3 Atoms and Molecules

Fastrack Revision

- **Maharishi Kanad,** an Indian Philosopher proposed that matter is made up of small particles called **parmanu**. The Greek Philosopher, **Democritus** proposed that matter is made up of extremely small particles called **atoms.**
- **Laws of Chemical Combination:** Certain laws which show that compounds are formed by chemical combination of reactants (atoms or molecules) in fixed proportion by weight or by volume. These are:
  - **Law of Conservation of Mass:** Mass can neither be created nor destroyed in a chemical reaction.
    Total mass of reactants = Total mass of products.
  - **Law of Constant Proportion:** In a chemical substance, the elements are always present in definite proportions by mass.

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Joseph Louis Proust gave the law of constant proportion hence, this law is also called Proust's Law. Law of constant proportion is also called the law of definite proportions.

- **Dalton's Atomic Theory:** All matter, whether an element, a compound or a mixture is composed of small particles called atoms.
- **Postulates of Dalton's Atomic Theory:**
  - All forms of matter are made up of very tiny particles called atoms.
  - Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.
  - Atoms of a given element are identical in mass and chemical properties.
  - Atoms of different elements have different masses as well as chemical properties.
  - Atoms combine in the ratio of small whole numbers to form compounds.
  - The relative number and kinds of atoms are constant in a given compound.
- **Atom:** Smallest unit of an element which may or may not exist independently but always take part in a chemical reaction.

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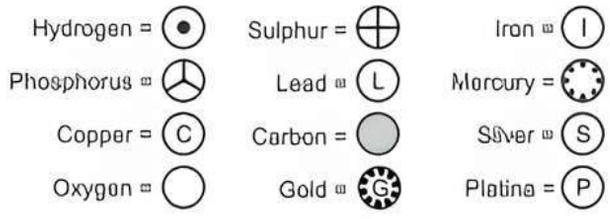
The smallest atom (by mass) in the periodic table is the hydrogen atom with one proton and one electron while the atom with smallest atomic radius is the helium atom (atomic radius = 31pm).

- **What are the Modern Day Symbols of Atoms of Different Elements?**
  - Dalton was the first scientist to suggest specific symbols in terms of figures for different elements known at that time (which were limited in number). In fact, the symbol used by him also represented the quantity of the element, *i.e.*, one atom of the element.



- IUPAC (International Union of Pure and Applied Chemistry) approves names of the different elements:
  - Many of the symbols are the first one or two letters of the element's name in English.
  - The first letter of a symbol is always written as a capital letter and the second letter as a small letter.
  - Symbols of some elements are formed from the first letter of the name and a letter, appearing later in the name.
  - Other symbols have been taken from the names of elements in Latin, German or Greek.
- **Atomic Mass:** According to Dalton, each element has a characteristic atomic mass. But determining the mass of an individual atom was a relatively difficult task due to its very small size. Hence, their relative atomic masses were determined using the laws of chemical combinations and the compounds formed.
  For this purpose, initially 1/16 of the mass of an atom of naturally occurring oxygen was taken as standard unit because of the following two reasons:
  (i) Oxygen reacted with a large number of elements and formed compounds.
  (ii) This unit gave masses of most of the elements as whole numbers.
  However in 1961, carbon (C-12 isotope) was chosen as standard reference for measuring atomic masses universally.
- **Atomic Mass Unit:** One atomic mass unit is a mass unit equal to exactly one-twelfth (1/12th) the mass of one atom of carbon –12.
  or Atomic mass unit = $\frac{1}{12}$ the mass of a carbon –12 atom.
- **Relative Atomic Mass:** The relative atomic mass of the atom of an element is defined as the average mass of the atom, as compared to 1/12th the mass of one carbon-12 atom.

- **How do Atoms Exist?**
  - Atoms of most elements are not able to exist independently.
  - Atoms form molecules and ions. These molecules or ions aggregate in large numbers to form the matter that we can see, feel or touch.
- **Molecules:** Smallest particle of an element or a compound that is capable of independent existence and shows all the properties of that substance. They can be divided into two categories:
  - **Molecules of Elements:** They contain two or more than two atoms of the same element, *e.g.*, O_2, S_8, etc.
  - **Molecules of Compounds:** They consist of two or more atoms of different elements which are joined together in a fixed ratio by chemical bonds. *e.g.*, H_2O, NH_3 etc.

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Atomicity is the number of atoms present in a molecule and on the basis of this, molecules can be monoatomic, diatomic, triatomic, tetra-atomic or polyatomic.

- **Molecular Formula:** It is the symbolic representation of a molecule of any substance representing the actual number of various atoms present in it, *e.g.*, molecular formula of water is H_2O.
- **Ions:** An electrically charged particle having either a positive or a negative charge. The positively charged particles are cations (*e.g.*, Na^+, Ca^{2+}, etc.) and negatively charged particles are anions (*e.g.*, Cl^-, O^{2-}, etc.)

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The compound is electrically neutral since the sum of the total of positive charges on cation is equal to the sum of negative charges on anion.

- **Radicals:** A group of atoms carrying a fixed charge on them. Radicals are also called polyatomic ions.
- **Valency:** It is the measure of combining capacity of an element with other atoms when it forms compounds or molecules.
- **Chemical Formula:** The shortest way to represent a compound with the help of symbols and valency of elements. The chemical formula of ionic compounds is determined by the charge on each ion present in them.
- **Writing Chemical Formula:** Some rules are followed to write the chemical formula of compounds:

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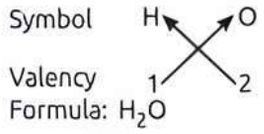
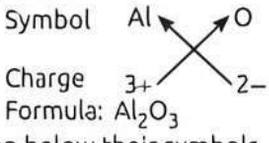
In general, metals are electropositive elements (tendency to donate electrons) whereas non-metals are electronegative elements (tendency to accept electrons).

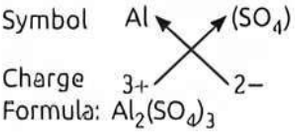
  - The valencies or charges on the ion must be balanced.
  - If a compound consist of a metal and a non-metal then, the name or symbol of the metal is written first.
  - If a compound is formed with polyatomic ions, then polyatomic ions are written in brackets.
- **Formulae of Simple Compounds**
  - In case of simple molecular compounds, which are made up of two different elements (also called binary compounds), the symbols of two elements are written side by side and their respective valencies are written below their symbols.



  - In case of simple ionic compounds, made up of monoatomic ions, the symbol of the metal atom (forming the cation) is written first followed by the symbol of the non-metal atom (forming the anion) and their respective charges are written below their symbols.



