CHAPTER 3

Atoms and Molecules

1. OBJECTIVE QUESTIONS

1. A sample of pure water, irrespective of its source contains 11.1% hydrogen and 88.9% oxygen. The data supports
(a) law of constant proportions
(b) law of conservation of mass
(c) law of reciprocal proportions
(d) law of multiple proportions

Ans : (a) law of constant proportions
Water obtained from any source contains hydrogen and oxygen in the same proportion by mass. Hence, the data supports the law of constant proportions.

2. The formula of chloride of a metal M is MCl_3, then the formula of the phosphate of metal M will be
(a) MPO_4 (b) M_2PO_4
(c) M_3PO_4 (d) $M_2(PO_4)_3$

Ans : (a) MPO_4

Symbol	M	PO_4
Valency	3	3
Dividing by common factor	1	1

3. Identify the correct statements.
1. In a compound such as water, the ratio of the mass of hydrogen to the mass of oxygen is always 8 : 1.
2. If 9 g of water is decomposed, 1 g of hydrogen and 8 g of oxygen are always obtained.
3. In ammonia, nitrogen and hydrogen are always present in the ratio 3 : 14 by mass.
4. Many compounds are composed of two or more elements and each such compound has the same elements in the same proportions.

(a) 1 and 3 (b) 1, 2 and 3
(c) 2 and 4 (d) All of these

Ans : (c) 2 and 4
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. Which of the following is a triatomic molecule?
(a) Carbon-di-oxide (b) Ammonia
(c) Helium (d) Sugar

Ans : (a) Carbon-di-oxide
Carbon-di-oxide contains one atom of carbon and two atoms of oxygen.

5. The atomic mass of calcium (Ca) is 40 g. The number of moles in 60 g of calcium are
(a) 0.5 mol (b) 2.0 mol
(c) 1.5 mol (d) 0.75 mol

Ans : (c) 1.5 mol

$$\text{No. of moles} = \frac{\text{Given mass}}{\text{Molar mass}}$$

$$= \frac{60}{40} = 1.5$$

6. All samples of carbon-di-oxide contain carbon and oxygen in the mass ratio 3 : 8. This is in agreement with the law of
(a) conservation of mass (b) constant proportions
(c) multiple proportions (d) gaseous volumes

Ans : (b) constant proportions
Law of constant proportions states that a chemical compound is always made up of the same elements combined together in the same fixed proportion by mass.

7. What mass of carbon-di-oxide (CO_2) will contain 3.011×10^{23} molecules?
(a) 11.0 g (b) 22.0 g
(c) 4.4 g (d) 44.0 g

Ans : (b) 22.0 g
6.022×10^{23} molecules of CO_2 corresponds to 44 g

3.011×10^{23} molecules of CO_2 corresponds to $= 22$ g

8. The number of atoms in $K_2Cr_2O_7$ is
(a) 9 (b) 11

(c) 10 (d) 12

Ans : (b) 11

9. How many grams of H_2SO_4 are present in 0.25 mole of H_2SO_4?
(a) 2.45 (b) 24.5
(c) 0.245 (d) 0.25

Ans : (b) 24.5

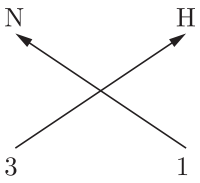
$$\text{Mass} = \text{Number of moles} \times \text{Molar mass}$$
$$= 0.25 \times 98 = 24.5\,\text{g}$$

10. The number of atoms present in a molecules of a substance is called
(a) molecularity (b) atomicity
(c) valency (d) reactivity

Ans : (b) atomicity

11. The valency of nitrogen in ammonia (NH_3) is
(a) 2 (b) 0
(c) 3 (d) 4

Ans : (c) 3



12. The mass of a molecule of water is
(a) 3×10^{-26} kg (b) 3×10^{-25} kg
(c) 1.5×10^{-26} kg (d) 2.5×10^{-26} kg

Ans : (a) 3×10^{-26} kg
6.022×10^{23} molecules have mass = 18 g
1 molecule of water has mass

$$= \frac{18}{6.022 \times 10^{23}}$$
$$= 3 \times 10^{-23}\ \text{g}$$
$$= 3 \times 10^{-26}\ \text{kg}$$

