INTRODUCTION TO CHEMISTRY

ATOMIC HYPOTHESIS:

Keeping in view various laws of chemical combination, a theoretical proof for the validity of different laws was given by John Dalton in the form of hypothesis called Dalton's atomic hypothesis. Postulates of Dalton's hypothesis are as follows:

(i) Each element is composed of extremely small particles called atoms which can take part in chemical combination.

(ii) All atoms of a given element are identical i.e., atoms of a particular element are all alike but differ from atoms of other elements.

(iii) Atoms of different elements possess different properties (including different masses).

(iv) Atoms are indestructible i.e., atoms are neither created nor destroyed in chemical reactions.

(v) Atoms of elements combine to form molecules and compounds are formed when atoms of more than one element combine.

(vi) In a given compound, the relative number and kind of atoms is constant.

Modern atomic hypothesis:

The main modifications made in Dalton's hypothesis as a result of new discoveries about atoms are :

(i) Atom is no longer considered to be indivisible.

(ii) Atoms of the same element may have different atomic weights. E.g. isotopes of oxygen O^{16}, O^{17} and O^{18}.

(iii) Atoms of different element may have same atomic weights. E.g. isobars Ca^{40} and Ar^{40}.

(iv) Atom is no longer indestructible. In many nuclear reactions, a certain mass of the nucleus is converted into energy along with α, β and γ rays.

(v) Atoms may not always combine in simple whole number ratios. E.g. in sucrose ($C_{12}H_{22}O_{11}$), the elements carbon, hydrogen and oxygen are present in the ratio of 12 : 22 : 11 and the ratio is not a simple whole number ratio.

Atomic & Molecular masses:

(a) Atomic mass: It is the average relative mass of atom of element as compared with $\frac{1}{12}$ times the mass of an atom of carbon-12 isotope.

$$\text{Atomic mass} = \frac{\text{Average mass of an atom}}{1/12 \times \text{Mass of an atom of } C^{12}}$$

(b) Average atomic mass: If an element exists in two isotopes having atomic masses 'a' and 'b' in the ratio m : n, then average atomic mass = $\frac{(m \times a) + (n \times b)}{m + n}$. Atomic mass is expressed in amu. 1 amu = 1.66×10^{-24} g. One atomic mass unit (amu) is equal to $\frac{1}{12}$th of the mass of an atom of carbon-12 isotope.

Gram atomic mass (GAM):

Atomic mass of an element expressed in grams is called Gram atomic mass or gram atom or mole atom.

(i) Number of gram atoms = $\frac{\text{Mass of an element}}{\text{GAM}}$

(ii) Mass of an element in g = No. of gram atoms × GAM

(iii) Number of atoms in 1 GAM = 6.02×10^{23}

Number of atoms in a given substance = No. of gram atoms × 6.02 × 10^{23}= $\frac{\text{Mass}}{\text{GAM}}$ × 6.02 × 10^{23}

(iv) Number of atoms in 1 g of element = $\frac{6.02 \times 10^{23}}{\text{GAM}}$

(v) Mass of one atom of the element (in g) = $\frac{\text{GAM}}{6.02 \times 10^{23}}$

Molecular mass:

Molecular mass of a molecule, of an element or a compound may be defined as a number which indicates how many times heavier is a molecule of that element or compound as compared with $\frac{1}{12}$ of the mass of an atom of carbon-12. Molecular mass is also expressed in amu.

$$\text{Molecular mass} = \frac{\text{Mass of one molecule of the substance}}{1/12 \times \text{Mass of one atom of C-12}}$$

Actual mass of one molecule = Mol. mass (in amu) × 1.66 × 10^{-24} g

Molecular mass of a substance is the additive property and can be calculated by adding the atomic masses of atoms present in one molecule.

Gram molecular mass (GMM):

Molecular mass of an element or compound when expressed in g is called its gram molecular mass, gram molecule or mole molecule.

Number of gram molecules = $\frac{\text{Mass of substance}}{\text{GMM}}$

Mass of substance in g = No. of gram molecules × GMM

Average atomic mass and molecular mass

$\bar{A}$ (Average atomic mass) = $\frac{\sum A_i X_i}{\sum X_{total}}$

(Average molecular mass) = $\frac{\sum M_i X_i}{\sum X_{total}}$

Where A_1, A_2, A_3 …… are atomic mass of species 1, 2, 3,…. etc. with % as X_1, X_2, X_3 …… etc. Similar terms are for molecular masses.