  - In case of ionic compounds containing polyatomic ions, the formula of the polyatomic ion is written in brackets and the charges are written below:



  - Then we must cross-over the valencies of the combining atoms or the charges.
- **Molecular Mass:** It is the sum of atomic masses of all atoms present in a molecule. In other words, it is the relative mass of a molecule expressed in atomic mass units (*u*).
- **Formula Unit Mass:** It is the sum of the atomic masses of all atoms present in a formula unit of a compound, *e.g.*, NaCl has formula unit mass = 1 × 23 + 1 × 35.5 = 58.5 u.

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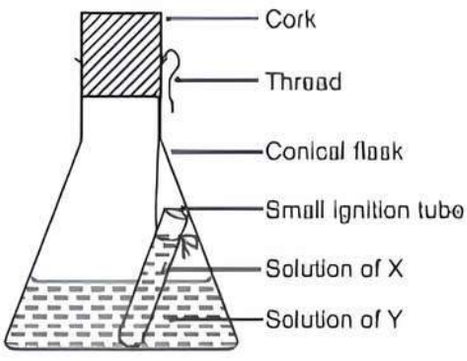
Compounds made of metal and non-metal are called salts. e.g., $CaCl_2$, ZnS, etc.

Practice Exercise

Multiple Choice Questions

Q 1. Observe the given experimental set-up in which an ignition tube containing solution of *X*, is dipped in a conical flask containing solution of *Y*. Tilt and swirl the flask, so that both the solutions get mixed.

According to the law of conservation of mass, what could be solutions *X* and *Y*?



	X	Y
a.	Copper sulphate	Sodium carbonate
b.	Barium chloride	Sodium sulphate
c.	Lead nitrate	Sodium chloride
d.	All of the above	

Q 2. According to the given reaction:

$$\underset{10.0\ g}{CaCO_{3(s)}} \xrightarrow{\Delta} \underset{5.6\ g}{CaO_{(s)}} + \underset{x\ g}{CO_{2(g)}}$$

What is the value of *x*?

a. 10.0 g b. 5.6 g
c. 4.4 g d. 10.11 g

Q 3. Identify the correct statements:

(i) In a compound such as water, the ratio of the mass of hydrogen to the mass of oxygen is always 8 : 1.

(ii) If 9 g of water is decomposed, 1 g of hydrogen and 8 g of oxygen are always obtained.

(iii) In ammonia, nitrogen and hydrogen are always present in the ratio 3 : 14 by mass.

(iv) Many compounds are composed of two or more elements and each such compound has the same elements in the same proportions.

a. (i) and (iii) b. (i), (ii) and (iii)
c. (ii) and (iv) d. All of these

Q 4. Identify the incorrect statement.

a. The building blocks of all matter are atoms.
b. Atoms are very small. They cannot be seen by the naked eye.
c. The size of an atom is measured in nanometres.
d. None of these

Q 5. John Dalton, devised a method of representing the atoms of elements in the form of symbols. When he used a symbol for an element he also meant a definite quantity of that element. Match the columns by choosing the correct option.

Column-I	Column-II
A. 	(i) Hydrogen
B. 	(ii) Sulphur
C. 	(iii) Mercury
D. 	(iv) Copper
E. 	(v) Carbon

a. A-(iii), B-(ii), C-(i), D-(iv), E-(v)
b. A-(iii), B-(i), C-(v), D-(iv), E-(ii)
c. A-(iv), B-(i), C-(iii), D-(ii), E-(v)
d. A-(iii), B-(iv), C-(v), D-(ii), E-(i)

Q 6. Identify the correct statements about the IUPAC names of the elements:

(i) Many of the symbols are the first one or two letters of the element's name in English.

(ii) The first letter of a symbol is always written as a capital letter and the second letter as a small letter.

(iii) Symbols of some elements are formed from the first letter of the name and a letter, appearing later in the name.

(iv) Other symbols have been taken from the names of elements in Latin, German or Greek.

a. (i) and (ii) b. (ii) and (iii)
c. (ii), (iii) and (iv) d. All of these

Q 7. Some elements along with their symbols are enlisted in the given table:

Elements					
(i)	Argon-Ar	(iv)	Lead-Pb	(vii)	Potassium-P
(ii)	Iron-I	(v)	Gold-Au	(viii)	Sodium-S
(iii)	Chlorine-Cl	(vi)	Magnesium-Ma	(ix)	Zinc-Zn

Identify the incorrect representation of symbols:

a. (iv), (v) and (vi)
b. (i), (ii), (iv), (v) and (ix)
c. (ii), (vi), (vii) and (viii)
d. (iii), (vi) and (viii)

Q 8. Which of the following statements is not true about an atom? *(NCERT EXEMPLAR)*

a. Atoms are not able to exist independently.
b. Atoms are the basic units from which molecules and ions are formed.
c. Atoms are always neutral in nature.
d. Atoms aggregate in large numbers to form the matter that we can see, feel or touch.

Q 9. Which of the following molecules are diatomic?

(i) Nitrogen (ii) Neon (iii) Oxygen
(iv) Sulphur (v) Phosphorus (vi) Ozone
(vii) Fluorine (viii) Hydrogen (ix) Fullerene

a. (ii), (iv), (v) and (vi) b. (iv), (v) and (ix)
c. (ii) and (vi) d. (i), (iii), (vii) and (viii)

Q 10. Identify the incorrect statement.

a. The ratio by number of atoms for water is H : O = 2 : 1
b. Ratio by mass of atoms present in ammonia is N : H = 17 : 3
c. Ratio by mass of atoms present in carbon dioxide is C : O = 3 : 8
d. All the statements are correct.

Q 11. Some elements and ions with their valencies are enlisted in the given table:

Name (Valency)			
(i)	Oxygen (2)	(vi)	Sodium (2)
(ii)	Iodine (1)	(vii)	Helium (2)
(iii)	Argon (0)	(viii)	Chlorine (1)
(iv)	Magnesium (3)	(ix)	Potassium (1)
(v)	Carbon (4)	(x)	Aluminium (3)

Select the incorrect match:

a. (iv), (v), (vii) and (ix) b. (iv), (vi) and (vii)
c. (i), (viii), (ix) and (x) d. (ii), (iii), (v) and (ix)

Q 12. What is the formula of carbon tetrachloride?

a. CCl_4 b. CCl_3 c. CCl_2 d. CCl

Q 13. Chlorine reacts with sodium to form the compound NaCL Chlorine also reacts with phosphorus to form the compound PCl_3. What will be the chemical formula of the compound formed between sodium and phosphorus?

a. Na_2P_3 b. Na_3P c. NaP d. NaP_3

Q 14. Some of the molecules with their molecular masses are enlisted in the given table:

	Molecule	Molecular mass (amu)
(i)	H_2O	18
(ii)	CO_2	54
(iii)	NH_3	17
(iv)	CH_3OH	32
(v)	C_2H_6	26
(vi)	CO	28
(vii)	CH_4	16
(viii)	O_2	34

Identify the incorrect molecular masses:

a. (iii), (v) and (viii) b. (ii), (v) and (viii)

c. (i), (ii) and (iv) d. (vi), (vii) and (viii)

Q 15. The formula mass of $CuSO_4.5H_2O$ is [At. mass of Cu = 63.5 u, S = 32 u, O = 16 u, H = 1 u]:

a. 265.5 u b. 249.5 u c. 408.2 u d. 329.7u

Assertion & Reason Type Questions

Directions (Q. Nos. 16-23): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 16. Assertion (A): In a chemical substance, the elements are always present in definite proportions by mass.
Reason (R): Atoms of different elements have different masses as well as chemical properties.

