BDOC

Bangladesh Olympiad Challenge

Chemistry Olympiad 2026

Chemistry Olympiad Preparation Book

Junior Category (Class 6–8)

1. Structure of Matter and Atoms
   Elements, atoms, molecules, isotopes, ions
2. Chemical Reaction
   Valency, equations, types of reactions, electrolysis
3. Acid, Base and Salt
   Indicators, properties, neutralization, pH

200 Multiple Choice Questions with Answer Key

BDOC Academic Panel

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Preface

Dear Students,

Chemistry is present in everything around us, from the salt in our kitchen to the rust on iron. This book has been prepared for the Junior Category of the BDOC Chemistry Olympiad 2026. Everything you need to know for this competition is included in this book, so reading it carefully will fully prepare you. Read each chapter with attention and try to solve the questions at the end on your own. Best wishes to all of you.

BDOC Academic Panel
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Chapter One

Structure of Matter and Atoms

Books, food, chairs, water, air, soil, iron, copper, sugar and salt around us are all **matter**. But what are they actually made of? Why are iron and sugar so different? In this chapter we will keep breaking matter down until we reach the tiny particles deep inside it.

After studying this chapter, we will be able to:

- differentiate between elements, compounds and mixtures
- explain the difference between atoms and molecules
- read and write symbols and formulae
- explain the structure of the atom (electron, proton, neutron)
- find the number of particles from atomic number and mass number
- explain isotopes and their uses
- write the electron distribution of atoms
- explain how cations and anions are formed

1.1 What Is Matter Made Of? Element, Compound and Mixture

The main reason why one kind of matter differs from another is its **constituents** and its **structure**. When the constituents and structure are different, the properties are also different. Based on structure, all matter can be divided into three groups.

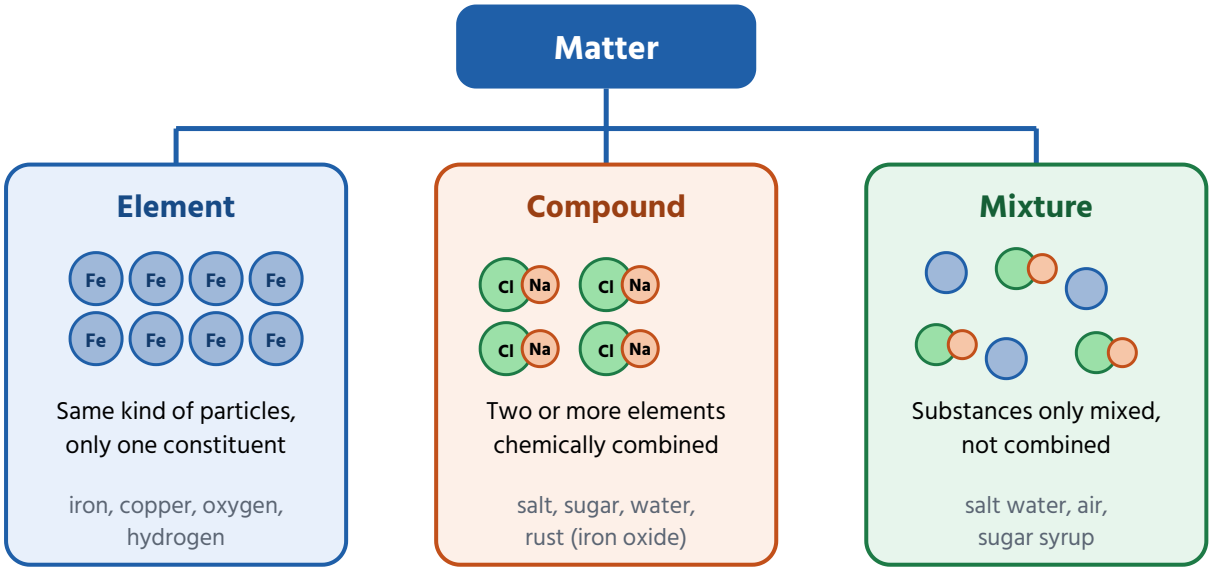


Figure 1.1: Three kinds of matter based on structure

Definitions

Element: Matter that is made of only one constituent is called an element. Examples: iron, copper, hydrogen, oxygen. If iron is broken, only tiny particles of iron are obtained.

Compound: Matter that is made of more than one constituent (element) with different properties is called a compound. Examples: common salt (sodium + chlorine), sugar (carbon + hydrogen + oxygen).

Mixture: When more than one substance is simply mixed together, it is called a mixture. Examples: salt water, air.

Example: Rusting of iron

If an iron rod (an element) is kept outside for a few days, a reddish-brown layer of rust forms. In the presence of water vapour, iron (an element) reacts with another element, oxygen, and forms a compound called **iron oxide**. So a compound is made of two or more elements.

Think about it

Air is a mixture. It contains elements like nitrogen and oxygen, and also compounds like water vapour and carbon dioxide. In salt water, both water and salt are compounds. So a mixture can contain both elements and compounds.

1.2 The Atom: The Idea of the Smallest Particle

If we keep breaking an element, we finally get particles so tiny that they cannot be seen with the bare eye. Over time, scientists and philosophers have given different ideas about these particles.

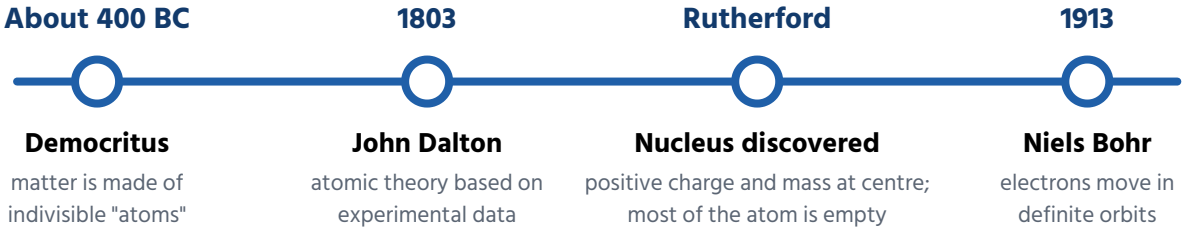


Figure 1.2: How the idea of the atom developed

In about **400 BC**, the Greek philosopher **Democritus** said that every kind of matter is made of tiny particles that cannot be broken any further. He called them **atoms**. The word comes from the Greek word *Atomos*, which means **indivisible**. Two philosophers of his time, **Plato** and **Aristotle**, opposed this idea. According to Aristotle, matter is continuous and can be divided without limit.

Dalton's Atomic Theory (1803)

1. Elements are made of extremely small particles called **atoms**.
2. All atoms of an element are identical in size, mass and chemical properties.
3. Atoms of different elements differ in size, mass and properties.
4. Compounds are made of more than one element; atoms of different elements combine in **simple whole-number ratios** to form compounds.
5. In chemical reactions, atoms are neither created nor destroyed; they are only joined or separated.

Careful: one of Dalton's ideas was proved wrong

Dalton said atoms are indivisible. But it has now been proved that atoms can be divided. Inside them are **electrons, protons and neutrons**. So the atom is not "indivisible".

1.3 The Molecule: When Atoms Join Together

Atoms usually cannot stay free or independent. Two or more atoms join together to form a **molecule**. A molecule can stay free and independent.

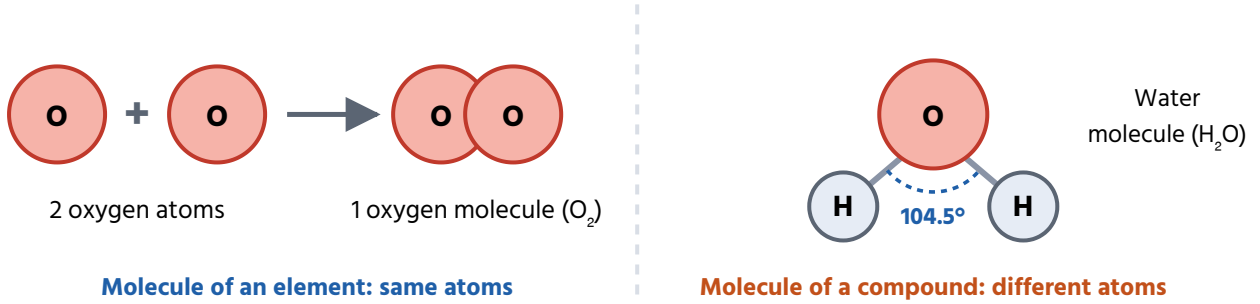


Figure 1.3: An oxygen molecule (molecule of an element) and a water molecule (molecule of a compound). In water, the two hydrogen atoms form an angle of 104.5° with the oxygen atom.

Molecule of an element

Two or more atoms of the same element join. Example: two oxygen atoms form one oxygen molecule O_2. Breaking an oxygen molecule gives two oxygen atoms again.

Molecule of a compound

Atoms of different elements join. Example: one oxygen atom and two hydrogen atoms form one water molecule H_2O.

If we keep dividing a drop of water, we finally get a particle that can stay free and has all the properties of water. This is a **molecule of water**. If a water molecule is broken further, the particles we get (1 O atom and 2 H atoms) cannot stay free, and they have none of the properties of water.

Point	Atom	Molecule
Definition	The smallest particle of an element	Particle formed by two or more atoms; the smallest particle of a compound
Free existence	Usually cannot stay free	Can stay free
Examples	H, O, N, Na	H_2, O_2, H_2O, CO_2

Know a little more

Noble gases such as helium (He) and neon (Ne) can stay free as single atoms. Their molecules are made of just one atom. You will learn why in section 1.9.

1.4 Symbol and Formula

So far **118 elements** are recognised. Most of them are found in nature, and some have been made artificially in laboratories. To write the name of each element in short, a **symbol** is used.

Rules for writing symbols

- A symbol is made from the first one or two letters of the English, Latin or Greek name of the element.
- A one-letter symbol is written as a **capital letter**: H, O, N, C.
- In a two-letter symbol, **the first letter is capital and the second is small**: He, Ca, Cl, Mg.

Element	Symbol	From the name
Hydrogen	**H**	Hydrogen
Helium	**He**	Helium
Carbon	**C**	Carbon
Nitrogen	**N**	Nitrogen
Oxygen	**O**	Oxygen
Chlorine	**Cl**	Chlorine
Calcium	**Ca**	Calcium
Magnesium	**Mg**	Magnesium

Element	Symbol	From the Latin name
Sodium	**Na**	Natrium
Potassium	**K**	Kalium
Iron	**Fe**	Ferrum
Copper	**Cu**	Cuprum
Silver	**Ag**	Argentum
Gold	**Au**	Aurum
Lead	**Pb**	Plumbum
Tin	**Sn**	Stannum

Formula

The short expression of a molecule is called a **formula**. A formula is written with the symbols of the atoms that form the molecule. A small number written at the lower right of a symbol (subscript) shows the number of atoms.

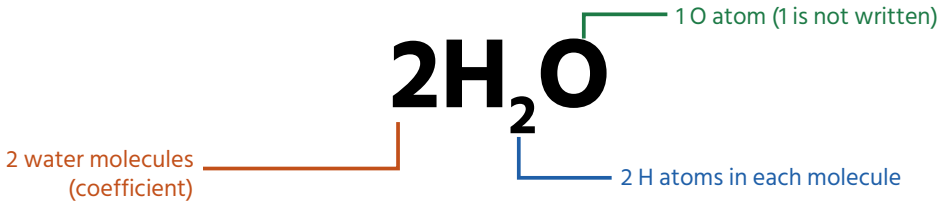


Figure 1.4: What a formula tells us. Here, total H atoms = 2 × 2 = 4 and O atoms = 2.

Formulae of elements: In many solid and liquid elements (such as sodium, copper and iron), countless atoms stay together without forming separate molecules, so their formula is the same as their symbol. In most gaseous elements two atoms form a molecule, so 2 is written as a subscript:

Element	Hydrogen	Nitrogen	Oxygen	Fluorine	Chlorine	Bromine (liquid)	Iodine (solid)
Formula	H_2	N_2	O_2	F_2	Cl_2	Br_2	I_2

Formulae and names of compounds: The formula of a compound tells us which elements it is made of and in what ratio.

Feature of the name	Formula	Name	Made of
Metal (sometimes non-metal) + non-metal: the name ends with **-ide**	NaCl	Sodium chloride	Sodium and chlorine
	CaO	Calcium oxide	Calcium and oxygen
	KI	Potassium iodide	Potassium and iodine
	CO_2	Carbon dioxide	Carbon and oxygen
A group of atoms made of a non-metal and some oxygen atoms joins a metal: the name ends with **-ite** or **-ate**	$CaSO_4$	Calcium sulphate	Calcium and sulphate
	$CaSO_3$	Calcium sulphite	Calcium and sulphite
	KNO_3	Potassium nitrate	Potassium and nitrate
	Na_2CO_3	Sodium carbonate	Sodium and carbonate

Remember

A group ending in -ate has more oxygen; the one ending in -ite has one oxygen less. Examples: sulphate SO_4, sulphite SO_3; nitrate NO_3, nitrite NO_2.

1.5 What Is Inside an Atom?

Atoms are so small that they cannot be seen with the bare eye or even with an ordinary microscope; they can be seen with an **electron microscope**. When an atom is divided, three fundamental particles are found: **electrons, protons and neutrons**.

Rutherford and his co-workers carried out an important experiment. They concluded that all the positive charge and almost all the mass of an atom is in a small region at its centre, now called the **nucleus**. Most of the space in an atom is **empty**. Negatively charged electrons, whose mass is negligible, revolve around the centre, like planets around the Sun. But Rutherford did not explain the exact paths of the electrons. In **1913, Niels Bohr** said that electrons revolve in certain **definite orbits**.

