longrightarrow CaSO_4 \cdot 2H_2O$$

Uses:

- It is used by doctors for setting fractured bones.
- It is used for making statues, models and other decorative materials.

Multiple Choice Questions

1. Acids react with metals to liberate _____ gas
a. Carbon dioxide **b.** Carbon monoxide
c. Hydrogen **d.** Water

2. Which of following is a dibasic acid?
a. HCl **b.** H_3PO_4 **c.** HNO_3 **d.** H_2SO_4

3. Lime water turns milky when carbon dioxide is passed due to the formation of _____
a. $CaCO_3$ **b.** CaO **c.** CO_2 **d.** $CaSO_4$

4. The milkiness (on passing excess carbon dioxide gas through lime water) disappears due to the formation of
a. Calcium carbonate ($CaCO_3$)
b. Calcium hydrogen carbonate ($CaHCO_3$)
c. Calcium oxide (CaO)
d. Calcium Nitrate $(Ca(NO_3)_2)$

5. Milk of magnesia is an
a. Acid **b.** Antacid
c. Rock salt **d.** Alkali

6. Acidity of aluminum hydroxide is
a. 1 **b.** 2
c. 3 **d.** 4

7. Basicity of acetic acid is
a. 4 **b.** 3
c. 2 **d.** 1

8. A compound formed by the reaction of an acid with base is
a. Indicator **b.** Vitamins
c. Salt **d.** All of these

9. Partial neutralisation of a polybasic acid gives
a. Acid salt **b.** Basic salt
c. Normal salt **d.** Double salt

10. A salt that contains a hydroxyl group is

a. Acid salt **b.** Basic salt

c. Normal salt **d.** Double salt

11. The salt which contains two different negative and/or positive ion is

a. Basic salt **b.** Normal salt

c. Acid salt **d.** Double salt

12. Acids react with bases to form salt and water. This reaction is known as

a. Combination **b.** Decomposition

c. Neutralisation **d.** Reduction

13. Potash alum is a

a. Simple salt **b.** Complex salt

c. Double salt **d.** Acid salt

14. Which type of salts are stored in air tight containers?

a. Anhydrous **b.** Hydrated

c. Dehydrated **d.** Deliquescence

15. Why does dry HCl gas not change the colour of the dry litmus paper?

a. Blue litmus becomes dry in presence of dry HCl gas

b. NaH_3O^+ ions will be present, litmus changes colour only in the presence of H_3O^+ ions

c. HCl gas acts as a dehydrating agent

d. None of the above

16. Epsom salt is

a. $CuSO_4$ **b.** $CaSO_4$

b. Na_2SO_4 **d.** $MgSO_4$

17. When a bee stings, immediately a paste of lime is put on the sting. Why?

a. Bee sting is made of a base

b. Bee sting contains an acid called formic acid. It gets neutralised with CaO

c. Bee sting is acidic due to hydrochloric acid and this is neutralised

d. All of the above

18. Which of the following ions is furnished by acids in aqueous solution?

a. OH^- ions **b.** H^+ ions

c. H_3O^+ ions **d.** None of these

19. Which of the following is acidic in nature?

a. Apple juice **b.** Soap solution

c. Slaked lime **d.** Lime

20. Which of following acids is called the king of the acids?

a. Acetic acid **b.** Phosphoric acid

c. Oxalic acid **d.** Sulphuric acid

21. Vitamin C is an organic acid known as

a. Ascorbic acid **b.** Citrus acid

c. Glycolic acid **d.** Acetic acid

22. Sodium bi-carbonate is used as

a. Baking soda **b.** Fire extinguisher

c. Antacid **d.** All of these

23. Which of the following is an organic acid?

a. Sulphurous acid **b.** Nitric acid

c. Hydrochloric acid **d.** Formic acid

24. When bitten by ant, the sting causes irritation due to the presence of:

a. A base in the sting **b.** Formic acid in the sting

c. Poisonous chemicals **d.** Both (**a.**) and (**b.**)

25. The substance which indicates the presence of acid or base by change of its smell is known as

a. Household indicator **b.** Acid-base indicator

c. Olfactory indicator **d.** None of these

26. When marble chips are treated with HCl, which of the following gas is liberated

a. CO **b.** NO_2

c. CO_2 **d.** O_2

27. Which of following are made up of bases?

a. Antacid tablet **b.** Soap

c. Toothpaste **d.** All of these

28. Which base is soluble in water is:

a. Oxides **b.** Hydroxides

c. Alkalis **d.** All of these

29. Which of the following is a strong base?

a. Ammonium hydroxide **b.** Sodium hydroxide

c. Magnesium hydroxide **d.** Copper hydroxide

30. The base which do not contain metal is

a. Ammonium hydroxide **b.** Caustic soda

c. Caustic pattern **d.** Dolomite

31. Which of the following method is not used in preparing a base?

a. Burning of metal in air

b. Heating metal carbonates

c. Adding water to a metal oxide

d. Reaction between an acid and base

32. Which of the following methods is not used for preparing salt?
a. Reaction between an acid and a base
b. Action of acid on metals
c. Action of acid on metal oxide
d. Dissolution of acids in water

33. Electrorefining which is based on phenomenon of Electrolysis where
a. Impure metal is made anode and pure metal is cathode
b. Impure metal is cathode and pure metal is anode
c. Pure metal is cathode and pure metal is anode
d. None of the above

