Chapter 7
Atoms and Molecules

I. Choose the best Answer:

Question 1.
Which of the following has the smallest mass?
(a) 6.023×10^{23} atoms of He
(b) 1 atom of He
(c) 2 g of He
(d) 1-mole atoms of He
Answer:
(b) 1 atom of He

Question 2.
Which of the following is a triatomic molecule?
(a) Glucose
(b) Helium
(c) Carbon dioxide
(d) Hydrogen.
Answer:
(c) Carbon dioxide
Hint:
(a) Glucose = $C_6H_{12}O_6$ (Polyatomic molecule)
(b) Helium = He (Monoatomic molecule)
(c) Carbon dioxide = CO_2 (Triatomic molecule)
(d) Hydrogen = H_2 (Diatomic molecule)
So, (c) is the correct Answer.

Question 3.
The volume occupied by 4.4 g of CO_2 at S.T.P:
(a) 22.4 litre
(b) 2.24 litre
(c) 0.24 litre
(d) 0.1 litre
Answer:
(b) 2.24 litre

Question 4.
Mass of 1 mole of Nitrogen atom is _____.
(a) 28 amu
(b) 14 amu
(c) 28 g

(d) 14 g.
Answer:
(b) 14 amu
Hint: Atomic mass of Nitrogen is 14.00674 grams. It is equal to 1 mole of Nitrogen atoms.
So, **Answer** (b) is correct.

Question 5.
Which of the following represents 1 amu?
(a) Mass of a C – 12 atom
(b) Mass of a hydrogen atom
(c) 1/12 th of the mass of a C – 12 atom
(d) Mass of O – 16 atom
Answer:
(c) 1/12 th of the mass of a C – 12 atom

Question 6.
Which of the following statement is incorrect?
(a) One gram of C – 12 contains Avogadro's number of atoms.
(b) One mole of oxygen gas contains Avogadro's number of molecules.
(c) One mole of hydrogen gas contains Avogadro's number of atoms.
(d) One mole of electrons stands for 6.023×10^{23} electrons.
Answer:
(a) One gram of C – 12 contains Avogadro's number of atoms.
Hint: 12 g of Carbon contains 6.023×10^{23} atoms,
1 g of Carbon contain $\frac{6.023 \times 10^{23}}{12} = 5.018 \times 10^{22}$ atoms and its is not Avogadro's number of atoms.
So (a) is the incorrect statement.

Question 7.
The volume occupied by 1 mole of a diatomic gas at S.T.P is:
(a) 11.2 litre
(b) 5.6 litre
(c) 22.4 litre
(d) 44.8 litre
Answer:
(c) 22.4 litre

Question 8.
In the nucleus of ${}_{20}Ca^{40}$, there are
(a) 20 protons and 40 neutrons
(b) 20 protons and 20 neutrons
(c) 20 protons and 40 electrons
(d) 40 protons and 20 electrons
Answer:
(b) 20 protons and 20 neutrons

Question 9.
The gram molecular mass of oxygen molecule is____.
(a) 16 g
(b) 18 g
(c) 32 g
(d) 17 g.
Answer:
(c) 32 g
Hint: By definition, the gram molecular mass of oxygen molecule O_2 is 32 g.
So the **Answer** (c) is correct.

Question 10.
1 mole of any substance contains molecules.
(a) 6.023×10^{23}
(b) 6.023×10^{-23}
(c) 3.0115×10^{23}
(d) 12.046×10^{23}
Answer:
(a) 6.023×10^{23}

II. Fill in the blanks:

1. Atoms of different elements having ……. mass number, but ……. atomic numbers are called isobars.
2. Atoms of different elements having same number of ……. are called isotones.
3. Atoms of one element can be transmuted into atoms of other element by ……..
4. The sum of the numbers of protons and neutrons of an atom is called its ……
5. Relative atomic mass is otherwise known as ……
6. The average atomic mass of hydrogen is ……. amu.
7. If a molecule is made of similar kind of atoms, then it is called ……. atomic molecule.
8. The number of atoms present in a molecule is called its ……..
9. One mole of any gas occupies …… ml at S.T.P
10. Atomicity of phosphorous is ……
Answer:
1. same, different
2. neutrons
3. artificial transmutation
4. mass number
5. standard atomic weight
6. 1.008
7. homo
8. atomicity
9. 22, 400
10. four