THE MOLE CONCEPT

One mole of any substance contains a fixed number (6.022×10^{23}) of any type of particles (atoms or molecules or ions) and has a mass equal to the atomic or molecular weight, in grams. Thus it is correct to refer to a mole of helium, a mole of electrons or a mole of any ion, meaning respectively Avogadro's number of atoms, electrons or ions.

$$\text{Number of moles} = \frac{\text{Weight (grams)}}{\text{Weight of one mole (g/mole)}} = \frac{\text{Weight}}{\text{GAM or GMM}}$$

Note : 1 mole = 1 g-atom = 1 g-molecule = 1 g-ion.

Properties of Gases

The state of matter in which the molecular forces of attraction between the particles of matter are minimum, is known as gaseous state. It is the simplest state and shows great uniformity in behaviour.

Characteristics of gases

(1) Gases or their mixtures are homogeneous in composition.

(2) Gases have very low density due to negligible intermolecular forces.

(3) Gases have infinite expansibility and high compressibility.

(4) Gases exert pressure.
(5) Gases possess high diffusibility.
(6) Gases do not have definite shape and volume like liquids.
(7) Gaseous molecules move very rapidly in all directions in a random manner i.e., gases have highest kinetic energy.
(8) Gaseous molecules collide with one another and also with the walls of container.
(9) Gases can be liquefied, if subjected to low temperatures & high pressures.
(10) Thermal energy of gases >> molecular attraction.
(11) Gases undergo similar change with the change of temperature and pressure. In other words, gases obey certain laws known as gas laws.

Measurable properties of gases

The characteristics of gases are described fully in terms of four parameters or measurable properties:
(i) The volume, V, of the gas.
(ii) Its pressure, P
(iii) Its temperature, T
(iv) The amount of the gas (i.e., mass or number of moles).

(1) Volume :
(i) Since gases occupy the entire space available to them, the measurement of volume of a gas only requires a measurement of the container confining the gas.
(ii) Volume is expressed in litres (L), millilitres (mL) or cubic centimetres (cm^3), cubic metres (m^3).
(iii) 1 L = 1000 mL; 1 mL = 10^{-3} L; 1 L = 1 dm^3 = 10^{-3} m^3
1 m^3 = 10^3 dm^3 = 10^6 cm^3 = 10^6 mL = 10^3 L

(2) Mass :
(i) The mass of a gas can be determined by weighing the container in which the gas is enclosed and again weighing the container after removing the gas. The difference between the two weights gives the mass of the gas.

(ii) The mass of the gas is related to the number of moles of the gas i.e.

$$\text{moles of gas (n)} = \frac{\text{Mass in grams}}{\text{Molar mass}} = \frac{m}{M}$$

(3) Temperature :
(i) Gases expand on increasing the temperature. If temperature is increased twice, the square of the velocity (v^2) also increases two times.
(ii) Temperature is measured in centigrade degree (ºC) or celsius degree with the help of thermometers. Temperature is also measured in Fahrenheit (ºF).
(iii) S.I. unit of temperature is kelvin (K) or absolute degree.
K = ºC + 273
(iv) Relation between ºF and ºC is $\frac{^oC}{5} = \frac{^oF - 32}{9}$

(4) Pressure :
(i) Pressure of the gas is the force exerted by the gas per unit area of the walls of the container in all directions. Thus, Pressure (P) $= \frac{\text{Force(F)}}{\text{Area(A)}} = \frac{\text{Mass(m)} \times \text{Acceleration(a)}}{\text{Area(A)}}$
(ii) Pressure exerted by a gas is due to kinetic energy $(KE = \frac{1}{2}mv^2)$ of the molecules. Kinetic energy of the gas molecules increases, as the temperature is increased.
(iii) Pressure of a gas is measured by manometer or barometer.
(iv) Commonly two types of manometers are used:
(a) Open end manometer
(b) Closed end manometer

(v) The S.I. unit of pressure, the pascal (Pa), is defined as 1 newton per metre square. It is very small unit.