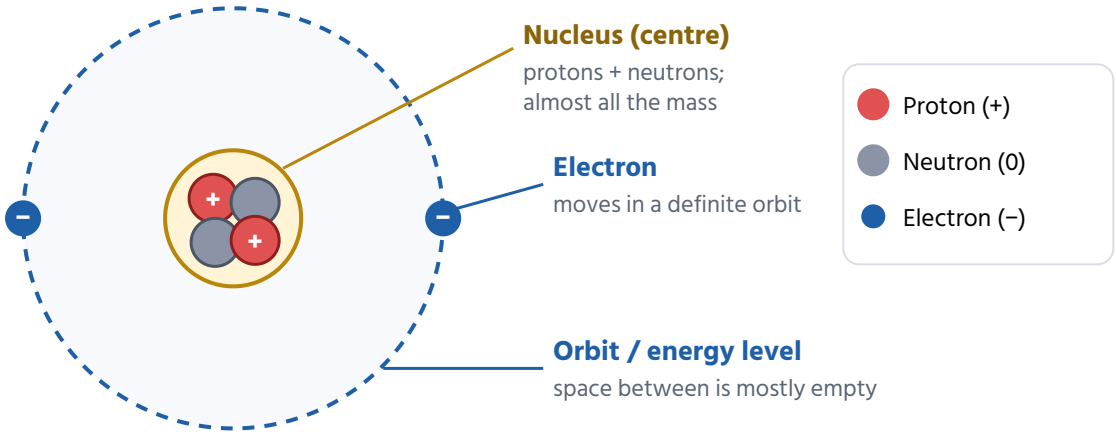


Figure 1.5: Structure of a helium atom: 2 protons and 2 neutrons in the nucleus, 2 electrons outside

Particle	Charge	Where it is found	Mass
Proton (p)	Positive (+)	In the nucleus	Almost equal to a neutron
Neutron (n)	No charge (neutral)	In the nucleus	Almost equal to a proton
Electron (e)	Negative (−)	In orbits around the nucleus	Negligible (almost zero)

Remember

- In a normal atom, **number of protons** = **number of electrons**, so the atom has no net charge.
- Only the **ordinary hydrogen** atom has no neutron in its nucleus: just 1 proton, with 1 electron outside.
- Helium: 2 protons, 2 neutrons, 2 electrons. Oxygen: 8 protons, 8 neutrons, 8 electrons.

1.6 Atomic Number and Mass Number

Why is a hydrogen atom different from an oxygen atom? Because they have different numbers of protons and electrons. An atom's identity is decided by its number of protons.

Atomic number (Z)

The number of protons in the nucleus of an atom is its atomic number.

Z = number of protons = number of electrons

Mass number (A)

The total number of protons and neutrons in the nucleus is the mass number. (Electrons are not counted because their mass is negligible.)

A = protons + neutrons



Figure 1.6: The mass number is written at the top left of the symbol and the atomic number at the bottom left

The most useful formula

Number of neutrons = mass number − atomic number $(n = A - Z)$

The atomic number alone cannot tell the number of neutrons; the mass number must also be known.

Example

The atomic number of an element A is 17 and its mass number is 35. How many protons, electrons and neutrons are in one atom?

Solution: Atomic number = number of protons = **17**. In a normal atom, electrons = protons = **17**. Neutrons = mass number − protons = 35 − 17 = **18**. (This is chlorine, Cl.)

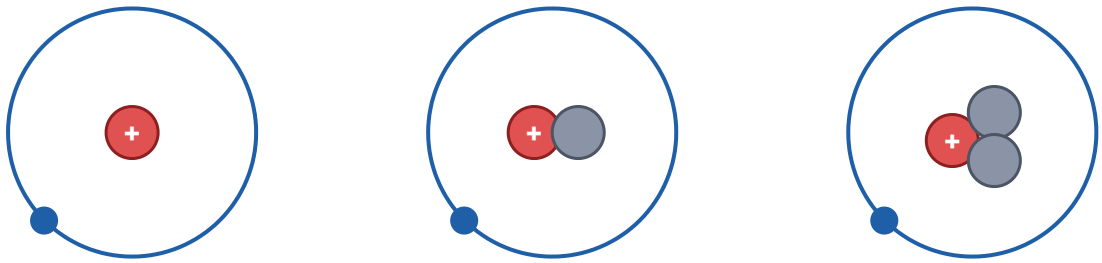
Element	Symbol	Atomic number	Mass number	Protons	Electrons	Neutrons
Hydrogen	H	1	1	1	1	0
Helium	He	2	4	2	2	2
Carbon	C	6	12	6	6	6
Nitrogen	N	7	14	7	7	7
Oxygen	O	8	16	8	8	8
Sodium	Na	11	23	11	11	12
Magnesium	Mg	12	24	12	12	12
Aluminium	Al	13	27	13	13	14
Chlorine	Cl	17	35	17	17	18

1.7 Isotopes

Every atom of an element has a fixed number of protons and electrons. But atoms of the same element can have **different numbers of neutrons**, so their mass numbers can also be different.

Definition

Atoms of the same element that have the **same number of protons and electrons** but **different mass numbers** (that is, different numbers of neutrons) are called **isotopes** of that element.



Protium
1p, 0n · mass number 1

Deuterium
1p, 1n · mass number 2

Tritium
1p, 2n · mass number 3

Figure 1.7: The three isotopes of hydrogen. Each has 1 proton and 1 electron; only the number of neutrons is different.

In the same way, most carbon atoms have 6 protons and 6 neutrons, but some carbon atoms have 7 or 8 neutrons. So carbon mainly has **three isotopes**: carbon-12, carbon-13 and carbon-14.

Properties of isotopes

- Isotopes of an element have the same number of protons and electrons, so their **chemical and electrical properties are the same**. (The chemical properties of an atom depend on its electron distribution.)
- Their **masses are different**, and this difference can be used to separate them.
- Usually the most stable isotope is the most common in nature. Unstable isotopes break down and give out radiation and particles. They are called **radioactive isotopes**.

Uses of radioactive isotopes

In medicine

To diagnose and treat diseases: detecting narrowed arteries, locating and destroying cancer cells, and sterilizing medical instruments.

In agriculture

To control insects, and to find out when, what kind and how much fertilizer a crop needs.

In food preservation

Radiation kills germs and bacteria, so food and fruits can be kept germ-free.

In geological research

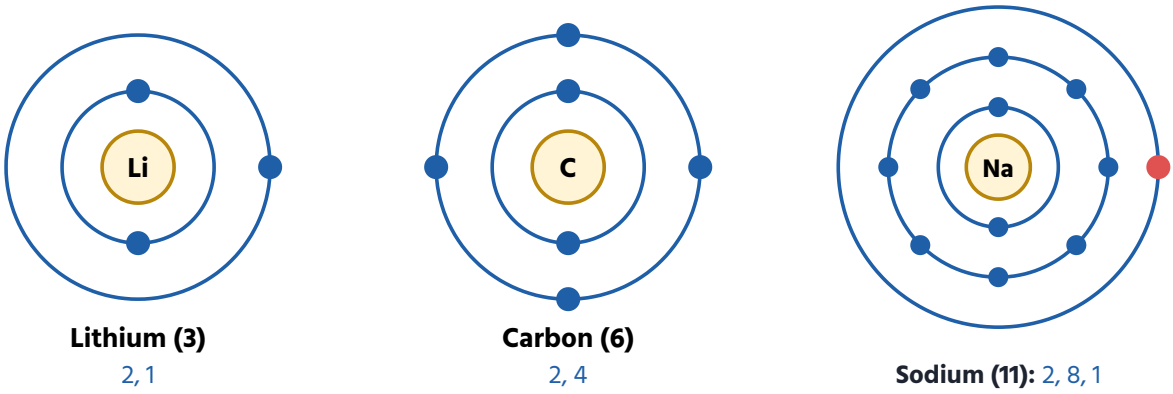
By studying the ratio of stable to unstable isotopes, scientists can find the age of fossils that are millions of years old.

1.8 Electron Distribution: How Many Electrons in Each Orbit?

Electrons revolve around the nucleus in definite orbits. An electron in each orbit has a definite energy, so the orbits are also called **energy levels**. The rule for the maximum number of electrons in an orbit is $\mathbf{2n^2}$ (where n = orbit number 1, 2, 3 ...).

Orbit (n)	1st (n = 1)	2nd (n = 2)	3rd (n = 3)	4th (n = 4)
Maximum electrons = $2n^2$	$2 \times 1^2 = \mathbf{2}$	$2 \times 2^2 = \mathbf{8}$	$2 \times 3^2 = \mathbf{18}$	$2 \times 4^2 = \mathbf{32}$

Electrons first fill the inner orbits and then go to the outer ones. For example, lithium has 3 electrons: 2 in the first orbit and 1 in the second, written as **2, 1**.



Lithium (3)
2, 1

Carbon (6)
2, 4

Sodium (11): 2, 8, 1

Figure 1.8: Electron distribution of lithium, carbon and sodium. Sodium has only 1 electron (red) in its last orbit.

Element	Z	Distribution	Element	Z	Distribution	Element	Z	Distribution
H	1	1	N	7	2, 5	Al	13	2, 8, 3
He	2	2	O	8	2, 6	Si	14	2, 8, 4
Li	3	2, 1	F	9	2, 7	P	15	2, 8, 5
Be	4	2, 2	Ne	10	2, 8	S	16	2, 8, 6
B	5	2, 3	Na	11	2, 8, 1	Cl	17	2, 8, 7
C	6	2, 4	Mg	12	2, 8, 2	Ar	18	2, 8, 8

1.9 Electron Distribution and Properties: Ions

The properties of an element mainly depend on its **electron distribution**. Because of differences in electron distribution, atoms can be active, inactive or charged.

Inert atoms

If the last orbit has the maximum number of electrons it can hold, the orbit is full and the atom is **inert** and stable. For example, helium has 2 electrons and its first orbit can hold only 2, so helium is inert. Every atom tends to reach such a stable state.

If the last orbit is not full, an atom tends to **lose** or **gain** electrons to make it full. Then the numbers of protons and electrons are no longer equal, and the atom becomes charged. **A charged atom is called an ion.**

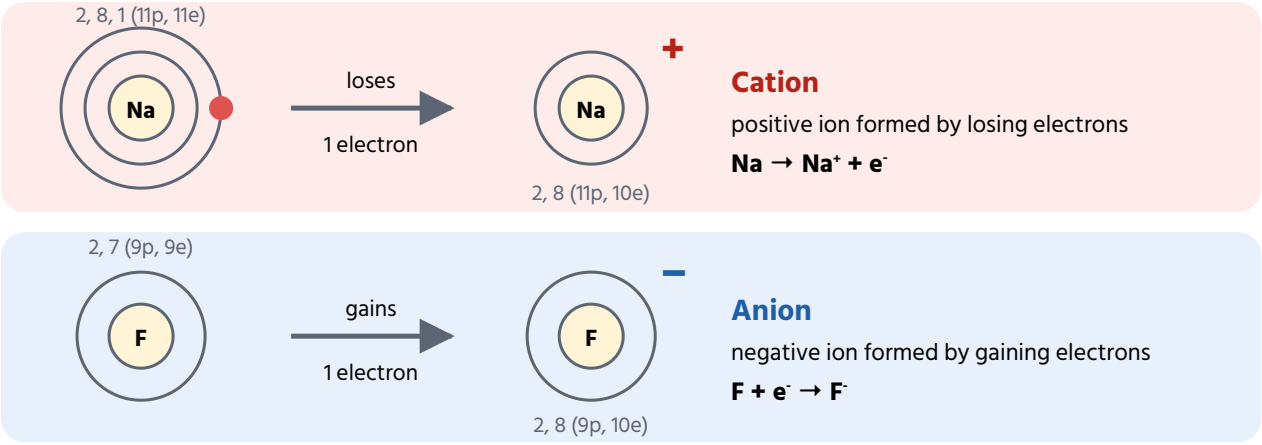


Figure 1.9: Sodium loses an electron to become a cation (Na^+), and fluorine gains an electron to become an anion (F^-)

Sodium (2, 8, 1): If it loses the single electron in its third orbit, its second orbit becomes the full outermost orbit. When a nearby atom wants an electron, sodium easily gives away 1 electron and becomes the positive ion $\mathbf{Na^+}$.

Fluorine (2, 7): It needs 8 electrons in its last orbit to be stable. Gaining 1 electron is much easier in terms of energy than losing 7. So fluorine gains 1 electron and becomes the negative ion $\mathbf{F^-}$.

The two oppositely charged ions attract each other and form a bond. A compound formed from ions in this way is called an **ionic compound**:

$$\mathbf{Na + F \longrightarrow Na^+F^- \text{ or } NaF}$$

sodium fluoride

Know a little more: ionic compounds have no molecules

Solid sodium fluoride (NaF) does not contain separate molecules. Instead, countless Na^+ and F^- ions are arranged side by side in a regular pattern called a **lattice**. The formula NaF only tells us that Na^+ and F^- ions are present in a 1 : 1 ratio. Common salt (NaCl) is also an ionic compound like this.

Remember

- **Cation** = positive ion formed by losing electrons (usually metals: Na^+, Mg^{2+}, Al^{3+}).
- **Anion** = negative ion formed by gaining electrons (usually non-metals: F^-, Cl^-, O^{2-}).
- When an ion forms, **the number of protons does not change**; only the number of electrons changes.

Know a little more

Magnesium (2, 8, 2) loses the 2 electrons of its last orbit to become Mg^{2+}. Oxygen (2, 6) gains 2 electrons to become O^{2-}. Chlorine (2, 8, 7) gains 1 electron to become Cl^-. Neon (2, 8) and argon (2, 8, 8) have 8 electrons in their last orbit, so they are inert.