Q 17. Assertion (A): Law of conservation of mass holds good for nuclear reactions.
Reason (R): It states that mass can neither be created nor destroyed in a chemical reaction.

Q 18. Assertion (A): Pure water obtained from different sources such as, river, well, spring, sea, etc. always contains hydrogen and oxygen combined in the ratio 1: 8 by mass.
Reason (R): A chemical compound always contains elements combined together in the same proportion by mass.

Q 19. Assertion (A): In most of the elements, atoms are not able to exist independently.
Reason (R): Atoms combine to form molecules or ions that aggregate in large numbers.

Q 20. Assertion (A): Atomic mass of aluminium is 27.
Reason (R): An atom of aluminium is 27 times heavier than 1/12th of the mass of carbon-12 atom.

Q 21. Assertion (A): A molecule is the smallest particle of an element or a compound which is capable of free existence.
Reason (R): The number of atoms present in one molecule of the substance is called its atomicity.

Q 22. Assertion (A): One atomic mass unit (amu) is mass of an atom equal to exactly one-twelfth the mass of a carbon-12 atom.
Reason (R): Carbon-12 isotope was selected as standard.

Q 23. Assertion (A): The molecular mass and formula unit mass of a substance is the sum of atomic masses of all the atoms in the molecular formula or formula unit of a compound.
Reason (R): The only difference between the molecular mass and formula unit mass is that, former is for molecular compounds (covalent compounds) and latter is for ionic compounds. However, their numerical value is the same.

Answers

1. (d) All of the above
2. (c) 4.4 g
   According to law of conservation of mass, mass of reactants is equal to the mass of products.

$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$$

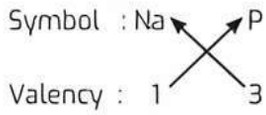
   Mass of reactant ($CaCO_3$) = 10 g
   Mass of products ($CaO + CO_2$) = (5.6 + x) g
   10 g = (5.6 + x) g
   x = 4.4 g
3. (c) (ii) and (iv)
   In a compound such as water, the ratio of the mass of hydrogen to the mass of oxygen is always 1 : 8. In ammonia, nitrogen and hydrogen are always present in the ratio 14 : 3 by mass.
4. (d) None of these
5. (d) A-(iii), B-(iv), C-(v), D-(ii), E-(i)
6. (d) All of these
7. (c) (ii), (vi), (vii) and (viii)
   Iron-Fe, Magnesium-Mg, Potassium-K, Sodium-Na.
8. (a) Atoms are not able to exist independently.
   Atoms of inert gases exist in monoatomic or independent form.
9. (d) (i), (iii), (vii) and (viii)
   (i) Nitrogen-N_2 (iii) Oxygen-O_2
   (vii) Fluorine-F_2 (viii) Hydrogen-H_2

10. (b) Ratio by mass of atoms present in ammonia is N : H = 17 : 3
Ratio by mass of atoms present in ammonia (NH_3) is N : H = 14 : 3.

11. (b) (iv), (vi) and (vii)
Magnesium-2, Sodium-1, Helium-0

12. (a) CCl_4

13. (b) Na_3P
Valency of sodium = 1
Valency of phosphorus = 3



Formula : Na_3P

14. (b) (ii), (v) and (viii)
Molecular mass of CO_2
= Atomic mass of C + 2(Atomic mass of O)
= 12 + 2 × 16 = 44 amu
Molecular mass of C_2H_6 = 2 × 12 + 6 × 1
= 24 + 6 = 30 amu
Molecular mass of O_2 = 2 × 16 = 32 amu

15. (b) 249.5 u
$CuSO_4 \cdot 5H_2O$ = At. mass of Cu + At. mass of S + 4 (At. mass of O) + 5(Mol. mass of H_2O)
= 63.5 + 32 + 4 × 16 + 5(18)
= 63.5 + 32 + 64 + 90 = 249.5 u

16. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

17. (d) Assertion (A) is false because law of conservation of mass does not hold good for nuclear reactions due to mass defect.
Law of conservation of mass states that matter can neither be created nor destroyed.

18. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Pure water always contains hydrogen and oxygen in the ratio 1 : 8 by mass. This is in accordance with the law of constant proportions.

19. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

20. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

21. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

22. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
For universally accepted atomic mass unit in 1961, C-12 was selected as standard. However, the new symbol used is 'u' (unified mass) in place of amu.

23. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Lavoisier, along with other scientists, noted that many compounds were composed of two or more elements and each such compound had the same elements in the same proportions, irrespective of where the compound came from or who prepared it. In a compound such as water, the ratio of the mass of hydrogen to the mass of oxygen is always 1 : 8, whatever be the source of water. Thus, if 9 g of water is decomposed, 1 g of hydrogen and 8 g of oxygen are always obtained. Similarly in ammonia, nitrogen and hydrogen are always present in the ratio 14 : 3 by mass, whatever the method or the source from which it is obtained. This led to the law of constant proportions which is also known as the law of definite proportions.

Read the given passage carefully and give the answer of the following questions:

Q 1. According to the law of definite proportions:
a. total mass of reactants is equal to the total mass of products
b. mass can neither be created nor destroyed
c. in a chemical substance, elements are always present in definite proportions by mass
d. Both a. and b.