III. Match the following:

Column - I		Column - II	
A	8 g of O_2	*(i)*	4 moles
B	4 g of H_2	*(ii)*	0.25 moles
C	52 g of He	*(iii)*	2 moles
D	112 g of N_2	*(iv)*	0.5 moles
E	35.5 g of Cl_2	*(v)*	13 moles

Answer:
A. (ii)
B. (iii)
C. (v)
D. (i)
E. (iv)

IV. True or False: (If false give the correct statement)

1. Two elements sometimes can form more than one compound.
2. Nobel gases are diatomic.
3. The gram atomic mass of an element has no unit.
4. 1 mole of Gold and Silver contain same number of atoms.
5. Molar mass of CO_2 is 42 g.

Answer:

1. True
2. False – Noble gases are Monoatomic.
3. False – The unit of gram atomic mass of an element is gram.
4. True
5. False – Molar mass of CO_2 is 44 g.

V. Assertion and Reason:

Answer the following Questions using the data given below:
Question 1.
Assertion: Atomic mass of aluminium is 27
Reason: An atom of aluminium is 27 times heavier than 1/12 th of the mass of the C-12 atom.
(a) Assertion and Reason are correct, Reason explains the Assertion.
(b) Assertion is correct, Reason is wrong.
(c) Assertion is wrong, Reason is correct.
(d) Assertion and Reason are correct, Reason doesn't explains Assertion.

Answer:
(a) Assertion and Reason are correct, Reason explains the Assertion.

Question 2.
Assertion: The Relative Molecular Mass of Chlorine is 35.5 a.m.u.
Reason: The natural abundance of Chlorine isotopes are not equal.
(a) Assertion and Reason are correct, Reason explains the Assertion.
(b) Assertion is correct, Reason is wrong.
(c) Assertion is wrong, Reason is correct.
(d) Assertion and Reason are correct, Reason doesn't explains Assertion.
Answer:
(c) Assertion is wrong, Reason is correct.

VI. Short Answer Questions:

Question 1.
Define: Relative atomic mass.
Answer:
Relative atomic mass of an element is the ratio between the average mass of its isotopes to $\frac{11}{12^{th}}$part of the mass of a carbon-12 atom. It is denoted as A_r.
[OR]

$$A_r = \frac{\text{Average mass of the isotopes of the element}}{\frac{1}{12^{\text{th}}} \text{ of the mass of one Carbon} - 12 \text{ atom}}$$

Question 2.
Write the different types of isotopes of oxygen and its percentage abundance.
Answer:
Oxygen has three stable isotopes. They are

	Mass	% abundance
$^{16}_{8}O$	15.9949	99.757
$^{17}_{8}O$	16.9991	0.038
$^{18}_{8}O$	17.9992	0.205

Question 3.
Define Atomicity.
Answer:
The number of atoms present in the molecule is called its 'Atomicity'.

Question 4.
Give any two examples for heteroatomic molecules.

Answer:
HI, HCl, CO, HBr, HF.

Question 5.
What is Molar volume of a gas?
Answer:
One mole of any gas occupies 22.4 litres.
(or)
22400 ml at S.T.R This volume is called as molar volume.

Question 6.
Find the percentage of nitrogen in ammonia.
Answer:
Molar mass of $NH_3 = 1(14) + 3(1) = 17$ g

$$\text{Mass \% of Nitrogen} = \frac{\text{Mass of nitrogen in the compound}}{\text{Molar mass of the compound}} \times 100$$

$$= \frac{14}{17} \times 100 = 82.35\%$$

VII. Long Answer Questions:

Question 1.
Calculate the number of water molecule present in one drop of water which weighs 0.18 g.
Answer:
The molecular mass of water (H_2O) is 18.
18 g of water molecule = 1 mole.
0. 18 g of water = $\frac{1}{18} \times 0.18 = 0.01$ mole.
1 mole of water (Avogadro's number) contains 6.023×10^{23} water molecules.
0. 01 mole of water contain $\frac{6.023 \times 10^{23}}{1} \times 0.01 = 6.023 \times 10^{21}$ molecules.