1.10 Water: The Universal Solvent

Water can dissolve almost all kinds of organic and inorganic substances, which other solvents cannot. That is why water is called the **universal solvent**. Tests show that inorganic substances such as common salt, baking soda and copper sulphate, and organic substances such as sugar, vinegar, spirit, vitamin C and glucose, all dissolve in water. But not all of them dissolve in another solvent such as spirit.

Chapter summary

- Matter is of three kinds: element (one constituent), compound (two or more elements chemically combined) and mixture (substances only mixed).
- The smallest particle of an element is the atom; two or more atoms form a molecule; the smallest particle of a compound is the molecule.
- There are 118 recognised elements. The first letter of a symbol is capital and the second is small.
- The nucleus (protons + neutrons) is at the centre of the atom and electrons move in orbits around it; most of the atom is empty.
- Z = number of protons; A = protons + neutrons; neutrons = A − Z.
- Isotopes: same number of protons, different number of neutrons (mass number); same chemical properties.
- Maximum electrons in an orbit = $2n^2$: 2, 8, 18, 32.
- An atom with a full last orbit is inert. Losing electrons gives a cation, gaining gives an anion; opposite ions form ionic compounds (such as NaF, NaCl).

Exercise: Multiple Choice Questions (MCQ)

Choose the correct answer from the five options. Total questions: 70.

1. **What is matter made of only one constituent called?**
   (a) Element
   (b) Compound
   (c) Mixture
   (d) Solution
   (e) Alloy

2. **Which of the following is a compound?**
   (a) Iron
   (b) Common salt
   (c) Oxygen
   (d) Air
   (e) Copper

3. **Which of the following is a mixture?**
   (a) Water
   (b) Air
   (c) Sugar
   (d) Sodium chloride
   (e) Carbon dioxide

4. **Which elements is sugar made of?**
   (a) Carbon, hydrogen and oxygen
   (b) Sodium and chlorine
   (c) Carbon and oxygen
   (d) Hydrogen and oxygen
   (e) Carbon, nitrogen and oxygen

5. **What is the compound formed when iron rusts?**
   (a) Iron sulphide
   (b) Iron chloride
   (c) Iron oxide
   (d) Iron carbonate
   (e) Iron sulphate

6. **The word "atom" comes from the Greek word "Atomos". What does it mean?**
   (a) Tiny
   (b) Rotating
   (c) Charged
   (d) Invisible
   (e) Indivisible

7. **Who first said that matter is made of tiny indivisible particles?**
   (a) Aristotle
   (b) Democritus
   (c) John Dalton
   (d) Rutherford
   (e) Niels Bohr

8. **In which year did John Dalton give his atomic theory?**
   (a) 1703
   (b) 1830
   (c) 1903
   (d) 1913
   (e) 1803

9. **Which idea of Dalton's atomic theory was later proved wrong?**
   (a) Atoms are indivisible
   (b) Elements are made of tiny particles
   (c) Atoms of different elements are different
   (d) Atoms combine in simple ratios
   (e) Atoms are not created or destroyed in reactions

10. **According to Dalton, what happens to atoms in a chemical reaction?**
    (a) New atoms are created
    (b) Some atoms are destroyed
    (c) The mass of atoms changes
    (d) Atoms are only joined or separated
    (e) Atoms of one element change into atoms of another

11. **What is the formula of an oxygen molecule?**

(a) O
(b) O_3
(c) 2O
(d) O_2
(e) H_2O

12. **The smallest particle of a compound that can stay free and has all its properties is called:**

(a) atom
(b) electron
(c) molecule
(d) ion
(e) nucleus

13. **In a water molecule, what angle do the two hydrogen atoms make with the oxygen atom?**

(a) 90°
(b) 100°
(c) 120°
(d) 104.5°
(e) 180°

14. **Which of the following is a molecule of an element?**

(a) H_2O
(b) N_2
(c) CO_2
(d) NaCl
(e) NH_3

15. **How many elements are recognised so far?**

(a) 92
(b) 98
(c) 108
(d) 120
(e) 118

16. **From which name does the symbol Na of sodium come?**

(a) Sodium
(b) Nitrium
(c) Neon
(d) Natron
(e) Natrium

17. **Which symbol is written correctly?**

(a) CL
(b) mg
(c) Cl
(d) cA
(e) HE

18. **Fe is the symbol of which element?**

(a) Fluorine
(b) Phosphorus
(c) Lead
(d) Iron
(e) Francium

19. **Which pair is correct?**

(a) Cu – copper
(b) K – calcium
(c) Ag – gold
(d) Pb – phosphorus
(e) Sn – sulphur

20. **How many hydrogen atoms in total does $2H_2O$ show?**

(a) 4
(b) 2
(c) 3
(d) 5
(e) 6

21. **What is the name of the compound $CaSO_4$?**

(a) Calcium sulphate
(b) Calcium sulphide
(c) Calcium sulphite
(d) Copper sulphate
(e) Calcium oxide

22. **KNO_3 is made of which parts?**

(a) Potassium and nitrate
(b) Calcium and nitrate
(c) Potassium and nitrite
(d) Potassium and nitrogen
(e) Krypton and nitrate

23. **Which fundamental particle of the atom has no charge?**

(a) Electron
(b) Proton
(c) Neutron
(d) Ion
(e) Cation

24. **Where is the mass of an atom mainly concentrated?**

(a) In the first orbit
(b) In the last orbit
(c) In the nucleus
(d) In the electrons
(e) In the empty space between orbits

25. **From Rutherford's experiment we learn that:**
i. most of the space in an atom is empty
ii. the positive charge and mass are in a small region at the centre
iii. the atom is indivisible
Which of the following is correct?

(a) i
(b) ii
(c) i and ii
(d) ii and iii
(e) i, ii and iii

26. **Who gave the idea that electrons move in definite orbits?**

(a) Dalton
(b) Rutherford
(c) Democritus
(d) Niels Bohr
(e) Aristotle

27. **Which atom usually has no neutron in its nucleus?**

(a) Helium
(b) Hydrogen
(c) Lithium
(d) Oxygen
(e) Carbon

28. **What does atomic number mean?**

(a) Number of neutrons
(b) Total number of protons and neutrons
(c) Number of orbits
(d) Number of protons in the nucleus
(e) Total number of electrons and neutrons

29. **An atom has mass number 23 and atomic number 11. How many neutrons does it have?**

(a) 11
(b) 23
(c) 12
(d) 34
(e) 1

30. **An atom has 10 protons and 8 neutrons. What is its mass number?**

(a) 8
(b) 10
(c) 2
(d) 18
(e) 28

31. **Oxygen has atomic number 8 and mass number 16. The numbers of protons, neutrons and electrons in one atom are respectively:**

(a) 8, 16, 8
(b) 8, 8, 8
(c) 16, 8, 8
(d) 8, 8, 16
(e) 8, 16, 16

32. **Atomic number 17 and mass number 35: which element is it?**

(a) Sulphur
(b) Chlorine
(c) Argon
(d) Phosphorus
(e) Potassium

33. **Which two pieces of information are needed to find the number of neutrons in an atom?**

(a) Symbol and formula
(b) Mass number and atomic number
(c) Number of electrons and number of orbits
(d) Atomic number only
(e) Valency and number of electrons

34. **Atoms of the same element with the same number of protons but different mass numbers are called:**

(a) isotopes
(b) ions
(c) molecules
(d) radicals
(e) cations

35. **What is in the nucleus of deuterium?**

(a) 1 proton
(b) 1 proton and 2 neutrons
(c) 1 proton and 1 neutron
(d) 2 protons and 2 neutrons
(e) 2 protons

36. **Why do isotopes of an element have the same chemical properties?**

(a) They have the same number and distribution of electrons
(b) They have the same mass
(c) They have the same number of neutrons
(d) They have the same mass number
(e) They are all radioactive

37. **How many main isotopes does carbon have?**

(a) 1
(b) 2
(c) 3
(d) 4
(e) 6

38. **Radioactive isotopes are used:**
i. to detect and destroy cancer cells
ii. to make fruits and food germ-free
iii. to find the age of fossils
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

39. **Which formula gives the maximum number of electrons in an orbit?**

(a) n^2
(b) 2n
(c) n + 2
(d) $2n^2$
(e) 8n

40. **What is the maximum number of electrons in the second orbit of an atom?**

(a) 2
(b) 18
(c) 32
(d) 10
(e) 8

41. **What is the electron distribution of sodium (atomic number 11)?**

(a) 2, 9
(b) 2, 8, 1
(c) 8, 2, 1
(d) 2, 7, 2
(e) 1, 8, 2

42. **How many electrons are in the last orbit of the element with atomic number 16?**

(a) 2
(b) 4
(c) 8
(d) 6
(e) 16

43. **The electron distribution is 2, 8, 7. Which element is it?**

(a) Fluorine
(b) Argon
(c) Sulphur
(d) Neon
(e) Chlorine

44. **Why is helium inert?**

(a) It has no neutron
(b) Its only orbit is full with 2 electrons
(c) It has many protons
(d) Its mass number is 4
(e) It loses electrons easily

45. **Which of the following elements is inert?**

(a) Sodium (2, 8, 1)
(b) Neon (2, 8)
(c) Fluorine (2, 7)
(d) Magnesium (2, 8, 2)
(e) Carbon (2, 4)

46. **What is formed when a sodium atom loses one electron?**

(a) Anion
(b) Isotope
(c) Neutral atom
(d) Molecule
(e) Cation

47. **How does a fluorine atom (2, 7) become stable?**

(a) By losing 7 electrons
(b) By losing 1 proton
(c) By gaining 1 electron
(d) By gaining 1 neutron
(e) By losing 2 electrons

48. **An ion has 11 protons and 10 electrons. Which ion is it?**

(a) F^-
(b) Ne
(c) Mg^{2+}
(d) Cl^-
(e) Na^+

49. **Which ion is formed when a magnesium atom (2, 8, 2) becomes an ion?**

(a) Mg^+
(b) Mg^-
(c) Mg^{2-}
(d) Mg^{2+}
(e) Mg^{3+}

50. **Which statement is NOT correct?**

(a) The number of protons does not change when an atom becomes an ion
(b) Water is the universal solvent
(c) The mass of an electron is negligible
(d) All isotopes of an element have the same mass number
(e) Air contains both elements and compounds

51. **What is the smallest particle of an element called?**

(a) Molecule
(b) Ion
(c) Atom
(d) Radical
(e) Electron

52. **According to Aristotle, what is matter like?**

(a) Continuous; it can be divided without limit
(b) Made of indivisible particles
(c) Made only of water
(d) Made of electrons
(e) Made of charged particles

53. **Which instrument is needed to see atoms?**

(a) Ordinary microscope
(b) Telescope
(c) Magnifying glass
(d) Prism
(e) Electron microscope

54. **Which of the following is a molecule of a compound?**

(a) CO_2
(b) O_2
(c) N_2
(d) H_2
(e) Cl_2

55. **K is the symbol of which element?**

(a) Sodium
(b) Calcium
(c) Potassium
(d) Cobalt
(e) Carbon

56. **Ag and Au are the symbols of which elements respectively?**

(a) Gold and silver
(b) Lead and tin
(c) Silver and gold
(d) Copper and gold
(e) Silver and aluminium

57. **What is the formula of a bromine molecule?**

(a) Br_2
(b) Br
(c) B_2
(d) Br_3
(e) BR

58. **How many elements are there in the compound NaCl?**

(a) 2
(b) 1
(c) 3
(d) 4
(e) None

59. **About molecules:**
i. a molecule can stay free
ii. a molecule is formed by two or more atoms
iii. every molecule contains atoms of the same element
Which of the following is correct?

(a) i
(b) iii
(c) i and ii
(d) ii and iii
(e) i, ii and iii

60. **What is the charge of an electron?**

(a) Positive
(b) Negative
(c) No charge
(d) Sometimes positive, sometimes negative
(e) Double positive

61. **Where are protons and neutrons found in an atom?**

(a) In the orbits
(b) Outside the atom
(c) In the nucleus
(d) Inside the electrons
(e) In the last orbit

62. **Carbon has atomic number 6 and mass number 12. How many neutrons are in one atom?**

(a) 12
(b) 18
(c) 2
(d) 0
(e) 6

63. **Aluminium has atomic number 13 and mass number 27. How many neutrons are in one atom?**

(a) 13
(b) 27
(c) 40
(d) 14
(e) 12

64. **What is the mass number of tritium?**

(a) 1
(b) 2
(c) 4
(d) 0
(e) 3

65. **What is the maximum number of electrons in the fourth orbit?**

(a) 8
(b) 18
(c) 50
(d) 16
(e) 32

66. **The electron distribution 2, 8, 3 belongs to which element?**

(a) Magnesium
(b) Aluminium
(c) Silicon
(d) Sodium
(e) Boron

67. **What is the electron distribution of nitrogen (atomic number 7)?**

(a) 5, 2
(b) 2, 4, 1
(c) 7
(d) 2, 5
(e) 2, 2, 3

68. **Which ion is formed when a chlorine atom (2, 8, 7) gains one electron?**

(a) Cl^{+}
(b) Cl^{-}
(c) Cl^{2-}
(d) Cl^{2+}
(e) Cl^{3-}

69. **How many electrons are in an oxide ion (O^{2-})? (Atomic number of oxygen is 8)**

(a) 10
(b) 6
(c) 8
(d) 16
(e) 12

70. **Why is water called the universal solvent?**

(a) It is colourless
(b) It is a liquid
(c) Its molecule has 3 atoms
(d) It evaporates easily
(e) Almost all organic and inorganic substances dissolve in it

Answer Key

1 a	**2** b	**3** b	**4** a	**5** c	**6** e	**7** b	**8** e	**9** a	**10** d
11 d	**12** c	**13** d	**14** b	**15** e	**16** e	**17** c	**18** d	**19** a	**20** a
21 a	**22** a	**23** c	**24** c	**25** c	**26** d	**27** b	**28** d	**29** c	**30** d
31 b	**32** b	**33** b	**34** a	**35** c	**36** a	**37** c	**38** e	**39** d	**40** e
41 b	**42** d	**43** e	**44** b	**45** b	**46** e	**47** c	**48** e	**49** d	**50** d
51 c	**52** a	**53** e	**54** a	**55** c	**56** c	**57** a	**58** a	**59** c	**60** b
61 c	**62** e	**63** d	**64** e	**65** e	**66** b	**67** d	**68** b	**69** a	**70** e

Explanations for selected questions

3. (b) Nitrogen, oxygen, water vapour and CO_2 are only mixed in air. The others are compounds.