Q 2. Law of constant proportion was proposed by:
a. Lavoisier b. Proust
c. Dalton d. Berzelius

Q 3. In ammonia, nitrogen and hydrogen are present in the ratio ..... by mass.
a. 14 : 3 b. 14 : 5 c. 1 : 8 d. 14 : 8

Q 4. A sample of pure water, irrespective of its source contains 11.1% hydrogen and 88.9% oxygen. The data supports:
a. law of conservation of mass
b. law of constant proportions
c. law of multiple proportions
d. Avogadro's law

Q 5. A sample of $CaCO_3$ has Ca = 40%, C = 12% and O = 48% by mass. If the law of constant proportion is true then the weight of O in 20 g $CaCO_3$ made from different processes will be:
a. 8 g b. 10.4 g c. 12 g d. 9.6 g

Answers

1. (c) In a chemical substance, elements are always present in definite proportions by mass
2. (b) Proust
3. (a) 14 : 3
4. (b) law of constant proportions
5. (d) 9.6 g
If law of constant proportion is true,
weight of O in 20 g of $CaCO_3$
$= \frac{48}{100} \times 20$
= 9.6 g

Case Study 2

The molecules of an element are constituted by the same type of atoms. Molecules of many elements, such as Argon (Ar), Helium (He) etc. are made up of only one atom of that element. But this is not the case with most of the non-metals. For example, a molecule of oxygen consists of two atoms of oxygen and hence it is known as a diatomic molecule, (O_2). If 3 atoms of oxygen unite into a molecule, instead of the usual 2, we get ozone, (O_3). The number of atoms constituting a molecule is known as its atomicity.

Let us look at the atomicity of some non-metals.

Atomicity of Some Elements

Type of elements	Name	Atomicity
Non-Metal	Argon	Monoatomic
	Helium	Monoatomic
	Oxygen	Diatomic
	Hydrogen	Diatomic
	Nitrogen	Diatomic
	Chlorine	Diatomic
	Phosphorus	Tetra-atomic
	Sulphur	Poly-atomic

Read the given passage carefully and give the answer of the following questions:

Q 1. Atomicity of sulphur is:
a. 8 b. 4 c. 2 d. 1

Q 2. Which of the following represents a polyatomic ion?
a. Hydrogen b. Oxygen
c. Argon d. Ammonium

Q 3. Which of the following is a triatomic molecule?
a. Carbon dioxide b. Ammonia
c. Hydrogen chloride d. Carbon tetrachloride

Q 4. All noble gas molecules are:
a. monoatomic b. diatomic
c. Both a. and b. d. triatomic

Q 5. Valency of noble gases is:
a. 1 b. 0
c. 2 d. None of these

Answers

1. (a) 8
2. (d) Ammonium
3. (a) Carbon dioxide
   Carbon dioxide contains one atom of carbon and two atoms of oxygen.
4. (a) monoatomic
5. (b) 0

Case Study 3

In the beginning, the names of elements were derived from the name of the place where they were found for the first time. For example, the name copper was taken from Cyprus. Some names were taken from specific colours. For example, gold was taken from the English word meaning yellow. Now-a-days, IUPAC (International Union of Pure and Applied Chemistry) is an international scientific organisation which approves names of elements, symbols and units. Many of the symbols are the first one or two letters of the element's name in English. The first letter of a symbol is always written as a capital letter (uppercase) and the second letter as a small letter (lowercase).

Symbols of some elements are formed from the first letter of the name and a letter, appearing later in the name.

Other symbols have been taken from the names of elements in Latin, German or Greek.

Read the given passage carefully and give the answer of the following questions:

Q 1. Give two symbols which have been derived from the 'English names' of the elements.

Q 2. Give two symbols which have been derived from the 'Latin names' of the elements.

Q 3. What is the chemical symbol for nitrogen gas?

Q 4. What is the chemical symbol for sodium?

Q 5. Which of the following symbols of elements are incorrect? Give their correct symbols.
(i) Cobalt (CO) **(ii) Carbon (c)**
(iii) Aluminium (AL) **(iv) Helium (He)**
(v) Tin (Tl)

Answers

1. Ca and Mg are derived from the 'English names' calcium and magnesium.
2. Cu (Copper), Au (Gold), Fe (Iron), K (Potassium) etc. are derived from their 'Latin names'.
3. Nitrogen gas exists as a diatomic molecules hence, its symbol is N_2.
4. Chemical symbol for sodium is Na.
5.

Elements	Correct symbols
(i) Cobalt	Co
(ii) Carbon	C
(iii) Aluminium	Al
(v) Tin	Sn

Case Study 4

We define the atomic mass unit (earlier abbreviated as 'amu', but according to the latest IUPAC recommendations, it is now written as 'u' - unified mass) as equal to one-twelfth the mass of one carbon-12 atom. While searching for various atomic mass units, scientists initially took 1/16 of the mass of an atom of naturally occurring oxygen as the unit.

However, in 1961 for a universally accepted atomic mass unit, carbon-12 isotope was chosen as the standard reference for measuring atomic masses.

Read the given passage carefully and give the answer of the following questions:

Q 1. What is the accepted unit of atomic mass and molecular mass?

Q 2. What is the reference standard used for defining atomic mass unit?

Q 3. Name the element whose gram-atomic mass and gram-molecular mass are the same.

Q 4. What do you understand from the statement 'relative atomic mass of sulphur is 32'?

Q 5. The relative atomic mass of beryllium is 9. How many times is an atom of beryllium heavier than atom of carbon-12?

Answers

1. Atomic mass unit (amu) or unified mass (u).
2. C-12 atom.
3. Argon.
4. This means that an atom of sulphur is 32 times heavier as compared to 1/12 of the mass of 1 atom of C-12.
5. $\frac{\text{Mass of one atom of beryllium}}{\text{Mass of one atom of carbon-12}} = \frac{9}{12} = 0.75$

   ∴ An atom of beryllium is 0.75 times heavier than an atom of carbon-12.

Case Study 5

Pankaj sir was explaining the 'crossing-over of valencies' method of working out the formula of molecular compounds as follows:

(i) We first write the symbols of the elements (ions) which from the compound.

(ii) Below the symbol of each element, we write down its valency (charge).

(iii) Finally, we cross-over the valencies (charges) of the combining elements (ions). This will give us the required formula.

Read the given passage carefully and give the answer of the following questions:

Q 1. The formula of chloride of a metal MCl_3. What is the formula of the phosphate of metal M?

Q 2. An element 'X' has a valency of 2. Write the simplest formula for:

(i) bromide of the element,

(ii) oxide of the element.

Q 3. Out of the following, the valency of each of the constituent elements is equal to the total number of atoms in one molecule of the compound?

NaCl, CaO, H_2S, $AlBr_3$

Q 4. Which of the following represents a correct chemical formula? Name it.

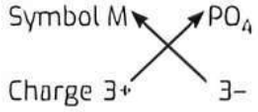
(i) CaCl (ii) $BiPO_4$ (iii) $NaSO_4$ (iv) NaS

Q 5. Write is the molecular formula of zinc phosphate.

Answers

1. The Metal 'M' is trivalent.

   ∴ The formula of phosphate of metal M will be MPO_4.

2. (i) Valency of X = 2
   Valency of Br = 1
   ∴ Formula for bromide of X is XBr_2.

   (ii) Valency of X = 2
   Valency of O = 2
   ∴ Formula for oxide of O is XO.