Question 2.
$N_2 + 3\ H_2 \rightarrow 2\ NH_3$
(The atomic mass of nitrogen is 14, and that of hydrogen is 1)
1 mole of nitrogen (……..g) +
3 moles of hydrogen (……..g) →
2 moles of ammonia (……..g)
Answer:
1 mole of nitrogen (28 g) +
3 moles of hydrogen (6 g) →
2 moles of ammonia (34 g)

Question 3.
Calculate the number of moles in
(i) 27 g of Al;
(ii) 1.51×10^{23} molecules of NH_4Cl.
Answer:
(i) 27 g of Al

Given mass atomic mass $= \frac{GivenMass}{\text{AtomicMass}} = \frac{27}{27}$

$= 1$ mole

(ii) 1.51 x 10^{23} molecules of NH_4Cl
Number of moles

$$= \frac{\text{Number of molecules given}}{6.023 \times 10^{23}}$$

$$= \frac{1.51 \times 10^{23}}{6.023 \times 10^{23}} = 0.25 \text{ moles}$$

Question 4.
Give the salient features of "Modern atomic theory".
Answer:
The salient features of "Modem atomic theory" are,

1. An atom is no longer indivisible.
2. Atoms of the same element may have different atomic mass.
3. Atoms of different elements may have the same atomic masses.
4. Atoms of one element can be transmuted into atoms of other elements. In other words, an atom is no longer indestructible.
5. Atoms may not always combine in a simple whole-number ratio.
6. Atom is the smallest particle that takes part in a chemical reaction.
7. The mass of an atom can be converted into energy [$E = mc^2$].

Question 5.
Derive the relationship between Relative molecular mass and Vapour density.
Answer:
Relative molecular mass : The relative molecular mass of a gas or vapour is the ratio between the mass of one molecule of the gas or vapour to mass of one atom of hydrogen.
Vapour density : Vapour density is the ratio of the mass of certain volume of a gas or vapour, to the mass of an equal volume of hydrogen, measured under the same conditions of temperature and pressure.

$$\text{Vapour density (V.D)} = \frac{\text{Mass of a given volume of gas or vapour at STP}}{\text{Mass of the same volume of hydrogen}}$$

According to Avogadro's law equal volumes of all gases contain equal number of molecules.
Let the number of molecules in one volume = n, then

$$V.D = \frac{\text{Mass of 'n' molecules of gas or vapour at STP}}{\text{Mass of 'n' molecules of hydrogen}}$$

When cancelling 'n' which is common at STP, we get

$$V.D = \frac{\text{Mass of 1 molecule of a gas or vapour at STP}}{\text{Mass of 1 molecule of hydrogen}}$$

Since hydrogen is diatomic,

$$V.D = \frac{\text{Mass of 1 molecule of gas or vapour at STP}}{\text{Mass of 2 atoms of hydrogen}}$$

$$V.D = \frac{\text{Mass of 1 molecule of gas or vapour at STP}}{2 \times \text{Mass of 1 atom of hydrogen}}$$

$$V.D = \frac{\text{Relative molecular mass}}{2}$$

$2 \times$ Vapour density = Relative Molecular mass of a gas

[OR]

Relative Molecular Mass = $2 \times$ Vapour density

VIII. HOT Question:

Question 1.

Calcium carbonate is decomposed on heating in the following reaction

$CaCO_3 \rightarrow CaO + CO_2$

1. How many moles of Calcium carbonate is involved in this reaction?
2. Calculate the gram molecular mass of calcium carbonate involved in this reaction.
3. How many moles of CO_2 are there in this equation?

Answer:

$CaCO_3 \rightarrow CaO + CO_2$

1. 1 mole of $CaCO_3$ is involved in this reaction.
2. Gram molecular mass of calcium carbonate
   $CaCO_3 = (40 + 12 + 3 \times 16) = 52 + 48 = 100$ g
3. 1 mole of CO_2 is in this equation.

IX. Solve the following problems:

Question 1.