9. (a) Breaking an atom gives electrons, protons and neutrons, so the atom is not indivisible.

14. (b) N_2 has two atoms of the same element; the others have atoms of different elements.

19. (a) K = potassium, Ag = silver, Pb = lead, Sn = tin. Only Cu = copper is correct.

20. (a) 2 molecules × 2 H in each molecule = 4 H atoms.

25. (c) Rutherford described the empty space and the central nucleus; "the atom is indivisible" was not his conclusion.

29. (c) Neutrons = mass number − atomic number = 23 − 11 = 12.

30. (d) Mass number = protons + neutrons = 10 + 8 = 18.

31. (b) Protons = electrons = 8; neutrons = 16 − 8 = 8.

35. (c) Deuterium has mass number 2 = 1 proton + 1 neutron.

42. (d) The distribution of 16 electrons is 2, 8, 6, so the last orbit has 6.

43. (e) 2 + 8 + 7 = 17 electrons, so atomic number 17, which is chlorine.

48. (e) 11 protons means sodium. It has one electron fewer, so it is Na^+.

49. (d) It loses the 2 electrons of its last orbit, so the charge is +2.

50. (d) Isotopes have different numbers of neutrons, so their mass numbers are also different.

59. (c) A molecule of a compound contains atoms of different elements (such as H_2O), so iii is wrong.

62. (e) Neutrons = 12 − 6 = 6.

63. (d) Neutrons = 27 − 13 = 14.

65. (e) $2n^2 = 2 \times 4^2 = 2 \times 16 = 32$.

66. (b) 2 + 8 + 3 = 13 electrons, so atomic number 13, which is aluminium.

69. (a) An oxygen atom has 8 electrons; it gains 2 electrons to become O^{2-}, so 8 + 2 = 10.

Chapter Two

Chemical Reaction

Different chemical reactions are happening around us all the time. Some reactions give us energy (like the fire for cooking), some make useful new materials, and some help us cure diseases. In this chapter we will learn how atoms join, how to write a reaction, and the different types of reactions.

After studying this chapter, we will be able to:

- differentiate between physical and chemical change
- explain valency and radicals
- write the formula of a compound from valency
- write and balance chemical equations
- identify different types of chemical reactions
- explain energy transformation in reactions
- explain how a dry cell works
- explain electrolysis

2.1 Physical Change and Chemical Change

When ice melts into water, it is still water; only its state changes. This is a **physical change**. But when paper burns, ash and smoke are formed and we cannot get the paper back, because a new substance has been formed. This is a **chemical change**. The process in which a chemical change takes place is called a **chemical reaction**.

Physical change	Chemical change
No new substance is formed	A completely new substance with new properties is formed
Usually can be reversed easily	Usually cannot be reversed
Examples: ice melting, water boiling, salt dissolving in water, wax melting	Examples: paper burning, rusting of iron, digestion of food, burning of a candle

Think about it

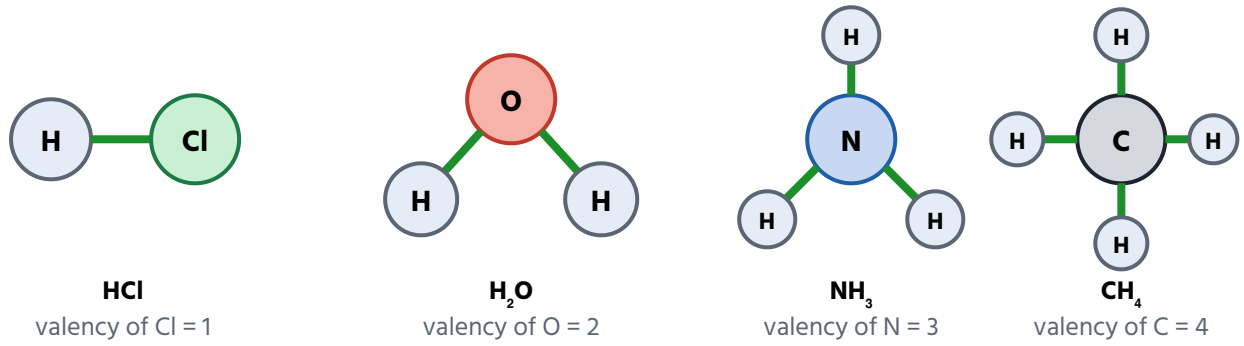
A burning candle shows both changes! The melting of wax is a **physical** change, and the burning of wax vapour with oxygen in the air, giving heat and light, is a **chemical** change.

2.2 Valency: The "Hands" of an Atom

To write the formula of a compound, we need to know the **valency** of the elements. Elements form compounds by chemical bonding according to their valency. We can compare valency with the **hands** of an atom.

Definition

The number of hydrogen atoms with which one atom of an element combines is called the **valency** of that element. When a compound forms, all the hands (valency) of every atom must be satisfied.



HCl
valency of Cl = 1

H_2O
valency of O = 2

NH_3
valency of N = 3

CH_4
valency of C = 4

Figure 2.1: The green lines are the "hands". Hydrogen has 1 hand; oxygen holds 2 H atoms with its 2 hands.

Some elements have more than one valency. For example, sulphur has valency 2 and 4, and iron has valency 2 and 3. For the lower valency the name ends with **-ous**, and for the higher valency with **-ic**: ferrous (Fe, valency 2), ferric (Fe, valency 3).

	Valency 1	Valency 2	Valency 3	Valency 4
Non-metals	H, F, Cl, Br, I	O, S, C	N, P	C, S
Metals	Na, K, Ag, Cu (ous), Au (ous)	Ca, Mg, Zn, Fe (ous), Cu (ic), Sn (ous), Pb (ous)	Al, Fe (ic), Au (ic)	Sn (ic), Pb (ic)
Radicals	Ammonium NH_4^+, hydroxyl OH^-, nitrite NO_2^-, nitrate NO_3^-, bicarbonate HCO_3^-	Carbonate CO_3^{2-}, sulphate SO_4^{2-}, sulphite SO_3^{2-}	Phosphate PO_4^{3-}	None

Radical

Groups of atoms such as SO_4^{2-}, CO_3^{2-}, NO_3^- and NH_4^+ cannot stay independently, but they take part in forming compounds just like a single atom of an element. Such a group of atoms is called a **radical**.

2.3 Rules for Writing Formulae from Valency

Rule 1: Equal valency

If both have the same valency, there is no need to write it; just write them side by side.

$$CaO,\ NH_4Cl,\ NH_4NO_3$$

Rule 2: One is a multiple

Divide both valencies by the smaller one, then write the results crosswise.

$$C(4),\ O(2) \rightarrow C_2O_4 \rightarrow CO_2$$

Rule 3: Criss-cross

If the valencies are different and not multiples, A's valency goes under B and B's valency goes under A: A_yB_x.

$$Al_2O_3$$

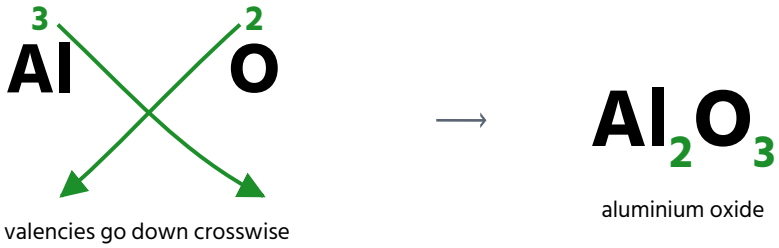


Figure 2.2: Formula of aluminium oxide by the criss-cross method. Check: total hands of Al = 2 × 3 = 6, of O = 3 × 2 = 6, equal!

Know a little more

When a radical is needed more than once, it is put in brackets. Examples: calcium (2) + hydroxyl (1) → $Ca(OH)_2$; aluminium (3) + sulphate (2) → $Al_2(SO_4)_3$; sodium (1) + carbonate (2) → Na_2CO_3.

2.4 Chemical Equation

A chemical reaction has two parts: the substances that react are the **reactants**, and the new substances formed are the **products**.

$$\underset{\text{sulphur}}{S} + \underset{\text{oxygen}}{O_2} \longrightarrow \underset{\text{sulphur dioxide}}{SO_2}$$

Definition

A short expression of a chemical reaction that uses symbols, formulae and some mathematical signs to show the reactants and products is called a **chemical equation**.

$$\underset{\text{zinc}}{Zn} + \underset{\text{sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{zinc sulphate}}{ZnSO_4} + \underset{\text{hydrogen}}{H_2}$$

Rules for writing equations

1. Reactants are written on the left and products on the right.
2. If there is more than one reactant or product, a plus (+) sign is placed between them.
3. If there is more than one molecule, a number (coefficient) is written before the formula.
4. An arrow (⟶) or an equals sign (=) shows the direction of the reaction.
5. The number of atoms of each element must be the same before and after the reaction. This is called **balancing**.

Why do we balance equations? Because in a chemical reaction atoms are **neither created nor destroyed**; they are only rearranged (Dalton's fifth point).

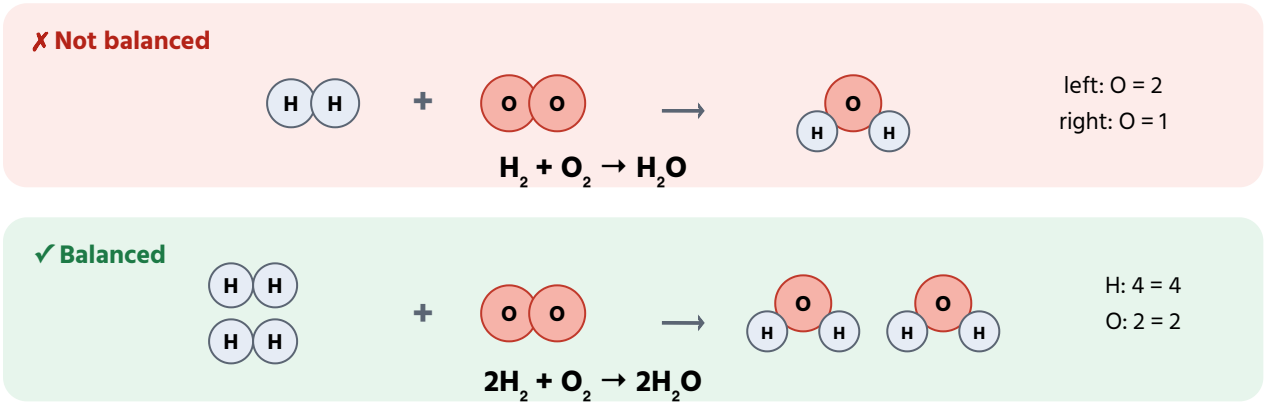


Figure 2.3: Balancing the equation for making water. Multiplying the right side by 2 balances O; then multiplying H_2 on the left by 2 balances H.

Example: count the atoms

$2H_2 + O_2 = 2H_2O$

H atoms: left $2 \times 2 = 4$, right $2 \times 2 = 4$ ✓ O atoms: left $1 \times 2 = 2$, right $2 \times 1 = 2$ ✓

Total atoms: left $4 + 2 = 6$, right $2 \times (2 + 1) = 6$ ✓

2.5 Types of Chemical Reactions

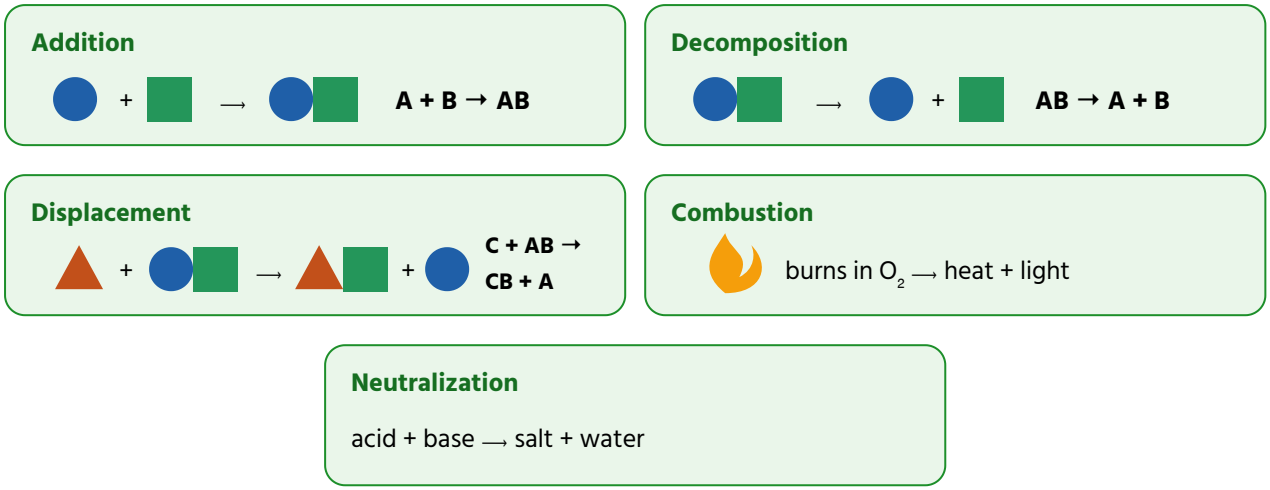


Figure 2.4: Five types of chemical reactions at a glance

a) Addition (synthesis) reaction

When iron powder and sulphur powder are mixed and heated in a test tube, the mixture becomes red hot. After cooling, a dark grey new substance is found: **ferrous sulphide**. It has none of the properties of the light yellow sulphur or of iron.