3. In CaO, valency of each constituent element is 2 and is equal to the total number of atoms (2) in one molecules of compound.
4. (ii) $BiPO_4$ is correct chemical formula.
   Bismuth phosphate is the name of the compound.
5. The molecular formula is $Zn_3(PO_4)_2$.

Very Short Answer Type Questions

Q 1. State the law of conservation of mass.

Ans. The law of conservation of mass states that mass can neither be created nor destroyed in a chemical reaction.

Q 2. As per the law of definite proportions, carbon and oxygen combine in a ratio of 3 : 8. Compute the mass of oxygen gas that would be required to react completely with 6 g carbon.

Ans. 3 g of carbon combines with 8 g of oxygen, thus, 6 g of carbon will combine with $\frac{8}{3} \times 6 = 16$ g of oxygen.

Q 3. Which postulate of Dalton's atomic theory can explain the law of definite proportions? *(NCERT INTEXT)*

Ans. The relative number and kinds of atoms are constant in given compound.

Q 4. Which postulate of Dalton's atomic theory is the result of the law of conservation of mass? *(NCERT INTEXT)*

Ans. Atom can neither be created nor destroyed.

Q 5. What is an atom?

Ans. An atom is the smallest particle which may or may not exist in free state in nature but takes part in a chemical reaction.

Q 6. Define atomicity.

Ans. Atomicity is the number of atoms present in a molecule.

Q 7. Is argon monoatomic or diatomic?

Ans. Argon is monoatomic because its atom can exist independently.

Q 8. Name the international organisation which approves the name given to the elements?

Ans. IUPAC, International Union of Pure And Applied Chemistry.

Q 9. Write the symbol for following elements:

(a) Iron (b) Potassium

Ans. (a) Fe (b) K

Q 10. How many atoms are present in one molecule of ozone?

Ans. Three atoms of oxygen are present in 1 molecule of ozone because it is triatomic.

TiP

Triatomic molecules are composed of three atoms of either the same or different chemical elements.

Q 11. Out of atoms and molecules, which can exist independently?

Ans. Molecules can exist independently while atoms are generally found in combined state. However, the atoms of noble gases (He, Ne, Ar, Kr, Xe) can also exist independently.

Q 12. What is a molecule?

Ans. A molecule is the smallest particle of an element or a compound that is capable of independent existence and shows all the properties of that substance.

Q 13. What are polyatomic ions? Give one example of it. *(NCERT EXERCISE)*

Ans. The ion which is made up of more than one atom is called polyatomic ion. *e.g.*, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}.

Q 14. How many atoms are present in a:

(i) H_2S molecule and

(ii) PO_4^{3-} ion. *(NCERT INTEXT)*

Ans. (i) 3 atoms (ii) 5 atoms

Q 15. Choose an ionic compound among $Cu(NO_3)_2$, P_4, H_2 and O_2.

Ans. $Cu(NO_3)_2$ is an ionic compound because it has Cu^{2+} and NO_3^- ions.

Q 16. What is the molecular formula of aluminium hydroxide?

Ans. Molecular formula of aluminium hydroxide is

Symbol Al OH

Charge +3 −1

Formula: $Al(OH)_3$

Q 17. The oxide of aluminium has a chemical formula Al_2O_3. State the valency of Al.

Ans. The valency of Al is 3.

TiP

Valency is the ability of an atom or a group of atoms to form chemical bonds with other atoms or groups of atoms.

Q 18. An element *X* has valency 3 while the element *Y* has valency 2. Write the formula of the compound between *X* and *Y*.

Ans. The formula of the compound between X and Y is X_2Y_3.

Q 19. Name the anion and cation which constitute the molecule of magnesium oxide.

Ans. Magnesium (Mg^{2+}) is cation, Oxide (O^{2-}) is anion.

Q 20. Calculate formula unit mass of sugar ($C_{12}H_{22}O_{11}$).

Sol. Formula unit mass of $C_{12}H_{22}O_{11}$ = 12 C + 22 H +11O

$= 12 \times 12 + 22 \times 1 + 11 \times 16$

$= 144 + 22 + 176 = 342$ u

Q 21. Write the name of the following compounds:

(i) $Al_2(SO_4)_3$ (ii) NH_4OH

Ans. (i) Aluminium sulphate

(ii) Ammonium hydroxide

Q 22. Calculate the formula unit mass of $NaHCO_3$ (Atomic mass of Na = 23 u, H = 1 u, C = 12 u and O = 16 u).

Sol. Formula unit mass of $NaHCO_3$ = (Atomic mass of Na) + (Atomic mass of H) + (Atomic mass of C) + 3 × Atomic mass of O) = 23 + 1 + 12 + 3 × 16 = 84 u

Q 23. Write the names of compounds (i) Ag_2O, (ii) CuS.

Ans. (i) Ag_2O is called silver oxide.

(ii) CuS is called copper(II) sulphide.

Short Answer Type-I Questions

Q 1. In a reaction, 5.3 g of sodium carbonate reacted with 6 g of acetic acid. The products were 2.2 g of carbon dioxide, 0.9 g water and 8.2 g of sodium acetate. Show that these observations are in agreement with the law of conservation of mass.

sodium carbonate + acetic acid ⟶ sodium acetate + carbon dioxide + water *(NCERT INTEXT)*

Ans. $2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$

Acetic acid (Ethanoic acid); Sodium carbonate; Sodium acetate; Carbon dioxide; Water

Mass of reactants = Mass of acetic acid + Mass of sodium carbonate = 5.3 g + 6 g = 11.3 g

Mass of products = Mass of sodium acetate + Mass of carbon dioxide + Mass of water

= 2.2 g + 0.9 g + 8.2 g = 11.3 g

Total mass of reactants = Total mass of products

Therefore, the given observation is in agreement with the law of conservation of mass.

Q 2. What are the postulates of Dalton's atomic theory ? Give any four points.

Ans. The postulates of Dalton's atomic theory are as follows:

(i) All matter is made of very tiny particles called atoms, which participate in chemical reactions.

(ii) Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.

(iii) Atoms of a given element are identical in mass and chemical properties.

(iv) Atoms of different elements have different masses and chemical properties.

(v) Atoms combine in the ratio of small whole numbers to form compounds.

(vi) The relative number and kinds of atoms are constant in a given compound. (Any four)

Q 3. A 0.24 g sample of compound of oxygen and boron was found by analysis to contain 0.096 g of boron and 0.144 g of oxygen.

Calculate the percentage composition of the compound by weight. *(NCERT EXERCISE)*

Sol.

$$\% \text{ of Boron} = \frac{\text{Mass of boron}}{\text{Mass of compound of oxygen and boron}} \times 100$$

$$= \frac{0.096}{0.24} \times 100 = 40\%$$

$$\% \text{ of Oxygen} = \frac{\text{Mass of oxygen}}{\text{Mass of compound of oxygen and boron}} \times 100$$

$$= \frac{0.144}{0.24} \times 100 = 60\%$$

Q 4. A packet of ORS consists of sugar ($C_{12}H_{22}O_{11}$) and common salt (NaCl) in the ratio 12 : 1 by weight. Find the percentage mass of chlorine present in packet.