$1Pa = 1\ Nm^{-2} = 1\ kgm^{-1}s^{-2}$

(vi) C.G.S. unit of pressure is dynes cm^{-2}.

(vii) M.K.S. unit of pressure is Newton m^{-2}. The unit Newton m^{-2} is sometimes called pascal (Pa).

(viii) Higher unit of pressure is bar, kPa or MPa.

$1\ bar = 10^5\ Pa = 10^5\ Nm^{-2} = 100\ KNm^{-2} = 100\ KPa$

(ix) Several other units used for pressure are,

Name	Symbol	Value
bar	*bar*	1 bar = 10^5 Pa
atmosphere	*atm*	1 atm = 1.01325×10^5 Pa
Torr	Torr	1 Torr = $\frac{101325}{760}$ Pa = 133.322 Pa
millimetre of mercury	mm *Hg*	1 mm Hg = 133.322 Pa

Ideal Gas Equation

PV = nRT

where, P : Pressure of gas ; V : Volume of gas ; n = Number of moles of gas

T : Temperature of gas ; R : Universal gas constant.

Values of R : $0.082\ LatmK^{-1}mol^{-1}$; $8.314\ JK^{-1}mol^{-1}$; $1.987\ CalK^{-1}mol^{-1}$

Prefixes used in the SI System

Multiple	Prefix	Symbol
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10	deca	da
10^{2}	hecto	h
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zeta	Z
10^{24}	yotta	Y

Exercise

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

1. How much time (in years) would it take to distribute one Avogadro number of wheat grains if 10^{10} grains are distributed each second ?

2. The weight of one atom of Uranium is 238 amu. Its actual weight is ..... g.

3.✍ Calculate the weight of 12.044×10^{23} atoms of carbon.

4. How many grams of silicon is present in 35 gram atoms of silicon (Given at. wt. of Si = 28).

5. Find the total number of nucleons present in 12 g of ^{12}C atoms.

6. Find (i) the total number of neutrons, and (ii) the total mass of neutrons in 7 mg of ^{14}C. (Assume that the mass of a neutron = mass of a hydrogen atom)

7.✍ Calculate the number of electrons, protons and neutrons in 1 mole of $^{16}O^{-2}$ ions.

8. How many atoms are there in 100 amu of He?

9. The density of liquid mercury is 13.6 g/cm^3. How many moles of mercury are there in 1 litre of the metal? (Atomic mass of Hg = 200.)

10. Calculate the atomic mass (average) of chlorine using the following data:

	% Natural Abundance	**Molar Mass**
^{35}Cl	75	35.0 g
^{37}Cl	25	37.0 g

11.✍ Average atomic mass of Magnesium is 24.31 amu. This magnesium is composed of 79 mole % of ^{24}Mg and remaining 21 mole % of ^{25}Mg and ^{26}Mg. Calculate mole % of ^{26}Mg.

12.✍ The number of molecules in 16 g of methane is :

13. Calculate the number of molecules in a drop of water weighing 0.09 g.

14. A sample of ethane has the same mass as 10.0 million molecules of methane. How many C_2H_6 molecules does the sample contain ?

15. The number of neutrons in 5 g of D_2O (D is $^{2}_{1}H$) are :

16.✍ Calculate the weight of 6.022×10^{23} formula units of $CaCO_3$.

17. From 200 mg of CO_2, 10^{21} molecules are removed. How many moles of CO_2 are left ?

18. Find the total number of H, S and 'O' atoms in the following :
(a) 196 g H_2SO_4 (b) 196 amu H_2SO_4 (c) 5 mole $H_2S_2O_8$ (d) 3 molecules $H_2S_2O_6$.

19.✍ If from 10 moles NH_3 and 5 moles of H_2SO_4, all the H-atoms are removed in order to form H_2 gas, then find the number of H_2 molecules formed.

20.✍ If from 3 moles $MgSO_4.7H_2O$, all the 'O' atoms are taken out and converted into ozone find the number of O_3 molecules formed.

21. If the components of air are N_2 - 78%; O_2 - 21%; Ar - 0.9% and CO_2 - 0.1% by volume (or mole), what would be the molecular weight of air ?