$$\underset{\text{iron}}{\mathrm{Fe}} + \underset{\text{sulphur}}{\mathrm{S}} \longrightarrow \underset{\text{ferrous sulphide}}{\mathrm{FeS}}$$

Definition

A reaction in which more than one substance (element or compound) combines chemically to form one new substance is called an **addition reaction**.

$$\underset{\text{zinc}}{\mathrm{Zn}} + \underset{\text{sulphur}}{\mathrm{S}} \longrightarrow \underset{\text{zinc sulphide}}{\mathrm{ZnS}} \qquad \underset{\text{ammonia}}{\mathrm{NH_3}} + \underset{\text{hydrogen chloride}}{\mathrm{HCl}} \longrightarrow \underset{\text{ammonium chloride}}{\mathrm{NH_4Cl}}$$

In the first two, compounds are formed from elements; in the last one, two **compounds** combine to form a new compound.

b) Combustion reaction

When sulphur is heated in a combustion spoon, it first melts and then burns with a **blue flame** and a pungent smell. Sulphur reacts with oxygen in the air and forms sulphur dioxide gas.

$$\underset{\text{sulphur}}{\mathrm{S}} + \underset{\text{oxygen}}{\mathrm{O_2}} \xrightarrow{\text{heat}} \underset{\text{sulphur dioxide}}{\mathrm{SO_2}}$$

A magnesium ribbon held in a flame burns with a **bright light**. The white ash-like substance left is **magnesium oxide**.

$$\underset{\text{magnesium}}{2Mg} + \underset{\text{oxygen}}{O_2} \longrightarrow \underset{\text{magnesium oxide}}{2MgO}$$

Definition

A reaction in which a substance burns with the help of oxygen in the air and produces a lot of heat and light is called a **combustion reaction**.

Safety

Wear protective glasses and hold the magnesium ribbon with tongs while burning it. All experiments in this chapter must be done under a teacher's supervision.

c) Substitution (displacement) reaction

When iron powder is added to a **blue** solution of copper sulphate and shaken, the solution slowly turns **light green** and reddish particles (copper) settle at the bottom of the test tube.

$$\underset{\text{iron}}{Fe} + \underset{\text{copper sulphate (blue)}}{CuSO_4} \longrightarrow \underset{\text{ferrous sulphate (light green)}}{FeSO_4} + \underset{\text{copper}}{Cu}$$

Definition

A reaction in which an element removes another element from a compound and takes its place, forming a new compound, is called a **displacement reaction**. Here iron has displaced copper.

d) Decomposition reaction

When limestone (calcium carbonate) is heated in a test tube, it breaks down into calcium oxide and carbon dioxide.

$$\underset{\text{calcium carbonate (limestone)}}{CaCO_3} \xrightarrow{\text{heat}} \underset{\text{calcium oxide}}{CaO} + \underset{\text{carbon dioxide}}{CO_2}$$

Definition

A reaction in which one compound breaks down into more than one new substance is called a **decomposition reaction**.

$$\underset{\text{copper carbonate}}{CuCO_3} \xrightarrow{\text{heat}} \underset{\text{copper oxide}}{CuO} + CO_2 \qquad \underset{\text{potassium chlorate}}{2KClO_3} \xrightarrow{\text{heat}} \underset{\text{potassium chloride}}{2KCl} + 3O_2$$

Remember: test for carbon dioxide

When CO_2 gas is passed through lime water, the lime water turns **milky**, because insoluble calcium carbonate is formed.

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$

e) Neutralization reaction

When vinegar is added drop by drop to lime in a beaker, the beaker becomes hot. Lime is basic and the acetic acid in vinegar is acidic. These two substances of opposite nature react and cancel each other's properties.

$$\underset{\text{calcium oxide (lime)}}{CaO} + \underset{\text{acetic acid}}{2CH_3COOH} \longrightarrow \underset{\text{calcium acetate}}{(CH_3COO)_2Ca} + \underset{\text{water}}{H_2O}$$

Definition

A reaction in which substances of opposite nature (an acid and a base) react with each other, cancel each other's properties and form salt and water, is called a **neutralization reaction**. (More in Chapter 3.)

2.6 Energy Transformation in Chemical Reactions

If you put your hand near a burning candle, you feel heat, and in the dark you can see things around it. A candle is a chemical substance; when it burns, the **chemical energy stored in it changes into heat and light energy**. So chemical reactions cause energy transformation.

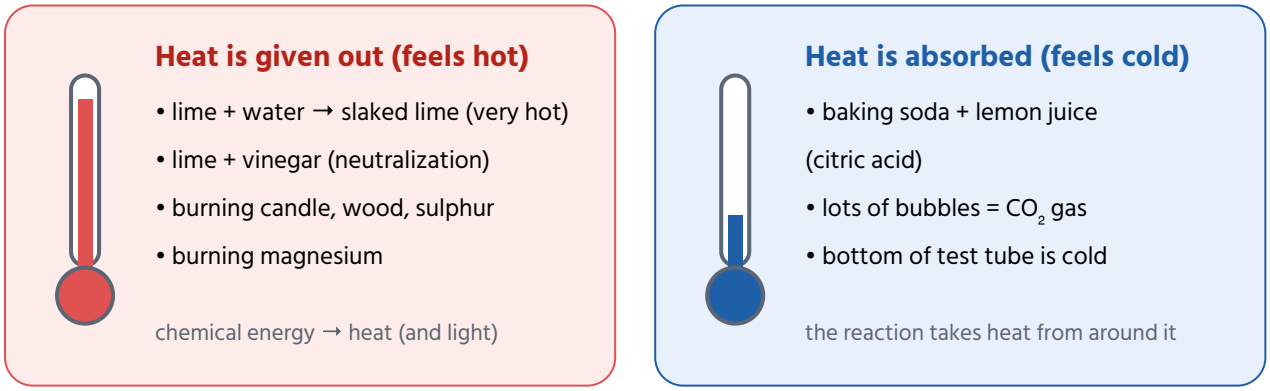


Figure 2.5: Some reactions give out heat, and some absorb heat

$$\text{baking soda} + \text{citric acid} \longrightarrow \text{sodium citrate} + CO_2 + H_2O$$

When water is added drop by drop to lime (calcium oxide) in a beaker, the beaker becomes very hot and the mixture bubbles like boiling water. Here **calcium hydroxide** is formed, commonly known as **slaked lime**.

$$\underset{\text{lime}}{CaO} + \underset{\text{water}}{H_2O} \longrightarrow \underset{\text{calcium hydroxide (slaked lime)}}{Ca(OH)_2}$$

Slaked lime dissolves only slightly in water. The saturated solution of $Ca(OH)_2$ in water is called **lime water**. If the mixture is left for some time, the clear water on top is lime water.

2.7 Dry Cell

A dry cell is a portable source of electrical energy. We use dry cells in torch lights, remote controls, toy cars and many other devices.

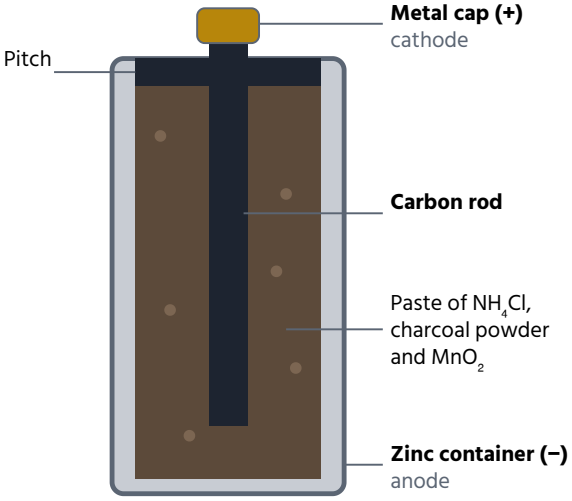


Figure 2.6: Structure of a dry cell

Structure: Ammonium chloride (NH_4Cl), charcoal powder and manganese dioxide (MnO_2) are mixed with a little water to make a paste. The paste is kept in a **cylindrical zinc container**. A **carbon rod** is placed in the middle so that it does not touch the zinc container. There is a metal cap on top of the carbon rod. The top of the cell is covered with a layer of pitch.

Remember

- Zinc container = negative electrode or **anode**
- Carbon rod with metal cap = positive electrode or **cathode**
- Energy change: **chemical energy → electrical energy → light**

When a bulb, a dry cell and two copper wires complete a circuit, the bulb lights up. The chemical energy stored in the substances inside the cell (zinc, charcoal, ammonium chloride and manganese dioxide) is the source of this light.

2.8 Electrolysis

A large amount of common salt (sodium chloride) is dissolved in water to make a **concentrated salt solution (brine)**. When two electrodes (rods) are dipped in it and connected to a battery, gas bubbles appear on both rods.

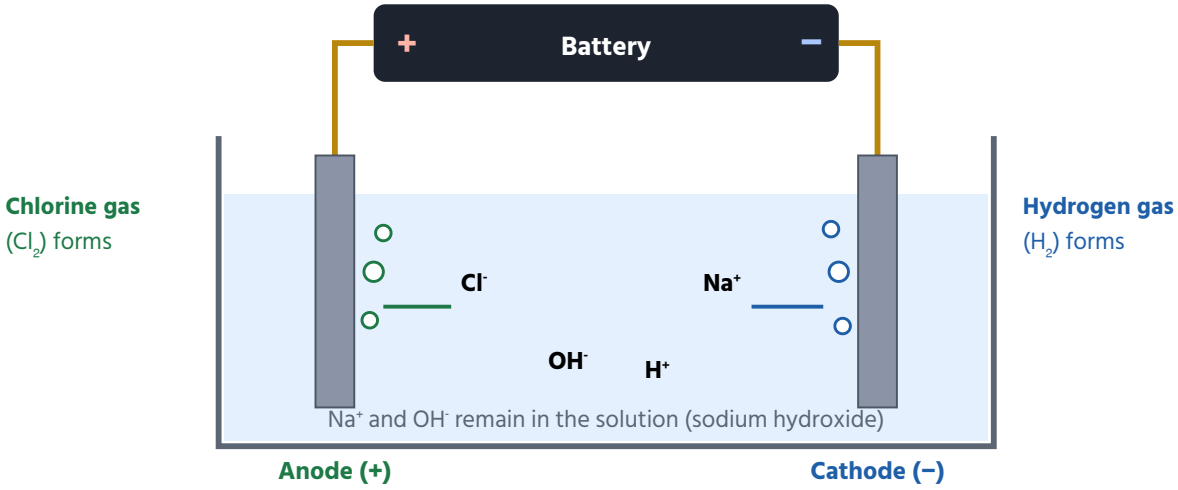


Figure 2.7: Electrolysis of concentrated sodium chloride solution (brine)

In the concentrated solution, sodium chloride splits into sodium ions (Na^+) and chloride ions (Cl^-). In the same way, some water molecules split into hydrogen ions (H^+) and hydroxide ions (OH^-).

$$NaCl \rightleftharpoons Na^+ + Cl^- \qquad H_2O \rightleftharpoons H^+ + OH^-$$

- **At the anode (+):** the negative Cl^- and OH^- ions move towards the anode. Cl^- ions react to form **chlorine gas (Cl_2)**, so bubbles appear at the anode.
- **At the cathode (−):** the positive Na^+ and H^+ ions move towards the cathode. H^+ ions react to form **hydrogen gas (H_2)**.
- Na^+ and OH^- remain in the solution, that is, **sodium hydroxide (NaOH)**.

Remember

For this result, the salt solution must be **concentrated**. If the solution is very dilute, **oxygen gas** may also form at the anode along with chlorine. Carbon (graphite) rods are usually used as electrodes.

Electrolyte

Substances that conduct electricity when dissolved or melted, and form new substances by chemical reaction due to electricity. Example: **common salt**.

Non-electrolyte

Substances that do not conduct electricity when dissolved or melted, and do not take part in reactions due to electricity. Examples: **sugar, glucose**.

Chapter summary

- A new substance forms in a chemical change, but not in a physical change.
- Valency = the number of H atoms one atom combines with. A radical is a group of atoms that behaves like a single atom.
- In an equation, reactants are on the left and products on the right; each element must have the same number of atoms on both sides.
- Addition: A + B → AB · Decomposition: AB → A + B · Displacement: C + AB → CB + A · Combustion: burning in oxygen with heat and light · Neutralization: acid + base → salt + water.
- Reactions transform energy; some give out heat and some absorb heat.
- In a dry cell, chemical energy changes into electrical energy; the zinc container is the anode (−) and the carbon rod is the cathode (+).
- In the electrolysis of concentrated NaCl solution (brine): Cl_2 at the anode, H_2 at the cathode, NaOH in the solution.

Exercise: Multiple Choice Questions (MCQ)

Choose the correct answer from the five options. Total questions: 65.