How many grams are there in the following?

(i) 2 moles of a hydrogen molecule, H_2

(ii) 3 moles of chlorine molecule, Cl_2

(iii) 5 moles of sulphur molecule, S_8

(iv) 4 moles of a phosphorous molecule, P_4

Solution:
(i) 2 moles of a hydrogen molecule, H_2
Mass of 1 mole of hydrogen molecule = 2 g
Mass of 2 moles of hydrogen molecule = 2 × 2 = 4 g.

(ii) 3 moles of chlorine molecule, Cl_2
Mass of 1 mole of chlorine molecule = 71 g
Mass of 3 moles of chlorine molecules = 71 × 3 = 213 g.

(iii) 5 moles of sulphur molecule, S_8
Mass of 1 mole of sulphur molecule = 32 g
Mass of 5 moles of sulphur molecules = 32 × 5 = 160 g.

(iv) 4 moles of the phosphorous molecule, P_4
Mass of 1 mole of phosphorous molecule = 30.97 g
Mass of 4 moles of phosphorous molecules = 30.97 × 4 = 123.88 g.

Question 2.
Calculate the % of each element in calcium carbonate. (Atomic mass: C – 12, O – 16, Ca – 40)
Answer:
Formula to find % of each element

$$= \frac{\text{Mass of the elemenet in the compound}}{\text{Molar mass of the compound}} \times 100$$

$$\left.\begin{matrix}\text{Molar mass of} \\ CaCO_3\end{matrix}\right\} = 100$$

$$\% \text{ of Ca} = \frac{\text{Mass of Ca in the compound}}{\text{Molar mass of } CaCO_3} \times 100$$

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

$$\% \text{ of C} = \frac{\text{Mass of C in the compound}}{\text{Molar mass of } CaCO_3} \times 100$$

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

$$\% \text{ of O} = \frac{\text{Mass of oxygen in the compound}}{\text{Molar mass of } CaCO_3} \times 100$$

$$= \frac{3 \times 16}{100} \times 100 = 48\%$$

Question 3.
Calculate the % of oxygen in $Al_2(SO_4)_3$.

(Atomic mass: Al – 27, O – 16, S – 32)

Answer:

Formula:

$$\% \text{ of Oxygen } = \frac{\text{Mass of oxygen in the compound}}{\text{Molar mass of } Al_2(SO_4)_3} \times 100$$

Molar mass of $Al_2(SO_4)_3$ = [2(Atomic mass of Al) + 3(Atomic mass of S) + 12(Atomic mass of O)]

$= 2(27) + 3(32) + 12(16) = 342$ g

% of Oxygen $= \frac{12(16)}{342} \times 100 = 56.14\%$.

Question 4.

Calculate the % relative abundance of B – 10 and B – 11, if its average atomic mass is 10.804 amu.

Answer:

% of relative abundance can be calculated by the formula.

Average atomic mass of the element

= Atomic mass of 1st isotope × abundance of 1st isotope + Atomic mass of 2nd isotope × abundance of 2nd isotope

∴ Average atomic mass of Boron

= Atomic mass of B – 0 × abundance of B -10 + Atomic mass of B – 11 × abundance of B – 11

Let the abundance of B – 10 be 'x' and B – 11 be (1 – x)

So, $10.804 = 10 \times x + 11\ (1 - x)$

$10.804 = 10x + 11 - 11x$

$x = 11 - 10.804$

$x = 0.196$

$1 - x = 1 - 0.196 = 0.804$

Therefore % abundance of B – 10 is 19.6% and B – 11 is 80.4%

[OR]

Let the % of the isotope B – 10 = x

Then the % of the isotope B – 11 = 100 – x

$$\left.\begin{matrix}\text{Average atomic} \\ \text{mass}\end{matrix}\right\} = \frac{10 \times x + 11(100 - x)}{100}$$

$$10.804 = \frac{10x + 1100 - 11x}{100}$$

$$10.804 = \frac{1100 - x}{100}$$

$1100 - x = 1080.4$

$x = 19.6$

% abundance of B – 10 = 19.6%

% abundance of B – 11 = 80.4%