22.✍ Find the expression of Universal Gas Constant R in SI system in terms of the given properties of oxygen gas.
Pressure = p (kPa)
Volume = V (mL)
Temperature = t (ºC)
Mass of oxygen = w (g)

23. The volume of a gas at 0ºC and 700 mm pressure is 760 cc. The number of molecules present in this volume is :

24. The weight of 350 mL of a diatomic gas at 0ºC and 2 atm pressure is 1 g. The weight of one atom is :

25.✍ Oxygen is present in a 1-litre flask at a pressure of 7.6×10^{-10} mm of Hg at 0ºC. Calculate the number of oxygen molecules in the flask.

26.✍ Fill in the blanks :
(i) 1μm = ... nm (ii) 10 MJ = ... J (iii) 100 Pa = ... kPa
(iv) 1dm = ... mm (v) 10 pm = ... cm

PART - II : OBJECTIVE QUESTIONS

Single Correct Questions (SCQ)

1. Which is not a basic postulate of Dalton's atomic theory ?
(A) Atoms are neither created nor destroyed in a chemical reaction.
(B) Different elements have different types of atoms.
(C) Atoms of an element may be different due to presence of isotopes.
(D) Each element is composed of extermely small particles called atoms.

2. The modern atomic weight scale is based on :
(A) ^{12}C (B) ^{16}O (C) ^{1}H (D) ^{18}O

3.✍ 1 amu is equal to
(A) $\frac{1}{12}$ of C–12 (B) $\frac{1}{14}$ of O–16 (C) 1 g of H_2 (D) 1.66×10^{-23} kg

4. If the atomic mass of sodium is 23, the number of moles in 46 g of sodium is :
(A) 1 (B) 2 (C) 2.3 (D) 4.6

5. How many grams are contained in 1 gram-atom of Na ?
(A) 13 g (B) 23 g (C) 1 g (D) $\frac{1}{23}$ g

6. 1.0 g of hydrogen contains 6×10^{23} atoms. The atomic weight of helium is 4. It follows that the number of atoms in 1 g of He is :
(A) $\frac{1}{4} \times 6 \times 10^{23}$ (B) $4 \times 6 \times 10^{23}$ (C) 6×10^{23} (D) 12×10^{23}

7.✍ The atomic weights of two elements A and B are 40u and 80u respectively. If x g of A contains y atoms, how many atoms are present in 2x g of B?
(A) $\frac{y}{2}$ (B) $\frac{y}{4}$ (C) y (D) 2y

8. A sample of aluminium has a mass of 54.0 g. What is the mass of the same number of magnesium atoms? (At. wt. Al = 27, Mg = 24)
(A) 12 g (B) 24 g (C) 48 g (D) 96 g.

9.✍ The number of atoms in 558.5 g of Fe (at wt.= 55.85) is :
(A) Twice that in 60 g carbon (B) 6.022×10^{22}
(C) Half in 8 g He (D) $558.5 \times 6.023 \times 10^{23}$

10. Which of the following has the Maximum mass ?
(A) 1 g-atom of C (B) $\frac{1}{2}$ mole of CH_4
(C) 10 mL of water (D) 3.011×10^{23} atoms of oxygen

11. The total number of protons, electrons and neutrons in 12 g of $^{12}_{6}C$ is :
(A) 1.084×10^{25} (B) 6.022×10^{23} (C) 6.022×10^{22} (D) 18

12. 1 mole of element X has mass, 3/10 times the mass of 1 mole of element Y. One average atom of element X has mass, 2 times the mass of one atom of ^{12}C. What is the atomic weight of Y ?
(A) 80 (B) 15.77 (C) 46.67 (D) 40.0

13.✍ The charge on 1 gram ions of Al^{3+} is : (N_A = Avogadro number, e = charge on one electron)
(A) $\frac{1}{27} N_A e$ coulomb (B) $\frac{1}{3} \times N_A e$ coulomb (C) $\frac{1}{9} \times N_A e$ coulomb (D) $3 \times N_A e$ coulomb

14. It is known that an atom contains protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value whereas that of proton is assumed to be twice of its original value, then the atomic mass of $^{14}_{6}C$ will be :
(A) same (B) 114.28 % less (C) 14.28 % more (D) 28.56 % less