1. **Which of the following is a chemical change?**
   (a) Melting of ice
   (b) Rusting of iron
   (c) Boiling of water
   (d) Salt dissolving in water
   (e) Melting of wax

2. **Which of the following is a physical change?**
   (a) Burning of paper
   (b) Digestion of food
   (c) Burning of magnesium
   (d) Heating limestone
   (e) Water freezing into ice

3. **The number of hydrogen atoms with which one atom of an element combines is called its:**
   (a) atomic number
   (b) mass number
   (c) coefficient
   (d) radical
   (e) valency

4. **Why is the formula of water H_2O?**
   (a) The valency of hydrogen is 2
   (b) The valency of oxygen is 1
   (c) Water is an element
   (d) The valency of oxygen is 2
   (e) Hydrogen is diatomic

5. **From the formula of ammonia, NH_3, what is the valency of nitrogen?**
   (a) 1
   (b) 2
   (c) 4
   (d) 3
   (e) 5

6. **What is the valency of carbon in a methane (CH_4) molecule?**
   (a) 1
   (b) 2
   (c) 4
   (d) 3
   (e) 6

7. **Which of the following is a radical?**
   (a) Na
   (b) SO_4^{2-}
   (c) Cl_2
   (d) H_2O
   (e) CO_2

8. **What are the formula and valency of the carbonate radical?**
   (a) CO_2, 2
   (b) HCO_3^-, 2
   (c) CO_3^{2-}, 2
   (d) CO_3^-, 1
   (e) C_2O_4, 4

9. **What is the valency of the phosphate radical?**
   (a) 1
   (b) 2
   (c) 4
   (d) 3
   (e) 5

10. **Which of the following does NOT have valency 1?**
    (a) Calcium
    (b) Sodium
    (c) Potassium
    (d) Hydroxyl
    (e) Ammonium

11. **"Ferric" means iron with which valency?**

(a) 1
(b) 2
(c) 4
(d) 3
(e) 0

12. **What is the formula of the compound made of aluminium (valency 3) and oxygen (valency 2)?**

(a) AlO
(b) Al_2O_3
(c) Al_3O_2
(d) AlO_3
(e) Al_2O

13. **The formula of the compound made of calcium (valency 2) and oxygen (valency 2) is:**

(a) Ca_2O_2
(b) CaO_2
(c) Ca_2O
(d) Ca_2O_4
(e) CaO

14. **When writing the formula from carbon (valency 4) and oxygen (valency 2), C_2O_4 is written as:**

(a) C_2O_4
(b) CO
(c) CO_2
(d) C_4O_2
(e) C_2O

15. **What is the correct formula of the compound made of calcium (valency 2) and hydroxyl (valency 1)?**

(a) CaOH
(b) $CaOH_2$
(c) Ca_2OH
(d) $Ca_2(OH)$
(e) $Ca(OH)_2$

16. **What are the substances that react in a chemical reaction called?**

(a) Products
(b) Reactants
(c) Catalysts
(d) Solvents
(e) Radicals

17. **Why must a chemical equation be balanced?**

(a) To show the colour of the products
(b) Because atoms are neither created nor destroyed in a reaction
(c) To make the reaction faster
(d) To show heat
(e) To reduce the reactants

18. **Balancing $H_2 + O_2 \rightarrow H_2O$ gives:**

(a) $H_2 + O_2 \rightarrow 2H_2O$
(b) $2H_2 + O_2 \rightarrow 2H_2O$
(c) $2H_2 + 2O_2 \rightarrow 2H_2O$
(d) $H_2 + 2O_2 \rightarrow H_2O$
(e) $4H_2 + O_2 \rightarrow 2H_2O$

19. **In the reaction $2H_2 + O_2 \rightarrow 2H_2O$, how many atoms are there in the reactants in total?**

(a) 3
(b) 4
(c) 5
(d) 6
(e) 8

20. **Which is the balanced equation for the burning of magnesium?**

(a) $2Mg + O_2 \rightarrow 2MgO$
(b) $Mg + O_2 \rightarrow MgO$
(c) $Mg + O \rightarrow MgO$
(d) $Mg + O_2 \rightarrow MgO_2$
(e) $2Mg + 2O_2 \rightarrow 2MgO$

21. **$2KClO_3 \rightarrow 2KCl + xO_2$. What is the value of x that balances the equation?**

(a) 3
(b) 1
(c) 2
(d) 4
(e) 6

22. **What type of reaction is Fe + S → FeS?**

(a) Decomposition
(b) Displacement
(c) Addition
(d) Neutralization
(e) Electrolysis

23. **What are the name and colour of the product of iron and sulphur?**

(a) Ferric sulphate, yellow
(b) Ferrous sulphate, light green
(c) Iron oxide, reddish brown
(d) Zinc sulphide, white
(e) Ferrous sulphide, dark grey

24. **Which statement about NH_3 + HCl → NH_4Cl is correct?**

(a) Two compounds combine to form a new compound
(b) It is a decomposition reaction
(c) It is a combustion reaction
(d) One element displaces another
(e) It needs oxygen

25. **What colour is the flame when sulphur burns?**

(a) Blue
(b) Yellow
(c) Red
(d) Green
(e) Bright white

26. **Which pungent-smelling gas is formed when sulphur burns?**

(a) CO_2
(b) SO_2
(c) H_2S
(d) SO_3
(e) O_2

27. **What is the white ash left after burning a magnesium ribbon?**

(a) Magnesium carbonate
(b) Magnesium oxide
(c) Magnesium hydroxide
(d) Magnesium sulphate
(e) Carbon

28. **What is essential for a combustion reaction?**

(a) Water
(b) Hydrogen
(c) Nitrogen
(d) Electricity
(e) Oxygen

29. **What colour does a blue copper sulphate solution become when iron powder is added?**

(a) Red
(b) Dark blue
(c) Colourless
(d) Light green
(e) Yellow

30. **What type of reaction is Fe + $CuSO_4$ → $FeSO_4$ + Cu?**

(a) Addition
(b) Combustion
(c) Displacement
(d) Decomposition
(e) Neutralization

31. **In Zn + H_2SO_4 → $ZnSO_4$ + H_2, which element has zinc displaced?**

(a) Hydrogen
(b) Sulphur
(c) Oxygen
(d) Chlorine
(e) None

32. **What is formed when limestone is heated?**

(a) Ca and CO_2
(b) $Ca(OH)_2$ and CO_2
(c) CaO and CO_2
(d) CaO and O_2
(e) $CaCl_2$ and H_2O

33. **A reaction in which one compound breaks down into more than one new substance is called:**

(a) addition
(b) displacement
(c) neutralization
(d) combustion
(e) decomposition

34. **Why does lime water turn milky when CO_2 is passed through it?**

(a) CaO is formed
(b) $CaCl_2$ is formed
(c) More $Ca(OH)_2$ dissolves
(d) Insoluble $CaCO_3$ is formed
(e) The water evaporates

35. **Heating copper carbonate produces:**

(a) copper and oxygen
(b) copper oxide and carbon dioxide
(c) copper sulphate and water
(d) copper hydroxide
(e) copper chloride and carbon

36. **What type of reaction takes place between lime and vinegar?**

(a) Combustion
(b) Decomposition
(c) Neutralization
(d) Addition
(e) Electrolysis

37. **What does lime (CaO) form when it reacts with water?**

(a) $CaCO_3$
(b) CaO_2
(c) CaH_2
(d) $Ca(OH)_2$
(e) $CaCl_2$

38. **What is the chemical name of slaked lime?**

(a) Calcium hydroxide
(b) Calcium oxide
(c) Calcium carbonate
(d) Calcium sulphate
(e) Calcium chloride

39. **Why does the bottom of the test tube feel cold when lemon juice is added to baking soda?**

(a) The reaction gives out heat
(b) Lemon juice is cold
(c) The test tube is made of glass
(d) The water freezes
(e) The reaction absorbs heat

40. **Which gas forms the bubbles in the reaction of baking soda and lemon juice?**

(a) Oxygen
(b) Hydrogen
(c) Carbon dioxide
(d) Nitrogen
(e) Chlorine

41. **Which energy change happens when a candle burns?**

(a) Chemical → heat and light
(b) Light → chemical
(c) Heat → chemical
(d) Electrical → light
(e) Mechanical → heat

42. **Which energy change happens in a dry cell?**

(a) Chemical → electrical
(b) Electrical → chemical
(c) Heat → electrical
(d) Light → electrical
(e) Mechanical → electrical

43. **What acts as the anode in a dry cell?**

(a) Carbon rod
(b) Metal cap
(c) Manganese dioxide
(d) Zinc container
(e) Pitch layer

44. **Which of the following is NOT used to make the paste of a dry cell?**

(a) Ammonium chloride
(b) Charcoal powder
(c) Manganese dioxide
(d) Water
(e) Sulphuric acid

45. **What does the carbon rod with the metal cap act as in a dry cell?**

(a) Negative electrode
(b) Electrolyte
(c) Insulator
(d) Anode
(e) Positive electrode (cathode)

46. **In the electrolysis of concentrated sodium chloride solution (brine), which gas is mainly formed at the anode?**

(a) Hydrogen
(b) Oxygen
(c) Chlorine
(d) Nitrogen
(e) Carbon dioxide

47. **What remains in the solution after the electrolysis of concentrated sodium chloride solution (brine)?**

(a) HCl
(b) NaOH
(c) Sodium metal
(d) Cl_2
(e) Pure water

48. **Which of the following is a non-electrolyte?**

(a) Common salt
(b) Glucose
(c) Sodium hydroxide
(d) Hydrochloric acid
(e) Copper sulphate

49. **In electrolysis, the ions that move towards the cathode are:**
i. Na^+
ii. H^+
iii. Cl^-
Which of the following is correct?

(a) i
(b) iii
(c) i and ii
(d) ii and iii
(e) i, ii and iii

50. **About chemical reactions:**
i. new substances are formed
ii. energy is transformed
iii. the total number of atoms is the same before and after the reaction
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

51. **What type of change is the burning of paper?**

(a) Physical change
(b) Only a change of state
(c) No change at all
(d) Chemical change
(e) Magnetic change

52. **Which valencies can sulphur have?**

(a) 1 and 2
(b) 3 and 5
(c) 2 and 4
(d) Only 1
(e) 1 and 3

53. **"Ferrous" means iron with which valency?**

(a) 2
(b) 1
(c) 3
(d) 4
(e) 0

54. **What is the formula of the ammonium radical?**

(a) NH_3
(b) NH_4^+
(c) NO_3^-
(d) NH_2
(e) N_2H_4

55. **What is the formula of the compound made of sodium (valency 1) and carbonate (valency 2)?**

(a) $NaCO_3$
(b) $Na(CO_3)_2$
(c) Na_3CO_2
(d) $NaCO_2$
(e) Na_2CO_3

56. **What is the new substance formed in a chemical reaction called?**

(a) Reactant
(b) Product
(c) Catalyst
(d) Solvent
(e) Indicator

57. **In $N_2 + 3H_2 \rightarrow 2NH_3$, how many hydrogen atoms are there on the left side?**

(a) 3
(b) 2
(c) 8
(d) 5
(e) 6

58. **What type of reaction is $Zn + S \rightarrow ZnS$?**

(a) Addition
(b) Decomposition
(c) Displacement
(d) Neutralization
(e) Electrolysis

59. **What type of reaction is $2KClO_3 \rightarrow 2KCl + 3O_2$?**

(a) Addition
(b) Displacement
(c) Decomposition
(d) Neutralization
(e) Combustion

60. **What is used to identify the gas produced when limestone is heated?**

(a) Lime water
(b) Litmus paper
(c) A burning stick
(d) Copper sulphate solution
(e) Lemon juice

61. **What is lime water?**

(a) Powdered calcium oxide
(b) A solution of calcium carbonate
(c) A saturated solution of $Ca(OH)_2$ in water
(d) A mixture of lime and vinegar
(e) A solution of sodium hydroxide

62. **Why does the beaker get hot when water is added to lime?**

(a) The reaction absorbs heat
(b) The water was already hot
(c) The lime evaporates
(d) The reaction gives out heat
(e) Carbon dioxide is formed

63. **Where is a dry cell commonly used?**

(a) In a torch light
(b) In a refrigerator
(c) In a car engine
(d) In a power station
(e) In a water pump

64. **About radicals:**
i. they cannot stay independently
ii. they behave like a single atom in forming compounds
iii. SO_4^{2-} is a radical
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

65. **A salt solution conducts electricity because the solution contains:**

(a) only water molecules
(b) neutrons
(c) gas bubbles
(d) ions
(e) carbon particles

Answer Key

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

Explanations for selected questions

4. (d) Oxygen has 2 hands and hydrogen has 1, so one O holds two H.

10. (a) Calcium has valency 2; the others have valency 1.

12. (b) Criss-cross method: 2 goes under Al and 3 goes under O, so Al_2O_3.

14. (c) Dividing 4 and 2 by 2 gives 2 and 1, so CO_2.

15. (e) OH is needed twice; because it is a radical it is put in brackets: $Ca(OH)_2$.

19. (d) 2 × 2 = 4 H and 2 O, so 6 atoms in total.

21. (a) Left side O = 2 × 3 = 6. To get 6 O on the right, 3 O_2 are needed.

24. (a) Two compounds have combined to form one new compound, so it is an addition reaction.

31. (a) Zinc sulphate is formed and hydrogen is set free.

34. (d) $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$; $CaCO_3$ is insoluble in water, so it looks milky.

39. (e) The reaction takes heat from its surroundings, so the test tube feels cold.

44. (e) The paste contains NH_4Cl, charcoal powder, MnO_2 and a little water; it contains no acid.

48. (b) Glucose does not form ions in water, so it does not conduct electricity.

49. (c) Positive ions (Na^+, H^+) move to the negative cathode; Cl^- moves to the anode.

55. (e) By the criss-cross method, 2 goes under Na and 1 under CO_3, so Na_2CO_3.

57. (e) 3 molecules of H_2 × 2 H in each = 6 H atoms.

65. (d) In water NaCl splits into Na^+ and Cl^- ions; these ions carry the electricity.