13. Select the incorrect match.
1. N_2O_4-Dinitrogen tetroxide
2. HCl-Hydrogen chloride
3. CO-Carbon dioxide
4. PCl_5-Phosphorus trichloride

(a) 1 and 2 (b) 3 and 4
(c) 1 and 3 (d) 2 and 4

Ans : (b) 3 and 4
CO – Carbon monoxide.
PCl_5 – Phosphorus pentachloride.

14. Molecular mass is defined as the
(a) mass of one atom compared with the mass of one molecule
(b) mass of one atom compared with the mass of one atom of hydrogen
(c) mass of one molecule of any substance compared with the mass of one atom of C-12
(d) none of the above

Ans : (c) mass of one molecule of any substance compared with the mass of one atom of C-12

15. Match the columns by choosing the correct option.

	Column I (Ion)		**Column II (Nature)**
(A)	Chloride ion	1.	Divalent, negative
(B)	Calcium ion	2.	Trivalent, positive
(C)	Aluminium ion	3.	Divalent, positive
(D)	Oxide ion	4.	Monovalent, negative

(a) A – 4, B – 2, C – 1, D – 3
(b) A – 4, B – 3, C – 2, D – 1
(c) A – 3, B – 2, C – 1, D – 4
(d) A – 1, B – 4, C – 3, D – 2

Ans : (b) A – 4, B – 3, C – 2, D – 1
Chloride ion – Cl^-, Calcium ion – Ca^{2+},
Aluminium ion – Al^{3+}, Oxide ion – O^{2-}

16. The molecular formula P_2O_5 means that
(a) a molecule contains 2 atoms of P and 5 atoms of O
(b) the ratio of the mass of P to the mass of O in the molecule is 2 : 5
(c) there are twice as many P atoms in the molecule as there are O atoms
(d) the ratio of the mass of P to the mass of O in the molecule is 5 : 2.

Ans : (a) a molecule contains 2 atoms of P and 5 atoms of O
Molecular formula represents the actual number of atoms of different elements present in one molecule of the compound.

17. An atom is the
(a) smallest particle of matter known
(b) smallest particle of a gas
(c) smallest particle of an element that can take part in a chemical change
(d) radioactive emission

Ans : (c) smallest particle of an element that can take part in a chemical change

18. Atomicity of sulphur is
(a) 8 (b) 4
(c) 2 (d) 1

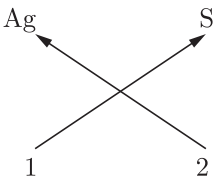
Ans : (a) 8
Sulphur exists as S_8 molecule.

19. Which of the following represents a polyatomic ion?
(a) Sulphide (b) Chloride
(c) Sulphate (d) Nitride

Ans : (c) Sulphate
Sulphate (SO_4^{2-}) ion consists of group of atoms. Sulphate is a polyatomic ion.

20. Valency of silver in Ag_2S is
(a) 1 (b) 2
(c) 0 (d) 3

Ans : (a) 1



21. 52 g of He contains
(a) $4 \times 6.022 \times 10^{23}$ atoms
(b) 13 atoms
(c) $13 \times 6.022 \times 10^{23}$ atoms
(b) 4 atoms

Ans : (c) $13 \times 6.022 \times 10^{23}$ atoms
No. of atoms

$$= \text{No. of moles} \times \text{Avogadro's number}$$
$$= \frac{52}{4} \times 6.022 \times 10^{23} \text{ atoms}$$
$$= 13 \times 6.022 \times 10^{23} \text{ atoms}$$

22. How many elements are present in one formula unit of $Al(OH)_3$?
(a) 3 (b) 4
(c) 5 (d) 6

Ans : (a) 3
One formula unit of $Al(OH)_3$ contains aluminium, oxygen and hydrogen.