15. The isotopic abundance of C–12 and C–14 is 98% and 2% by mass respectively. What would be the number of C–14 isotope in 12 g carbon sample ?
(A) 1.032×10^{22} (B) 3.01×10^{23} (C) 5.88×10^{23} (D) 6.02×10^{23}

16. In chemical scale, the relative mass of the isotopic mixture of X atoms (X^{20}, X^{21}, X^{22}) is approximately equal to : (X^{20} has 99 percent abundance)
(A) 20.002 (B) 21.00 (C) 22.00 (D) 20.00

17.✍ Indium (atomic weight = 114.8) has two naturally occurring isotopes, the predominant one form has isotopic weight 115 and abundance of 95.00%. Which of the following isotopic weights is the most likely for the other isotope ?
(A) 111 (B) 112 (C) 113 (D) 114

18. The number of molecules of CO_2 present in 44 g of CO_2 is :
(A) 6.0×10^{23} (B) 3×10^{23} (C) 12×10^{23} (D) 3×10^{10}

19. The number of mole of ammonia in 4.25 g of ammonia is :
(A) 0.425 (B) 0.25 (C) 0.236 (D) 0.2125

20. Which one of the following pairs of gases contains the same number of molecules :
(A) 16 g of O_2 and 14 g of N_2 (B) 8 g of O_2 and 22 g of CO_2
(C) 28 g of N_2 and 22 g of CO_2 (D) 32 g of O_2 and 32 g of N_2

21.✍ The weight of a molecule of the compound $C_{60}H_{22}$ is :
(A) 1.09×10^{-21} g (B) 1.24×10^{-21} g (C) 5.025×10^{-23} g (D) 16.023×10^{-23} g

22. Number of electrons in 1.8 mL of $H_2O(\ell)$ is about :
(A) 6.02×10^{23} (B) 3.011×10^{23} (C) 0.6022×10^{21} (D) 60.22×10^{20}

23. One mole of P_4 molecules contain :
(A) 1 molecule (B) 4 molecules
(C) $\frac{1}{4} \times 6.022 \times 10^{23}$ atoms (D) 24.088×10^{23} atoms

24. A sample of ammonium phosphate $(NH_4)_3PO_4$ contains 3.18 mole of H atoms. The number of mole of O atoms in the sample is :
(A) 0.265 (B) 0.795 (C) 1.06 (D) 3.18

25. Torr is unit of :
(A) Temperature (B) Pressure (C) Volume (D) Density

26. The atmospheric pressure on Mars is 0.61 kPa. What is the pressure in mm Hg ?
(A) 0.63 (B) 4.6 (C) 6.3 (D) 3.2

27. Centigrade and Fahrenheit scales are related as :
(A) $\frac{C}{5} = \frac{F-32}{9}$ (B) $\frac{C}{9} = \frac{F-32}{5}$ (C) $\frac{C}{8} = \frac{F-32}{5}$ (D) None of these

28. At what temperature, both Celsius and Fahrenheit scale read the same value :
(A) 100º (B) 130º (C) 60º (D) –40º

29. The value of universal gas constant R depends on :
(A) temperature of gas (B) volume of gas
(C) number of moles of gas (D) units of volume and pressure

30. The value of gas constant in calorie per degree temperature per mol is approximately :
(A) 1 cal (B) 2 cal (C) 3 cal (D) 4 cal

31. The value of R in SI unit is :
(A) 8.314×10^{-7} erg K^{-1} mol^{-1} (B) 8.314 JK^{-1} mol^{-1}
(C) 0.082 litre atm K^{-1} mol^{-1} (D) 2 cal K^{-1} mol^{-1}

32. The pressure of sodium vapour in a 1.0 L container is 9.5 torr at 927ºC. How many atoms are in the container ?
(A) 9.7×10^{7} (B) 7.5×10^{19} (C) 4.2×10^{17} (D) 9.7×10^{19}

33. The pressure of a gas having 2 mole in 44.8 litre vessel at 546 K is :
(A) 1 atm (B) 2 atm (C) 3 atm (D) 4 atm

34. According to the ideal gas laws, the molar volume of a gas is given by :
(A) 22.4 litre (B) RT / P (C) 8RT / PV (D) RT / PV

35. Equal volumes of oxygen gas and a second gas weigh 1.00 and 19/8 grams respectively under the same experimental conditions. Which of the following is the unknown gas?
(A) NO (B) SO_2 (C) CS_2 (D) CO