34. Which of the following may be regarded as weak electrolytes?
a. NaCl **b.** CH_3COONa
c. HCl **d.** CH_3COOH

35. Which of the following is an example of strong electrolyte?
a. NaOH **b.** NH_4OH solution
c. CH_3COONa **d.** HCN

36. The acidity and alkalinity of a compound is represented on a scale known as
a. pH Scale **b.** Hess scale
c. Kelvin scale **d.** None of these

37. The term 'pH' comes from
a. Hydrogen purity **b.** Pure hydrogen
c. Hydrogen power **d.** None of these

38. $-\log [H^+] =$ _____
a. Concentration of H^+ **b.** pH
c. pOH **d.** None of these

39. The pH value of blood is
a. 7.4 **b.** 7
c. 6.5 **d.** 6

40. The hydroxyl ion concentration of a solution is 0.00001 M, its pH is:
a. 8 **b.** 5
c. 9 **d.** 10

41. The pH value of 0.0001 molar acid is
a. 4 **b.** 6
c. 2 **d.** 0

42. An aqueous solution with pH valve zero is
a. Acidic **b.** Basic
c. Neutral **d.** Either acidic or basic

43. The pH of three solutions A, B, C is 6, 4, 8 receptivity which of the following is the correct option?
a. A > B > C decreasing acidic strength
b. C > B > A increasing acidic strength
c. B > A > C is decreasing acidic strength
d. C > B > A decreasing acidic strength

44. $Fe_2(SO_4)_3$ solution will
a. turn blue litmus red
b. turn red litmus blue
c. turn phenolphthalein solution pink
d. none of these

45. Which of following compound is an acid?
a. KOH **b.** ZnO
c. $Al(OH)_3$ **d.** NaCl

46. The compound formed during electrolysis of brine is
a. Cl_2 **b.** H_2
c. NaOH **d.** None of these

47. Brine is aqueous solution of
a. KCl **b.** NaCl
c. LiCl **d.** $MgCl_2$

48. Which one of the following types of medicines is used for treating indigestion?
a. Antibiotic **b.** Analgesic
c. Antacid **d.** Antiseptic

49. An acid used in lead storage batteries is
a. H_2SO_4 **b.** HNO_3
c. HCl **d.** CH_3COOH

50. Which of the following acid is used by goldsmiths for cleaning gold and silver ornaments?
a. HCl **b.** H_2SO_4
c. HNO_3 **d.** H_3PO_4

51. The acid used in the manufacture of glass is
a. Ascorbic acid **b.** Tartaric acid
c. Phosphoric acid **d.** Boric acid

52. Which of the following acid is present in vinegar?
a. Acetic acid **b.** Lactic acid
c. Malic acid **d.** None of these

53. Soft drink contain
a. Acetic acid **b.** Carbonic acid
c. Tartaric acid **d.** Nitric acid

54. Which of the following acid is used in fire extinguishers?
a. Oxalic acid **b.** Nitric acid
c. Sulphuric acid **d.** Hydrochloric acid

55. Alkalis turn methyl orange
a. Red **b.** Pink
c. Yellow **d.** Colourless

56. A solution of sodium chloride will turn
a. Red litmus blue
b. Blue litmus red
c. Red litmus orange
d. Not change the colour of either red, blue litmus

57. The incorrect statement about acids is:
a. They give H^+ ion in water
b. They turn blue litmus red
c. They are sour in taste
d. They give pink colour with phenolphthalein

58. When a little sulphur in a spoon is heated, it burns with a blue flame which slowly disappears after some time and we can feel a pungent odour, this pungent odour is due to
a. Carbon dioxide **b.** Sulphur dioxide
c. Sulphur gas **d.** Sulphuric acid

59. Fixed number of water molecules chemically attached to each formula unit of salt in its crystalline form is known as
a. Water of crystallisation
b. Heat of hydration
c. Hydrated crystal
d. None of these

60. Which of the following is spread on icy roads to melt ice cold countries?
a. Sodium bicarbonate **b.** Sodium hydroxide
c. Rock salt **d.** None of these

61. Many salts absorb water from the atmosphere, this property is called
a. Hydration **b.** Dehydration
c. Deliquescence **d.** Efflorescence

62. The loss of water of crystallis/ation to the atmosphere by a compound is termed
a. Hydrolysis **b.** Dehydration
c. Deliquescence **d.** Efflorescence

63. Baking powder is a mixture of $NaHCO_3$ and _____
a. Tartaric acid **b.** Ascorbic acid
c. Citric acid **d.** Formic acid

64. The acid used to produce explosives is
a. HNO_3 **b.** H_2SO_4
c. HCl **d.** H_3PO_4

65. Acids are always stored in containers made of
a. Plastic **b.** Glass
c. Metals **d.** Clay

66. The substance which on treating with chlorine, yields bleaching powder is
a. Quick lime **b.** Limestone
c. Slaked lime **d.** Gypsum

67. When a gas is passed through dry slaked lime, an oxidising agent is produced, then the gas is
a. H_2 **b.** O_2
c. N_2 **d.** Cl_2

68. Fats + NaOH $\longrightarrow$ _____ + Glycerol, one of the product formed in this reaction is
a. Cloth **b.** Paper
c. Wood **d.** Soap

ANSWERS

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
c	d	a	b	d	c	d	c	a	b
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
d	c	c	d	b	d	b	c	a	d
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
a	d	d	b	c	c	d	c	b	a
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
c	d	a	d	a	a	c	b	a	c
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**
a	a	c	a	d	c	b	c	a	c
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
d	a	b	c	a	d	d	b	a	c
61.	**62.**	**63.**	**64.**	**65.**	**66.**	**67.**	**68.**		
c	d	a	a	a	c	d	d		

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