Chapter Three

Acid, Base and Salt

Lemon juice, vinegar, lime, antacid medicine and common salt are all very useful substances for us. Some of them are sour or **acids**, some are **bases** and some are **salts**. Their chemical properties are different, so they are used for different purposes.

After studying this chapter, we will be able to:

- explain the properties of acids
- differentiate between bases and alkalis
- identify salts and neutral substances
- identify acids and bases using indicators
- describe the uses of acids, bases and salts
- follow safety rules in the laboratory

3.1 Indicators: Showing Identity by Changing Colour

If **red litmus paper** is dipped in lemon juice using forceps, its colour does not change. But **blue litmus paper** turns **red**. Again, red litmus dipped in lime water turns **blue**, while blue litmus does not change. In a common salt solution, neither litmus changes colour.

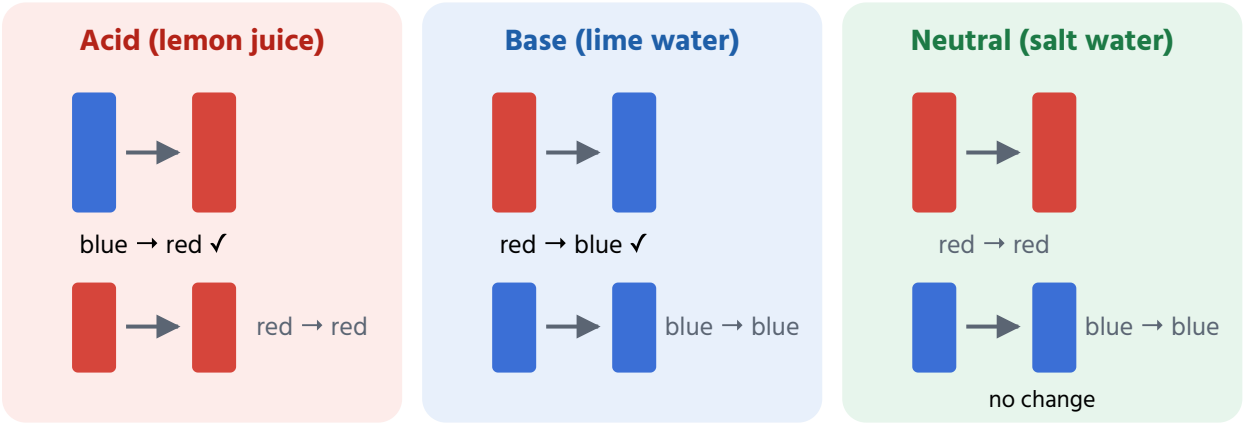


Figure 3.1: The litmus test. An acid turns blue litmus red; a base turns red litmus blue.

A trick to remember

"Acid: blue to red. Base: red to blue." An acid turns blue litmus red; a base turns red litmus blue.

Litmus paper is made using a colour taken from organisms called **lichens**. Litmus paper made this way looks red; when tested in an alkaline solution it turns blue.

Indicator

Substances that show whether something is an acid, a base or neutral by changing colour are called **indicators**. Examples: **litmus paper, methyl orange, phenolphthalein, methyl red**.

Know a little more: colours of other indicators

Indicator	In acid	In alkali
Litmus	Red	Blue
Phenolphthalein	Colourless	Pink
Methyl orange	Red	Yellow

Extracts of hibiscus (joba), bougainvillea and yellow krishnachura petals, red cabbage or beetroot also work as natural indicators; their colours are different in acids and alkalis.

3.2 Acids

Why are lemon, amloki, carambola, karamcha and grapes sour? Because these fruits contain different kinds of acids. So we can say that **acids taste sour**.

Fruit / food	Acid present
Lemon, orange, grapes	Citric acid
Tamarind	Tartaric acid
Tomato	Oxalic acid
Amloki	Ascorbic acid (vitamin C)
Apple, pineapple	Malic acid
Vinegar	Acetic acid

Look at the formulae of some acids: acetic acid (CH_3COOH), oxalic acid ($HOOC–COOH$), hydrochloric acid (HCl) and sulphuric acid (H_2SO_4).

What do they have in common? All of them contain one or more **hydrogen atoms**, which produce **hydrogen ions (H^+)** in contact with water.

Definition of an acid

Chemical substances that contain hydrogen atoms and produce **H^+ ions** in water are called **acids**.

$$HCl \xrightarrow{H_2O} H^+ + Cl^- \qquad CH_3COOH \xrightarrow{H_2O} H^+ + CH_3COO^-$$

Think about it: is methane (CH_4) an acid?

No! Methane has four hydrogen atoms, but it does not produce H^+ in water. So having hydrogen is not enough to be an acid; **it must give H^+ in water**.

Organic acids and mineral acids

Organic acids

Found in fruits and vegetables. We eat many such organic acids with our food in safe amounts, and some are even essential for the body. For example, ascorbic acid or **vitamin C**; its lack causes **scurvy**. But not all organic acids are fit to eat.

Mineral acids

Obtained from minerals in nature: HCl, H_2SO_4, H_3PO_4 (phosphoric), HNO_3 (nitric), $HClO_4$ (perchloric). They are not for eating; when concentrated they are very harmful to the body and cause serious damage if they touch the skin.

Acid violence: a terrible crime

Some criminals throw mineral acids on people, causing serious burns. The punishment for throwing acid is very severe and can even be the death penalty. By making posters and spreading awareness, we can help prevent this crime.

3.3 Bases and Alkalis

Look at two bases: sodium hydroxide (NaOH) and calcium hydroxide [$Ca(OH)_2$]. They contain hydrogen and oxygen atoms and produce **hydroxide ions (OH^-)** in water.

$$NaOH \xrightarrow{H_2O} Na^+ + OH^- \qquad Ca(OH)_2 \xrightarrow{H_2O} Ca^{2+} + 2OH^-$$

Now look at calcium oxide (lime) and ammonia (NH_3). CaO has no hydrogen and NH_3 has no oxygen; still, they react with water and produce OH^-. So they are also **bases**.

$$CaO + H_2O \longrightarrow Ca(OH)_2 \qquad NH_3 + H_2O \longrightarrow NH_4OH$$

Base

A metal oxide or hydroxide is called a **base**. A base turns red litmus blue. Some bases dissolve in water and some do not.

Alkali

Bases that **dissolve in water** are called **alkalis**. Examples: NaOH, $Ca(OH)_2$, NH_4OH. An alkali is a special kind of base.

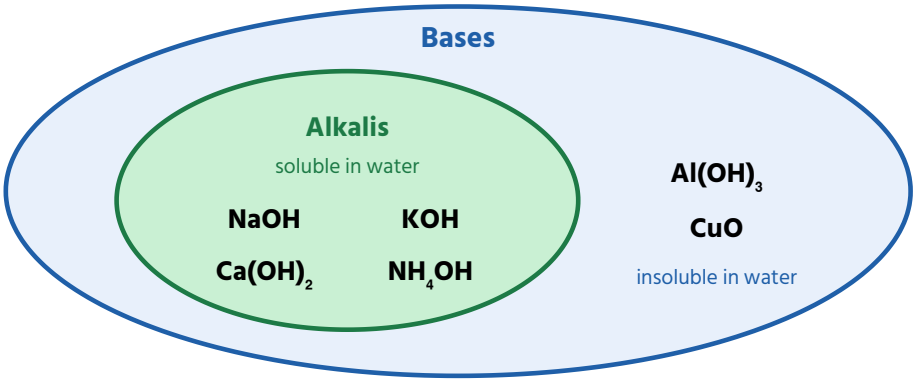


Figure 3.2: All alkalis are bases, but not all bases are alkalis. $Al(OH)_3$ does not dissolve in water, so it is a base but not an alkali.

Properties of bases

- Soap feels slippery because it contains a base. Both alkalis and soap are **slippery**.
- Bases and alkalis taste **bitter**.
- A base turns red litmus blue.

Safety

Never test any alkali or acid by tasting it in the laboratory. Wear gloves and an apron when working with acids and alkalis, and use forceps and droppers.

3.4 Uses of Acids and Bases in Daily Life

Substance	Uses
Hydrochloric acid (HCl)	Helps digest food in our stomach; used in steel mills and in the medicine and leather industries.
Sulphuric acid (H_2SO_4)	A main ingredient of the fertilizer industry; used in batteries (IPS, cars, solar power) and in making detergents, paints, medicines, insecticides, paper, explosives and rayon. **A country's industrial development is usually judged by how much H_2SO_4 it uses.**
Nitric acid (HNO_3)	Used by goldsmiths for making gold ornaments; in the fertilizer industry, making explosives, extracting precious metals like gold from mines, and in rocket fuel.
Sodium hydroxide (NaOH)	Making soap; the paper and rayon industries.
Calcium hydroxide [$Ca(OH)_2$]	Dry $Ca(OH)_2$ reacts with chlorine gas to make **bleaching powder**; its dilute solution (lime water) is used for whitewashing buildings; its mixture with water (milk of lime) is used as an insecticide.
Magnesium hydroxide [$Mg(OH)_2$]	**Antacid** medicine, taken for stomach acidity. Its suspension is called **milk of magnesia**. Some antacids contain aluminium hydroxide [$Al(OH)_3$].

Think about it

Why does an antacid give relief from acidity? Because the extra HCl (acid) in the stomach undergoes a **neutralization reaction** with the base $Mg(OH)_2$ in the antacid.

3.5 Some Important Properties of Acids

a) Acid + carbonate/bicarbonate → salt + water + carbon dioxide

When dilute hydrochloric acid is added to powdered limestone, bubbles and foam form. After the CO_2 escapes, a clear solution of calcium chloride is left.

$$\underset{\text{limestone}}{CaCO_3} + 2HCl \longrightarrow \underset{\text{calcium chloride}}{CaCl_2} + H_2O + CO_2\uparrow$$

$$\underset{\text{baking soda}}{NaHCO_3} + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$$

This property of acids is used to produce CO_2 for **putting out fires**.

b) Acid + metal → salt + hydrogen gas

When a little zinc is added to dilute HCl in a test tube, gas bubbles come out. If a burning matchstick is held at the mouth of the test tube, the gas **burns with a "pop" sound**. This is the test for hydrogen gas.

$$Zn + 2HCl \longrightarrow \underset{\text{zinc chloride}}{ZnCl_2} + H_2\uparrow$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow \qquad Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2\uparrow$$

Gas	How to identify it
Hydrogen (H_2)	Burns with a "pop" sound when a burning stick is held near it
Carbon dioxide (CO_2)	Turns lime water milky

3.6 Neutralization and Salts

Dip red litmus in lime water in a beaker and it turns blue; lime water is alkaline. Now slowly add dilute sulphuric acid while stirring, and keep testing with litmus. At one point you will see that **the litmus no longer changes colour**. This is because all the $Ca(OH)_2$ has reacted with H_2SO_4, forming calcium sulphate (a salt) and water.

$$\underset{\text{base}}{Ca(OH)_2} + \underset{\text{acid}}{H_2SO_4} \longrightarrow \underset{\text{salt}}{CaSO_4} + \underset{\text{water}}{2H_2O}$$



Acid and base cancel each other's properties and form salt and water: this is neutralization

Figure 3.3: The main idea of neutralization

Base		Acid		Salt		Water
NaOH	+	HCl	⟶	NaCl (sodium chloride)	+	H_2O
KOH	+	HNO_3	⟶	KNO_3 (potassium nitrate)	+	H_2O
$Ca(OH)_2$	+	H_2SO_4	⟶	$CaSO_4$ (calcium sulphate)	+	$2H_2O$

Salt

The compound formed along with water in the reaction between an acid and a base is called a **salt**. But salts are not formed only by acid-base reactions. Salts are also formed when **acids react with metals** ($Mg + 2HCl \rightarrow MgCl_2 + H_2$) and when **acids react with carbonates** ($Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$).

Neutral substances: If 10–15 g of common salt is dissolved in 50 mL of water and blue and red litmus are dipped in it, neither changes colour, because there is no acid or base in the solution. Common salt is a **neutral substance**. Pure water is also neutral. But polluted water may contain acids or bases from impurities, and then litmus may change colour.

Not every salt solution is neutral

A solution of common salt (NaCl) is neutral. But a solution of ammonium chloride (NH_4Cl) is slightly **acidic**, and a solution of washing soda or sodium carbonate (Na_2CO_3) is **alkaline**. So it is not correct to say that "every salt is neutral".

3.7 The pH Scale

Know a little more

To measure how acidic or alkaline a solution is, scientists use the **pH scale**. The scale goes from **0 to 14**.

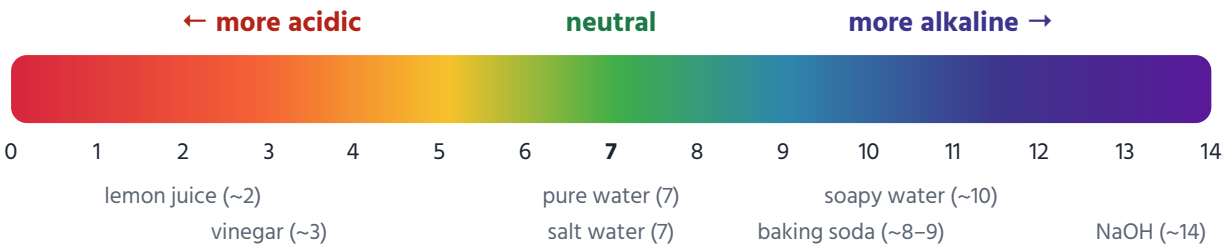


Figure 3.4: The pH scale. pH below 7 is acidic, 7 is neutral and above 7 is alkaline.

Remember

pH < 7 → acidic · pH = 7 → neutral · pH > 7 → alkaline. The lower the pH, the more acidic the solution; the higher the pH, the more alkaline the solution.