36. A high altitude balloon contains 6.0 g of helium in 10^4 L at 240 K. Assuming ideal gas behaviour, how many grams of helium would have to be added to increase the pressure to 4.0×10^{-3} atm ?
(A) 1 (B) 1.2 (C) 1.5 (D) 2.0

37. Four 1-1 litre flasks are separately filled with the gases H_2, He, O_2 and O_3 at the same temperature and pressure. The ratio of total number of atoms of these gases present in different flask would be :
(A) 1 : 1 : 1 : 1 (B) 1 : 2 : 2 : 3 (C) 2 : 1 : 2 : 3 (D) 3 : 2 : 2 : 1

38. Under the same conditions, two gases have the same number of molecules. They must
(A) be noble gases (B) have equal volumes
(C) have a volume of 22.4 dm^3 each (D) have an equal number of atoms

39. 16 g of an ideal gas SO_x occupies 5.6 L. at STP. The value of x is
(A) x = 3 (B) x = 2 (C) x = 4 (D) none of these

40. The ratio of the weight of one litre of a gas to the weight of 1.0 L oxygen gas both measured at S.T.P. is 2.22. The molecular weight of the gas would be :
(A) 14.002 (B) 35.52 (C) 71.04 (D) 55.56

41. Avogadro number is :
(A) Number of atoms in one gram of the element
(B) Number of mililitre which one mole of a gaseous substance occupies at NTP (1 atm & 0ºC)
(C) Number of molecules present in one gram molecular mass of a substance.
(D) All are correct

42. The weight of 1×10^{22} molecules of $CuSO_4.5H_2O$ is **:**
(A) 41.59 g (B) 415.9 g (C) 4.159 g (D) None of these

43.✍ How many moles of electron weigh one kilogram :
(A) 6.023×10^{23} (B) $\frac{1}{9.108} \times 10^{31}$ (C) $\frac{6.023}{9.108} \times 10^{54}$ (D) $\frac{1}{9.108 \times 6.023} \times 10^{8}$

44. Number of atoms in 560 g of Fe (atomic mass 56 $gmol^{-1}$) is :
(A) Twice that in 70 g N (B) Half that in 20 g H (C) Both (A) and (B) (D) None of these

45. Which has maximum number of atoms :
(A) 24 g of C (12) (B) 56 g of Fe (56) (C) 27 g of Al (27) (D) 108 g Ag (108)

46.✍ If we consider that 1/6, in place of 1/12 mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will :
(A) decrease twice
(B) increase two fold
(C) remain unchanged
(D) be a function of the molecular mass of the substance

47. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms ?
(A) 0.02 (B) 3.125×10^{-2} (C) 1.25×10^{-2} (D) 2.5×10^{-2}

48.✍ Given that the abundances of isotopes ^{54}Fe, ^{56}Fe and ^{57}Fe are 5%, 90% and 5% respectively, the atomic mass of Fe is :
(A) 55.85 (B) 55.95 (C) 55.75 (D) 56.05

Multiple Correct Questions (MCQ)

49. Which property of an element may have non-integral value.
(A) Atomic weight (B) Atomic number (C) Atomic volume (D) None of these

50. Which of the following would contain 1 mole of particles :
(A) 0.5 mole of H_2 (B) 1 g of H-atoms (C) 16 g of O-18 (D) 16 g of methane

51. Which of the following will have the same number of electrons :
(A) 1 g Hydrogen (B) 2 g Oxygen (C) 2 g Carbon (D) 2 g Nitrogen

52.✍ Which the following is equal to 10^{-2} atm :
(A) 0.76 cm of Hg (B) 7.6 torr (C) 0.076 dm of Hg (D) 0.0076 torr

53. Pressure exerted by a sample of oxygen is same for the following conditions :

(A) 2 L, 27ºC (B) 1 L, 150 K (C) 4 L, 54ºC (D) 10 L, 1227ºC

Assertion / Reasoning (A/R)

Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is not correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.
(E) Both statements are false.

54. **Statement-1 :** Gram molecular weight of O_2 is 32 g.
Statement-2 : Relative atomic weight of oxygen is 32.