23. A chemical equation is always balanced to fulfil the condition of
(a) Dalton's atomic theory
(b) law of constant composition
(c) law of multiple proportions
(d) law of conservation of mass

Ans : (d) law of conservation of mass
A chemical equation is always balanced to fulfil the condition of law of conservation of mass. According to this law, the total mass of the rectants is equal to the total mass of the products.

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

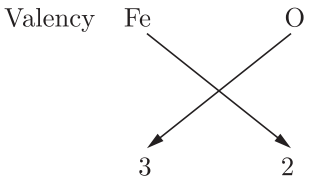
Elements			
1.	Argon-Ar	2.	Iron-I
3.	Chlorine-Cl	4.	Lead-Pb
5.	Gold-Au	6.	Magnesium-Ma
7.	Potassium-P	8.	Sodium-S
9.	Zinc-Zn		

Identify the incorrect representation of symbols.
(a) 4, 5 and 6 (b) 1, 2, 4, 5 and 9
(c) 2, 6, 7, and 8 (d) 3, 6 and 7

Ans : (c) 2, 6, 7, and 8
Iron − Fe, Magnesium − Mg, Potassium − K, Sodium − Na

25. Chemical formula of ferric oxide is
(a) FeO (b) Fe_2O_3
(c) Fe_3O_4 (d) none of these

Ans : (b) Fe_2O_3



Hence,

Chemical formula $= Fe_2O_3$

26. 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 expressed in metres.
(d) An atom of hydrogen has the radius of the order of 10^{-10} m.

Ans : (c) The size of an atom is expressed in metres.
The size of an atom is expressed in nanometres.

$$1 \text{ nm} = 10^{-9} \text{ m}$$

27. Mass of 1 mole of nitrogen atoms is
(a) 28 g (b) 14.0 g
(c) 28 amu (d) 14 amu

Ans : (b) 14.0 g
Mass of 1 mole of nitrogen atoms

$$= \text{Gram atomic mass of nitrogen}$$
$$= 14 \text{ g}$$

28. Latin name for gold is
(a) aurum (b) kalium
(c) natrium (d) ferrum

Ans : (a) aurum

29. The atomic mass of sodium is 23. The number of moles in 46 g of sodium are
(a) 1 (b) 2
(c) 2.3 (d) 4.6

Ans : (b) 2

$$\text{No. of moles} = \frac{\text{Given mass}}{\text{Molar mass}}$$
$$= \frac{46}{23} = 2$$

30. All noble gas molecules are
(a) monatomic (b) diatomic
(c) triatomic (d) both a and b

Ans : (a) monatomic

31. In which of the following the valency of each of the constituent elements is equal to the total number of atoms is one molecule of the compound?

(a) HCl (b) H_2S

(c) CaO (d) $MgCl_2$

Ans : (c) CaO

In CaO, valency of each of the constituent elements is 2 and is equal to the total number of atoms (2) in one molecule of the compound.

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

Name (Valency)		Name (Valency)	
1.	Oxygen (2)	6.	Sodium (2)
2.	Iodine (1)	7.	Helium (2)
3.	Argon (0)	8.	Chlorine (1)
4.	Magnesium (3)	9.	Potassium (1)
5.	Carbon (4)	10.	Aluminium (3)

Select the incorrect match.

(a) 4, 5, 7 and 9 (b) 4, 6 and 7

(c) 1, 8, 9 and 10 (d) 2, 3, 5 and 9

Ans : (b) 4, 6 and 7

Magnesium – 2, Sodium – 1, Helium – 0

33. The total number of electrons present in 16 g of methane gas is

(a) 96.352×10^{23} (b) 48.176×10^{23}

(c) 60.22×10^{23} (d) 30.110×10^{23}

Ans : (c) 60.22×10^{23}

Total no. of electrons in 16 g i.e., 1 mole of CH_4

$= 10 \times 6.022 \times 10^{23}$ electrons

$= 60.22 \times 10^{23}$ electrons

2. FILL IN THE BLANK

1. In ionic compounds, the charge on each ion is used to determine the ..... of the compound.

Ans : chemical formula

2. Mole is link between the ..... and .....

Ans : mass of atoms & number of atoms.