Chapter summary

- An acid gives H^+ ions in water, tastes sour and turns blue litmus red.
- A metal oxide or hydroxide is a base; it gives OH^- in water, turns red litmus blue, tastes bitter and feels slippery.
- A water-soluble base = an alkali. All alkalis are bases, but not all bases are alkalis [e.g. $Al(OH)_3$].
- The colour change of an indicator shows whether a substance is an acid, a base or neutral.
- Acid + base → salt + water (neutralization). A solution of common salt is neutral, but not every salt solution is neutral.
- Acid + metal carbonate/bicarbonate → salt + water + CO_2.
- Acid + metal → salt + hydrogen gas.
- Many organic acids in fruits can be eaten in safe amounts; mineral acids are harmful. Industrial development is judged by the use of H_2SO_4.

Exercise: Multiple Choice Questions (MCQ)

Choose the correct answer from the five options. Total questions: 65.

1. **What colour does an acid turn blue litmus paper?**
   (a) Green
   (b) Red
   (c) Yellow
   (d) Colourless
   (e) It stays blue

2. **What colour does a base turn red litmus paper?**
   (a) Blue
   (b) Yellow
   (c) Pink
   (d) Green
   (e) It stays red

3. **Litmus paper is made from the colour of which organisms?**
   (a) Lichens
   (b) Algae
   (c) Fungi
   (d) Mosses
   (e) Ferns

4. **Substances that identify acids, bases or neutral substances by changing colour are called:**
   (a) catalysts
   (b) solvents
   (c) indicators
   (d) electrolytes
   (e) radicals

5. **Which of the following is NOT an indicator?**
   (a) Litmus
   (b) Phenolphthalein
   (c) Methyl orange
   (d) Sodium chloride
   (e) Methyl red

6. **How does an acid taste?**
   (a) Sour
   (b) Sweet
   (c) Bitter
   (d) Salty
   (e) Tasteless

7. **Which ion does an acid produce in water?**
   (a) OH^-
   (b) H^+
   (c) Na^+
   (d) Cl^-
   (e) O^{2-}

8. **Which ion does a base produce in water?**
   (a) H^+
   (b) Cl^-
   (c) SO_4^{2-}
   (d) CO_3^{2-}
   (e) OH^-

9. **Which acid is present in lemon juice?**
   (a) Tartaric acid
   (b) Oxalic acid
   (c) Citric acid
   (d) Malic acid
   (e) Acetic acid

10. **Which acid is present in tamarind?**
    (a) Citric acid
    (b) Ascorbic acid
    (c) Tartaric acid
    (d) Lactic acid
    (e) Formic acid

11. **Which acid is present in tomato?**
    (a) Citric acid
    (b) Oxalic acid
    (c) Acetic acid
    (d) Malic acid
    (e) Tartaric acid

12. **What is the other name of the acid present in amloki?**

(a) Vitamin A
(b) Vitamin D
(c) Vitamin C
(d) Vitamin K
(e) Vitamin B

13. **Which disease is caused by the lack of ascorbic acid?**

(a) Night blindness
(b) Scurvy
(c) Rickets
(d) Goitre
(e) Anaemia

14. **Which acid is present in vinegar?**

(a) Citric acid
(b) Acetic acid
(c) Hydrochloric acid
(d) Nitric acid
(e) Oxalic acid

15. **Which acid is present in apples and pineapples?**

(a) Malic acid
(b) Citric acid
(c) Tartaric acid
(d) Oxalic acid
(e) Ascorbic acid

16. **Which of the following is a mineral acid?**

(a) Citric acid
(b) Ascorbic acid
(c) Acetic acid
(d) Sulphuric acid
(e) Tartaric acid

17. **Which of the following is an organic acid?**

(a) Citric acid
(b) HNO_3
(c) HCl
(d) H_2SO_4
(e) H_3PO_4

18. **Methane (CH_4) has four hydrogen atoms. Why is it not an acid?**

(a) It is a gas
(b) It has no oxygen
(c) It does not taste sour
(d) It does not produce H^+ ions in water
(e) It produces OH^- in water

19. **Which acid helps digest food in our stomach?**

(a) Hydrochloric acid
(b) Sulphuric acid
(c) Nitric acid
(d) Acetic acid
(e) Citric acid

20. **A country's industrial development is usually judged by the amount of which acid it uses?**

(a) H_2SO_4
(b) HCl
(c) HNO_3
(d) CH_3COOH
(e) H_3PO_4

21. **Which acid is used in car batteries?**

(a) Sulphuric acid
(b) Hydrochloric acid
(c) Nitric acid
(d) Citric acid
(e) Acetic acid

22. **Which acid do goldsmiths use for making gold ornaments?**

(a) Nitric acid
(b) Sulphuric acid
(c) Hydrochloric acid
(d) Acetic acid
(e) Oxalic acid

23. **Which salt is formed when limestone reacts with dilute HCl?**

(a) CaO
(b) $CaCO_3$
(c) $CaSO_4$
(d) $CaCl_2$
(e) NaCl

24. **What is a metal oxide or hydroxide called?**

(a) Acid
(b) Salt
(c) Indicator
(d) Base
(e) Radical

25. **What is a water-soluble base called?**

(a) Acid
(b) Salt
(c) Neutral substance
(d) Indicator
(e) Alkali

26. **Which of the following is a base but not an alkali?**

(a) NaOH
(b) KOH
(c) $Ca(OH)_2$
(d) NH_4OH
(e) $Al(OH)_3$

27. **What does ammonia (NH_3) form when it reacts with water?**

(a) NH_4Cl
(b) HNO_3
(c) NH_4OH
(d) N_2
(e) NH_2

28. **Why does soap feel slippery?**

(a) Soap contains acid
(b) Soap contains a base
(c) Soap contains salt
(d) Soap contains water
(e) Soap contains sugar

29. **Which base is used to make soap?**

(a) Magnesium hydroxide
(b) Sodium hydroxide
(c) Aluminium hydroxide
(d) Calcium carbonate
(e) Ammonium chloride

30. **What is the main ingredient of antacid medicine?**

(a) NaOH
(b) $Ca(OH)_2$
(c) HCl
(d) $Mg(OH)_2$
(e) NaCl

31. **What is milk of magnesia?**

(a) A solution of $Ca(OH)_2$
(b) Powdered MgO
(c) A solution of $MgCl_2$
(d) A suspension of $Mg(OH)_2$
(e) A mixture of milk and magnesium

32. **Bleaching powder is made by the reaction of which two substances?**

(a) Dry $Ca(OH)_2$ and Cl_2
(b) CaO and O_2
(c) NaOH and HCl
(d) $CaCO_3$ and HCl
(e) $Mg(OH)_2$ and Cl_2

33. **A dilute solution of which substance is used for whitewashing buildings?**

(a) NaOH
(b) $Mg(OH)_2$
(c) H_2SO_4
(d) NaCl
(e) $Ca(OH)_2$

34. **Which gas is produced when dilute HCl is added to limestone?**

(a) H_2
(b) O_2
(c) CO_2
(d) Cl_2
(e) N_2

35. **$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + X$. What is X?**

(a) H_2
(b) CO
(c) O_2
(d) CO_2
(e) CaO

36. **How can the gas produced by zinc and dilute HCl be identified?**

(a) It turns lime water milky
(b) It turns blue litmus red
(c) It has a pungent smell
(d) It puts out a burning stick
(e) It burns with a "pop" sound when a burning stick is held near it

37. **What is produced when an acid reacts with a metal?**

(a) Salt and water
(b) Salt and hydrogen gas
(c) Salt, water and CO_2
(d) Base and water
(e) Only water

38. **Which property of acids is used to produce CO_2 for putting out fires?**

(a) Acid + metal
(b) Acid + base
(c) Acid + indicator
(d) Acid + carbonate
(e) Acid + water

39. **$NaOH + HCl \rightarrow ? + H_2O$. What fills the blank?**

(a) NaH
(b) NaCl
(c) NaO
(d) Cl_2
(e) NaOCl

40. **What is the formation of salt and water from an acid and a base called?**

(a) Combustion
(b) Neutralization
(c) Decomposition
(d) Addition
(e) Electrolysis

41. **In $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$, which is the salt?**

(a) $Ca(OH)_2$
(b) H_2SO_4
(c) H_2O
(d) None of these
(e) $CaSO_4$

42. **Which salt is formed by the reaction of KOH and HNO_3?**

(a) KNO_3
(b) KCl
(c) K_2SO_4
(d) KNO_2
(e) $NaNO_3$

43. **What happens if red and blue litmus are dipped in a common salt solution?**

(a) Neither changes colour
(b) Red litmus turns blue
(c) Blue litmus turns red
(d) Both turn white
(e) Both turn green

44. **What is the pH of pure water?**

(a) 7
(b) 0
(c) 5
(d) 10
(e) 14

45. **A solution has pH 3. What is its nature?**

(a) Alkaline
(b) Neutral
(c) Salty but neutral
(d) Acidic
(e) Cannot be determined

46. **What colour does phenolphthalein show in an alkaline solution?**

(a) Colourless
(b) Yellow
(c) Blue
(d) Pink
(e) Red

47. **Taking an antacid gives relief from stomach acidity because:**

(a) the antacid increases acid
(b) the antacid stops digestion
(c) the antacid absorbs water
(d) the antacid is an organic acid
(e) the base in the antacid neutralizes the extra acid

48. **About bases:**
i. bases taste bitter
ii. bases turn red litmus blue
iii. all bases dissolve in water
Which of the following is correct?

(a) i
(b) iii
(c) i and ii
(d) ii and iii
(e) i, ii and iii

49. **About mineral acids:**
i. they are obtained from minerals in nature
ii. HCl and H_2SO_4 are examples
iii. they cause serious damage if they touch the skin
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

50. **Salts are formed:**
i. by the reaction of acids and bases
ii. by the reaction of acids and metals
iii. by the reaction of acids and carbonates
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

51. **How does a base taste?**

(a) Sour
(b) Sweet
(c) Salty
(d) Tasteless
(e) Bitter

52. **What happens when blue litmus paper is dipped in lemon juice?**

(a) It stays blue
(b) It turns green
(c) It turns white
(d) It turns yellow
(e) It turns red

53. **What happens when red litmus paper is dipped in lime water?**

(a) It stays red
(b) It turns blue
(c) It turns green
(d) It turns yellow
(e) It becomes colourless

54. **What colour does phenolphthalein show in an acidic solution?**

(a) Red
(b) Colourless
(c) Pink
(d) Blue
(e) Yellow

55. **What colour does methyl orange show in an alkaline solution?**

(a) Red
(b) Blue
(c) Yellow
(d) Pink
(e) Colourless

56. **Which ions does HCl produce in water?**

(a) Na^+ and Cl^-
(b) H^+ and OH^-
(c) H^+ and Cl^-
(d) Cl^- and OH^-
(e) H^- and Cl^+

57. **Which ions does NaOH produce in water?**

(a) H^+ and OH^-
(b) Na^+ and H^+
(c) Na^+ and OH^-
(d) Na^- and OH^+
(e) Na^+ and O^{2-}

58. **Which acid is a main ingredient of the fertilizer industry?**

(a) Hydrochloric acid
(b) Acetic acid
(c) Sulphuric acid
(d) Citric acid
(e) Oxalic acid

59. **In $Mg + 2HCl \rightarrow MgCl_2 + H_2$, which is the salt?**

(a) Mg
(b) HCl
(c) $MgCl_2$
(d) H_2
(e) None of these

60. **$NaHCO_3 + HCl \rightarrow NaCl + H_2O + X$. What is X?**

(a) H_2
(b) O_2
(c) Cl_2
(d) CO
(e) CO_2

61. **What kind of substance is pure water?**

(a) Acidic
(b) Alkaline
(c) A salt
(d) An alkali
(e) Neutral

62. **A solution has pH 12. What is its nature?**

(a) Acidic
(b) Neutral
(c) Alkaline
(d) Salty but neutral
(e) Cannot be determined

63. **The water solution of which salt is alkaline?**

(a) NaCl
(b) NH_4Cl
(c) KNO_3
(d) Na_2CO_3
(e) $CaCl_2$

64. **Which of the following is NOT a mineral acid?**

(a) HCl
(b) H_2SO_4
(c) HNO_3
(d) H_3PO_4
(e) Ascorbic acid

65. **About acids:**
i. they produce H^+ ions in water
ii. they turn blue litmus red
iii. they give hydrogen gas when they react with metals
Which of the following is correct?

(a) i
(b) i and ii
(c) ii and iii
(d) i and iii
(e) i, ii and iii

Answer Key

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

Explanations for selected questions

17. (a) Citric acid is found in lemons and oranges; the others are mineral acids.

18. (d) To be an acid, a substance must give H^+ in water; methane does not.

23. (d) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$.

26. (e) $Al(OH)_3$ does not dissolve in water, so it is not an alkali.

27. (c) $NH_3 + H_2O \rightarrow NH_4OH$.

35. (d) Acid + carbonate → salt + water + CO_2.

36. (e) H_2 gas is formed here, and it burns with a pop sound near a burning stick.

38. (d) An acid reacts with a carbonate to give CO_2, which helps put out fires.

42. (a) K from the base and NO_3 from the acid make KNO_3.

43. (a) A solution of NaCl is neutral, so neither litmus changes colour.

45. (d) A solution with pH below 7 is acidic.

47. (e) The $Mg(OH)_2$ in the antacid undergoes neutralization with the extra HCl in the stomach.

48. (c) Not all bases dissolve in water (e.g. $Al(OH)_3$), so iii is wrong.

60. (e) A bicarbonate reacts with an acid to give salt, water and CO_2.

62. (c) A solution with pH above 7 is alkaline.

63. (d) A solution of sodium carbonate (washing soda) is alkaline; NH_4Cl solution is acidic, and the others are nearly neutral.