Ans. Since the ratio of sugar and common salt is 12 : 1 so, let the content present in the packet is 13 g out of which sugar is 12 g and common salt is 1 g.

Mass of NaCl = 23 + 35.5 = 58.5 g

i.e., 58.5 g NaCl consists of 35.5 g of Cl.

$\therefore$ 1 g NaCl consists of $\frac{35.5}{58.5}$ g of Cl.

i.e., Mass of Cl present in the packet = 0.61 g

$\therefore$ Percentage mass of Cl $= \frac{0.61\,g}{13\,g} \times 100 = 4.67\%$

Q 5. Give the names of the elements present in the following compounds:

(i) Quick lime (ii) Hydrogen bromide

(iii) Baking powder (iv) Potassium sulphate

(NCERT EXERCISE)

Ans. (i) Quick lime contains calcium and oxygen.

(ii) Hydrogen bromide contains hydrogen and bromine.

(iii) Baking powder ($NaHCO_3$) contains sodium, hydrogen, carbon and oxygen.

(iv) Potassium sulphate contains potassium, sulphur and oxygen.

Q 6. Write down the formulae of:

(i) sodium oxide,

(ii) aluminium chloride,

(iii) sodium sulphide,

(iv) magnesium hydroxide. *(NCERT INTEXT)*

Ans. (i) Symbol Na, O; Charge 1+, 2−; Formula: Na_2O

(ii) Symbol Al, Cl; Charge 3+, 1−; Formula: $AlCl_3$

(iii) Symbol Na, S; Charge 1+, 2−; Formula: Na_2S

(iv) Symbol Mg, OH; Charge 2+, 1−; Formula: $Mg(OH)_2$

Q 7. An element '*X*' forms an oxide with formula X_2O_3.

(i) State the valency of *X*.

(ii) Write the formula of

(a) chloride of *X*, (b) sulphate of *X*.

Ans. (i) X has valency equal of 3.

X^{3+} O^{2-}

X_2 O_3

(ii) (a) X, Cl; 3, 1; Formula: XCl_3

(b) X, SO_4; 3, 2; Formula: $X_2(SO_4)_3$

Q 8. Write the cations and anions present (if any) in the following compounds:

(i) CH_3COONa (ii) NaCl

(iii) H_2 (iv) NH_4NO_3

Ans. (i) Na^+ (Cation) and CH_3COO^- (Anion)

(ii) Na^+ (Cation) and Cl^- (Anion)

(iii) H_2 is a covalent compound

(iv) NH_4^+ (Cation) and NO_3^- (Anion)

Q 9. State the number of atoms present in each of the following chemical species:

(i) CO_3^{2-} (ii) PO_4^{3-}

(iii) P_2O_5 (iv) CO *(NCERT EXERCISE)*

Ans. (i) CO_3^{2-} contains 4 atoms

(ii) PO_4^{3-} contains 5 atoms

(iii) P_2O_5 contains 7 atoms

(iv) CO contains 2 atoms

Short Answer Type-II Questions

Q 1. (i) When 5 g of calcium is burnt in 2 g of oxygen then 7 g of calcium oxide is produced. What mass of calcium oxide will be produced when 5 g of calcium is burnt in 20 g of oxygen. Which law of chemical combination will govern your answer? State the law.

(ii) Write the chemical formula of calcium oxide.

Ans. (i) When 5 g of calcium is burnt in 2 g of oxygen, 7 g of calcium oxide is produced. From this, we understand that calcium and oxygen react in a fixed ratio of 5 : 2 by mass.

Hence, when 5 g of calcium is burnt in 20 g of oxygen, 7 g of calcium oxide will be produced and remaining oxygen (18 g) will remain unreacted.

This is in accordance with law of constant proportions. It states that in a chemical substance the elements are always present in definite proportions by mass.

(ii) CaO is the formula of calcium oxide.

Q 2. The percentage of three elements-calcium, carbon and oxygen in a sample of calcium carbonate is given as:

Calcium = 40 %; Carbon = 12%; Oxygen = 48%.

If the law of constant proportion is true, what weight of these elements will be present in 1.5 g of another sample of calcium carbonate?

(Given atomic mass of Ca = 40 u, C = 12 u, O = 16 u)

Sol. The other compound will also contain the same percentage of various elements Ca = 40%, C = 12%, O = 48%.

(i) 100 g of $CaCO_3$ consists of 40 g of calcium.

1.5 g of $CaCO_3$ will contain $= \frac{40}{100} \times 1.5$

$= 0.6$ g of calcium.

(ii) 100 g of $CaCO_3$ consists of 12 g of carbon.

1.5 g of $CaCO_3$ will contain $= \frac{12}{100} \times 1.5$

$= 0.18$ g of carbon.

(iii) 100 g of $CaCO_3$ consists of 48 g of oxygen.

1.5 g of $CaCO_3$ will contain $= \frac{48}{100} \times 1.5$

$= 0.72$ g of oxygen.

Q 3. Find out the percentage composition of each element present in sulphuric acid (H_2SO_4).

Ans. Molecular mass of H_2SO_4 = 2 × Atomic mass of H + 1 × Atomic mass of S + 4 × Atomic mass of O

$= 2 \times 1 + 1 \times 32 + 4 \times 16 = 98$ u.

Percentage of Hydrogen (H)

$$= \frac{\text{Mass of hydrogen}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{2 \times 1\text{u}}{98\text{u}} \times 100 = 2.04\%$$

Percentage of Sulphur (S)

$$= \frac{\text{Mass of sulphur}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{32\text{u}}{98\text{u}} \times 100 = 32.65\%$$

Percentage of Oxygen (O)

$$= \frac{\text{Mass of oxygen}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{4 \times 16\text{u}}{98\text{u}} \times 100 = 65.31\%$$

Q 4. (i) Define atomic mass unit.
(ii) Define molecular mass.
(iii) Give an example of:
(a) Diatomic and
(b) Triatomic molecule of compounds.

Ans. (i) Atomic mass unit is defined as 1/12th of the mass of 1 atom of C–12.

(ii) Molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance.

(iii) (a) HCl is a diatomic molecule of compound.
(b) H_2O is a triatomic molecule of compound.

Q 5. (i) How would you differentiate between a molecule of an element and a molecule of a compound? Write one example of each type.
(ii) Write the chemical formula of ammonium sulphate.