3. The Avogadro constant ..... is defined as the number of atoms in exactly ..... of carbon-12.

Ans : 6.022×10^{23}, 12 g

4. The valency of an ion is ..... to the charge on the ion.

Ans : equal.

5. The abbreviation used for lengthy names of elements are termed as their .....

Ans : symbol.

6. Those ions which are formed from single atoms are called .....

Ans : simple ions.

7. During a chemical reaction, the sum of the of the reactansts and products remains unchanged.

Ans : masses

8. The SI unit of amount of a substance is .....

Ans : mole

9. Clusters of atoms that act as an ion are called ..... ions.

Ans : polyatomic

10. Ionic compounds are formed by the combination between ..... and .....

Ans : metal and non-metals.

11. A chemical formula is also known as a .....

Ans : molecular formula.

3. TRUE/FALSE

1. In a pure chemical compound, elements are always present in a definite proportion by mass.

Ans :

True

2. Formula mass of Na_2O is 62 amu.

Ans : True

3. Mass of 1 mole of a substance is called its formula mass.

Ans : False

4. Those particles which have more or less electrons than the normal atoms are called ions.

Ans : True

5. Water is an atom.

Ans : False

6. Formula for sulphur dioxide is SO_3.

Ans : False

7. Number of molecules in 32 gram of oxygen is 6.02×10^{23}.

Ans : True

8. Molar mass of ethyne (C_2H_2) is 26 g/mol.

Ans : True

9. 22 gm of CO_2 consists of 1 mole.

Ans : False

4. MATCHING QUESTIONS

DIRECTION : In the section, each question has two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (a), (b), (c) and (d) out of which one is correct.

1.

List-I		List-II	
(P)	52 g of He	(1)	2 moles
(Q)	8 g of O_2	(2)	1 mole
(R)	2 g of H_2	(3)	0.25 mole
(S)	56 g of N_2	(4)	13 mole

	P	Q	R	S
(a)	4	3	2	1
(b)	1	4	3	2
(c)	2	3	1	4
(d)	4	2	3	1

Ans : (a) P – 4, Q – 3, R – 2, S – 1

2.

List-I		List-II	
(P)	K_2CO_3	(1)	62 u
(Q)	Na_2O	(2)	138 u
(R)	HNO_3	(3)	64 u
(S)	SO_2	(4)	63 u

	P	Q	R	S
(a)	1	4	3	2
(b)	3	2	4	1
(c)	2	1	4	3
(d)	2	3	1	4

Ans : (c) P – 2, Q – 1, R – 4, S – 3

3.

List-I		List-II	
(P)	0.25 mole oxygen	(1)	6.022×10^{23} molecules
(Q)	18 g water	(2)	1.505×10^{23} molecules
(R)	46 g Na atom	(3)	6.022×10^{23} atoms
(S)	1 mole C atom	(4)	12.044×10^{23} atoms

	P	Q	R	S
(a)	1	2	3	4
(b)	2	1	4	3
(c)	4	1	3	2
(d)	1	4	3	2

Ans : (b) P – 2, Q – 1, R – 4, S – 3

4.

List-I (Compound)		List-II (Ratio of atoms by mass)	
(P)	Water	(1)	14 : 3
(Q)	Ammonia	(2)	1 : 8
(R)	Carbon-di-oxide	(3)	1 : 1
(S)	Sulphur-di-oxide	(4)	3 : 8

	P	Q	R	S
(a)	4	3	2	1
(b)	1	2	3	4
(c)	3	1	4	2
(d)	2	1	4	3

Ans : (d) P – 2, Q – 1, R – 4, S – 3

5.