Ans. (i) A molecule of an element contains the same kind of atoms, *e.g.*, P_4 is a molecule of the element which contains all the four atoms of phosphorus. A molecule of a compound contains two or more kinds of atoms, in definite proportions, *e.g.*, H_2O is a molecule of compound which contains 2 atoms of hydrogen and 1 atom of oxygen.

(ii) $(NH_4)_2SO_4$ is the chemical formula of ammonium sulphate.

Q 6. Write the formulae of:
(i) Magnesium hydroxide (ii) Hydrogen sulphide
(iii) Potassium chloride (iv) Calcium oxide
(v) Barium chloride (vi) Sodium carbonate.

Ans. (i) Symbol Mg OH; Charge 2+ 1–; Formula: $Mg(OH)_2$

(ii) Symbol H S; Charge 1+ 2–; Formula: H_2S

(iii) Symbol K Cl; Charge 1+ 1–; Formula: KCl

(iv) Symbol Ca O; Charge 2+ 2–; Formula: CaO

(v) Symbol Ba Cl; Charge 2+ 1–; Formula: $BaCl_2$

(vi) Symbol Na CO_3; Charge 1+ 2–; Formula: Na_2CO_3

Q 7. Using criss-cross method, write the chemical formulae of:
(i) copper chloride (ii) calcium sulphate
(iii) sodium phosphate

Ans. (i) Symbol Cu Cl; Charge 2+ 1–; Formula: $CuCl_2$

(ii) Symbol Ca SO_4; Charge 2+ 2–; Formula: $CaSO_4$

(iii) Symbol Na PO_4; Charge 1+ 3–; Formula: Na_3PO_4

Q 8. Write the molecular formulae for the following compounds:
(i) Copper (II) bromide (ii) Aluminium (III) nitrate
(iii) Calcium (II) phosphate (iv) Iron (III) sulphite
(v) Mercury (II) chloride (vi) Magnesium (II) acetate

Ans. (i) Symbol Cu Br; Charge 2+ 1–; Formula: $CuBr_2$

(ii) Symbol Al NO_3; Charge 3+ 1–; Formula: $Al(NO_3)_3$

(ii) 100 g of $CaCO_3$ consists of 12 g of carbon.

1.5 g of $CaCO_3$ will contain $= \frac{12}{100} \times 1.5$

$= 0.18$ g of carbon.

(iii) 100 g of $CaCO_3$ consists of 48 g of oxygen.

1.5 g of $CaCO_3$ will contain $= \frac{48}{100} \times 1.5$

$= 0.72$ g of oxygen.

Q 3. Find out the percentage composition of each element present in sulphuric acid (H_2SO_4).

Ans. Molecular mass of H_2SO_4 = 2 × Atomic mass of H + 1 × Atomic mass of S + 4 × Atomic mass of O

$= 2 \times 1 + 1 \times 32 + 4 \times 16 = 98$ u.

Percentage of Hydrogen (H)

$$= \frac{\text{Mass of hydrogen}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{2 \times 1\text{u}}{98\text{u}} \times 100 = 2.04\%$$

Percentage of Sulphur (S)

$$= \frac{\text{Mass of sulphur}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{32\text{u}}{98\text{u}} \times 100 = 32.65\%$$

Percentage of Oxygen (O)

$$= \frac{\text{Mass of oxygen}}{\text{Molecular mass of } H_2SO_4} \times 100$$

$$= \frac{4 \times 16\text{u}}{98\text{u}} \times 100 = 65.31\%$$

Q 4. (i) Define atomic mass unit.
(ii) Define molecular mass.
(iii) Give an example of:
(a) Diatomic and
(b) Triatomic molecule of compounds.

Ans. (i) Atomic mass unit is defined as 1/12th of the mass of 1 atom of C–12.

(ii) Molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance.

(iii) (a) HCl is a diatomic molecule of compound.
(b) H_2O is a triatomic molecule of compound.

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(ii) Write the chemical formula of ammonium sulphate.

Ans. (i) A molecule of an element contains the same kind of atoms, *e.g.*, P_4 is a molecule of the element which contains all the four atoms of phosphorus. A molecule of a compound contains two or more kinds of atoms, in definite proportions, *e.g.*, H_2O is a molecule of compound which contains 2 atoms of hydrogen and 1 atom of oxygen.

(ii) $(NH_4)_2SO_4$ is the chemical formula of ammonium sulphate.

Q 6. Write the formulae of:
(i) Magnesium hydroxide (ii) Hydrogen sulphide
(iii) Potassium chloride (iv) Calcium oxide
(v) Barium chloride (vi) Sodium carbonate.

Ans. (i) Symbol Mg OH; Charge 2+ 1–; Formula: $Mg(OH)_2$

(ii) Symbol H S; Charge 1+ 2–; Formula: H_2S

(iii) Symbol K Cl; Charge 1+ 1–; Formula: KCl

(iv) Symbol Ca O; Charge 2+ 2–; Formula: CaO

(v) Symbol Ba Cl; Charge 2+ 1–; Formula: $BaCl_2$

(vi) Symbol Na CO_3; Charge 1+ 2–; Formula: Na_2CO_3

Q 7. Using criss-cross method, write the chemical formulae of:
(i) copper chloride (ii) calcium sulphate
(iii) sodium phosphate

Ans. (i) Symbol Cu Cl; Charge 2+ 1–; Formula: $CuCl_2$

(ii) Symbol Ca SO_4; Charge 2+ 2–; Formula: $CaSO_4$

(iii) Symbol Na PO_4; Charge 1+ 3–; Formula: Na_3PO_4

Q 8. Write the molecular formulae for the following compounds:
(i) Copper (II) bromide (ii) Aluminium (III) nitrate
(iii) Calcium (II) phosphate (iv) Iron (III) sulphite
(v) Mercury (II) chloride (vi) Magnesium (II) acetate

Ans. (i) Symbol Cu Br; Charge 2+ 1–; Formula: $CuBr_2$

(ii) Symbol Al NO_3; Charge 3+ 1–; Formula: $Al(NO_3)_3$

(iii) During the formation of ammonia, what mass of hydrogen gas would be required to react completely with 42 g of nitrogen gas?

Ans. (i) Mass of reactants = Mass of products

$\Rightarrow$ Mass of CH_3COOH + Mass of $NaHCO_3$

= Mass of CH_3COONa + Mass of CO_2 + Mass of H_2O

Putting the values in equation:

$6.0 + 8.4 = 10.0 +$ Mass of CO_2

or Mass of $CO_2 = 6.0 + 8.4 - 10.0$

$= 14.4 - 10.0 = 4.4$ g

(ii) In ammonia (NH_3), N and H are present in a fixed ratio that supports the law of definite or constant proportions.

This law states, 'a pure chemical compound always consists of the same elements that are combined together in a fixed proportion by mass.'