List-I (Atom)		List-II (Atomic mass)	
(P)	Calcium	(1)	14
(Q)	Nitrogen	(2)	16
(R)	Oxygen	(3)	23
(S)	Sodium	(4)	40

	P	Q	R	S
(a)	3	4	1	2
(b)	2	3	4	1
(c)	4	1	2	3
(d)	1	2	3	4

Ans : (c) P – 4, Q – 1, R – 2, S – 3

5. ASSERTION AND REASON

DIRECTION : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(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.

1. **Assertion :** When 10 g of $CaCO_3$ is decomposed, 5.6 g of residue is left and 4.4 g of CO_2 escapes.
Reason : Law of conservation of mass is followed.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

2. **Assertion :** 1 amu equals to 1.6×10^{-24} g.
Reason : 1.66×10^{-24} g equals to $\frac{1}{12}$th of mass of a $C-12$ atom.

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
$1/12^{th}$ of mass of 1 atom of $C-12$ is 1.66×10^{-24} g and atomic mass unit (1 amu) $= 1.66 \times 10^{-24}$ g.

3. **Assertion :** Pure water obtained from different sources such as river, well, spring, sea etc. always contains hydrogen and oxygen combined in the ratio of 1 : 8 by mass.
Reason : A chemical compound always contains same elements combined in same fixed proportion by mass.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

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

Ans : (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.

5. **Assertion :** Molecular weight of SO_2 is double to that O_2.
Reason : One mole of SO_2 contains double the number of molecules present in one mole of O_2.

Ans : (c) Assertion (A) is true but reason (R) is false. Both, 1 mole of SO_2 and 1 mole of O_2 contain same number of molecules i.e., Avogadro's number of molecules.

6. **Assertion :** Law of conservation of mass holds good for nuclear reactions.
Reason : It states that energy can neither be created nor destroyed in a chemical reaction.

Ans : (d) Assertion (A) is false but reason (R) is true. 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.

7. **Assertion :** 1 mole of H_2 and O_2 each occupy 22.4 L at standard temperature and pressure.
Reason : Molar volume for all gases at the standard temperature and pressure has the same value.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

8. **Assertion :** Atomicity of oxygen is 2.
Reason : 1 mole of an element contains 6.023×10^{23} atoms.

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
Number of atoms present in a molecule of a gaseous element is called atomicity. e.g., O_2 has two atoms and hence, its atomicity is 2.

9. **Assertion :** Atomic mass of aluminium is 27.
Reason : An atom of aluminium is 27 times heavier than $1/12^{th}$ of the mass of carbon-12 atom.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

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

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

11. **Assertion :** Atomicity of O_3 is 3.
Reason : 1 mole of an element contains 6.023×10^{23} atoms.

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

12. **Assertion :** 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 : 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.

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

13. **Assertion :** Number of gram-molecules of SO_2Cl_2 in 13.5 g of sulfuryl chloride is 0.1.
Reason : Gram molecular mass is equal to one gram molecule.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

Gram molecular mass of,

$$SO_2Cl_2 = 1 \text{ g molecule}$$

$$135 \text{ g of } SO_2Cl_2 = 1 \text{ g molecule}$$

[Since, GMM of $SO_2Cl_2 = 135$ g]

$$13.5 \text{ g of } SO_2Cl_2 = \frac{13.5}{135}$$

$$= 0.1 \text{ g molecule}$$

14. **Assertion :** One mole of molecules has mass equal to gram molecular mass and contains Avogadro's number of molecules or has a volume of 22.4 L at STP if the substance is a gas.
Reason : One mole of an ionic compound has mass equal to gram formula unit mass and contains Avogadro's number of formula units.

Ans : (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

15. **Assertion :** Percentage of carbon in Na_2CO_3 is 11.32%.
Reason :

$$\% \text{ of Carbon} = \frac{\text{Mass of carbon element}}{\text{Molecular mass of } Na_2CO_3} \times 100$$

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

% of carbon in the compound

$$= \frac{12}{106} \times 100$$

$$= 11.32\%$$

16. **Assertion :** Atomic mass of aluminium is 27.
Reason : An atom of aluminium is 27 times heavier than $1/12^{th}$ of the mass of carbon-12 atom.

Ans : (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).