(iii) Molecular mass of ammonia (NH_3)

= Mass of N + Mass of H

$= 14 + 3 \times 1 = 17$

To react with 14 g N, mass of H required = 3 g

Therefore, to react with 42 g N, mass of H required $= \frac{3}{14} \times 42 = 9$ g

Q 2. (i) What do the following symbols/formulae stands for?

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

(ii) Give the chemical formulae of the following compounds:

(a) Potassium carbonate

(b) Calcium chloride

(iii) Calculate the formula unit mass of $Al_2(SO_4)_3$. (Given atomic mass of Al = 27 u, S = 32 u, O = 16 u)

Ans. (i) (a) 2O → 2 atoms of oxygen

(b) O_2 → Diatomic oxygen/Dioxygen

(c) O_3 → Triatomic oxygen/Ozone

(d) H_2O → Two atoms of hydrogen and one atom of oxygen combine to form one molecule of water (H_2O).

(ii) (a) Symbol K CO_3 (b) Symbol Ca Cl

Charge 1+ 2– Charge 2+ 1–

Formula: K_2CO_3 Formula: $CaCl_2$

(iii) Atomic mass of Al = $27 \times 2 = 54$ u

Atomic mass of S = $32 \times 3 = 96$ u

Atomic mass of O = $16 \times 12 = 192$ u

Formula unit mass of $Al_2(SO_4)_3 = 54 + 96 + 192$

= 342 u

Q 3. (i) Write the molecular formula of all the compounds that can be formed by the combination of the following ions:

Cu^{2+}, Na^+, Fe^{3+}, Cl^-, SO_4^{-2}, PO_4^{3-}

(ii) Calculate the formula unit masses of ZnO and Na_2O, given atomic masses of Zn = 65 u, Na = 23 u, K = 39 u and O = 16 u.

(NCERT EXEMPLAR)

Sol. (i)

Cu^{2+} Cl^- → $CuCl_2$	Cu^{2+} SO_4^{2-} → $CuSO_4$	Cu^{2+} PO_4^{3-} → $Cu_3(PO_4)_2$
Na^+ Cl^- → $NaCl$	Na^+ SO_4^{2-} → Na_2SO_4	Na^+ PO_4^{3-} → Na_3PO_4
Fe^{3+} Cl^- → $FeCl_3$	Fe^{3+} SO_4^{2-} → $Fe_2(SO_4)_3$	Fe^{3+} PO_4^{3-} → $FePO_4$

(ii) Formula unit mass of ZnO = 65 + 16 = 81 u

Formula unit mass of Na_2O = $2 \times 23 + 16$

= 46 + 16 = 62 u

Chapter Test

Multiple Choice Questions

Q 1. Latin name for iron is:

a. falium
b. fatrium
c. femur
d. ferrum

Q 2. Which law states that the total mass of the reactants is equal to the total mass of the products in a chemical reaction?

a. Law of constant proportions
b. Law of conservation of energy
c. Law of conservation of mass
d. Law of multiple proportions

Q 3. All noble gas molecules are:

a. monoatomic b. diatomic
c. Both a. and b. d. triatomic

Q 4. Symbols for some elements as proposed by Dalton are given below:

(i) ⊙ Hydrogen (ii) ● Carbon
(iii) ○ Oxygen (iv) ⊛ Platinum
(v) ⊕ Sulphur (vi) (I) Iodine
(vii) (C) Copper (viii) (L) Lead
(ix) (S) Sodium (x) (G) Gold
(xi) (P) Phosphorus (xii) ◎ Mercury

Which of the following are incorrectly labelled?

a. (i). (iv). (v) and (ii)
b. (i). (iv). (ii). (v) and (iii)
c. (iv). (vi). (ix) and (xi)
d. (vii). (ix). (x). (xi) and (xii)

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is* ***Assertion*** *(A) and the other is* ***Reason*** *(R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. **Assertion (A):** Relative atomic mass is a pure number and hence it has no unit.
Reason (R): It indicates the number of times one atom of that element is lighter than $\frac{1}{12}$ of a C-12 atom.

Q 6. **Assertion (A):** The laws of chemical combination ultimately led to the idea of 'atoms' being the smallest unit of matter.
Reason (R): The laws of chemical combination played a significant role in the development of Dalton's atomic theory of matter.

Case Study Based Question

Q 7. Dalton's atomic theory was a scientific theory on the nature of matter proposed by British physicist and chemist John Dalton in the year 1808. The theory states that matter consists of indivisible particles called atoms which are identical in mass and can neither be created nor destroyed in a chemical reaction. However, the indivisibility of an atom was proved wrong later as atom can be further divided into electron, proton and neutron. The theory also fails to explain the existence of allotropes.

Read the given passage carefully and give the answer of the following questions:

(i) What is an atom?
(ii) State any two postulates of Dalton's atomic theory.
(iii) Which postulate of Dalton's atomic theory can explain the law of definite proportions?
(iv) Give one drawback of Dalton's atomic theory.

Very Short Answer Type Questions

Q 8. An element *X* has a valency 3. Write the formulae of its oxide.

Q 9. Give difference between 2H and H_2.

Short Answer Type-I Questions

Q 10. Give reasons why scientists choose $\frac{1}{16}$ th of the mass of an atom of naturally occurring oxygen as the atomic mass unit?

Q 11. Give one example each of (i) Monovalent cation (ii) Bivalent cation (iii) Monovalent anion and (iv) Bivalent anion.

Q 12. Calculate the relative formula mass for:
(i) $Al_2(SO_4)_3$ (ii) $Ba(OH)_2$
[Al = 27 u, S = 32u, Ba = 137 u, O = 16 u, H = 1 u]

Short Answer Type-II Questions

Q 13. (i) State the law of constant proportions.
(ii) Show that water illustrates the law of constant proportions.
(iii) Mention any two important rules for writing a chemical formula.

Q 14. (i) What are polyatomic Ions?
(ii) Write the formulae and names of the compounds formed by combination of:
(a) Fe^{3+} and SO_4^{2-}
(b) Mg^{2+} and HCO_3^-

Q 15. (a) Write the full form of IUPAC.
(b) Given an example of :
(i) diatomic and
(ii) triatomic
(iii) polyatomic molecule of compounds.
(c) Find the formula unit mass of $NaHCO_3$.

Long Answer Type Questions

Q 16. (i) What is an atom? How do atoms usually exist?
(ii) What is a molecule? Explain with an example.
(iii) What is the difference between the molecule of an element and the molecule of a compound? Give one example of each.

Q 17. (i) Define the following terms:
(a) Atomicity (b) Valency (c) Relative atomic mass.
(ii) Write down the formulae of:
(a) Potassium sulphate (b) Sodium carbonate