55. **Statement-1 :** 1 mole of all ideal gases exert same pressure in same volume at same temperature.
Statement-2 : Behaviour of ideal gases is independent of their nature.

56. **Statement-1 :** Value of the universal gas constant depends upon the choice of sytem of units.
Statement-2 : Values of universal gas constant are 8.314 J/molK, 0.0821 L.atm/molK, 2 cal/molK.

Comprehension #

A vessel of 25 L contains 20 g of ideal gas X at 300K. The pressure exerted by the gas is 1 atm. 20 g of ideal gas Y is added to the vessel keeping the same temperature. Total pressure became 3 atm. Upon further addition of 20 g ideal gas Z the pressure became 7 atm. Answer the following questions. (Hint: Ideal gas equation is applicable on mixture of ideal gases) [Take, R = 1/12 L.atm / mol K]

57. Find the molar mass of gas X.

(A) 20 g (B) 10 g (C) 30 g (D) 5 g

58. Identify the correct statement(s) :
I. Gas Y is lighter than gas X.
II. Gas Z is lighter than gas Y

(A) I only (B) II only (C) Both I and II (D) None of the statements

59. Find the average molar mass of the mixture of gases X, Y and Z.

(A) 40/7 (B) 50/7 (C) 20 (D) 60/7

60. Match the column:

<table>
<tr><th></th><th colspan="3">Column-I</th><th></th><th>Column-II</th></tr>
<tr><th rowspan="2"></th><th colspan="3">(Atomic mass (M))</th><th rowspan="2"></th><th rowspan="2">(% composition of heavier isotope)</th></tr>
<tr><th>Isotope-I</th><th>Isotope-II</th><th>Average</th></tr>
<tr><td>(A)</td><td>(z – 1)</td><td>(z + 3)</td><td>z</td><td>(p)</td><td>25% by moles</td></tr>
<tr><td>(B)</td><td>(z + 1)</td><td>(z + 3)</td><td>(z + 2)</td><td>(q)</td><td>50% by moles</td></tr>
<tr><td>(C)</td><td>z</td><td>3z</td><td>2z</td><td>(r)</td><td>% by mass dependent on z</td></tr>
<tr><td>(D)</td><td>(z – 1)</td><td>(z + 1)</td><td>z</td><td>(s)</td><td>75% by mass</td></tr>
</table>

Answers

PART – I

1.	1.9×10^6 years (approx.)	**2.**	3.95×10^{-22}	**3.**	24 g
4.	980 g of Si	**5.**	$12 \times 6.022 \times 10^{23}$	**6.**	24.088×10^{20}, 0.004 g.
7.	$10 \times 6.022 \times 10^{23}$, $8 \times 6.022 \times 10^{23}$, $8 \times 6.022 \times 10^{23}$.			**8.**	25
9.	68 mole	**10.**	35.5	**11.**	10
12.	6.02×10^{23}	**13.**	3.01×10^{21} molecules of H_2O		
14.	5.33×10^6	**15.**	2.5 N_A	**16.**	100 g
17.	0.00288				

18. (a) H = $4N_A$, S = $2N_A$, O = $8N_A$ atoms (b) H = 4 atoms, S = 2 atoms, O = 8 atoms.
(c) H = $10N_A$, S = $10N_A$, O = 40 N_A atoms (d) H = 6 atoms, S = 6 atoms, O = 18 atoms.

19.	20 N_A	**20.**	11 N_A	**21.**	28.964 u
22.	$R = \dfrac{32pV}{1000 \times w \times (t+273)}$	**23.**	1.88×10^{22}	**24.**	16 amu
25.	2.647×10^{10}				

26. (i) 1000 (ii) 10^7 (iii) 0.1 (iv) 100 (v) 10^{-9}

PART – II

1.	(C)	**2.**	(A)	**3.**	(A)	**4.**	(B)	**5.**	(B)
6.	(A)	**7.**	(C)	**8.**	(C)	**9.**	(A)	**10.**	(A)
11.	(A)	**12.**	(A)	**13.**	(D)	**14.**	(C)	**15.**	(A)
16.	(A)	**17.**	(A)	**18.**	(A)	**19.**	(B)	**20.**	(A)
21.	(B)	**22.**	(A)	**23.**	(D)	**24.**	(C)	**25.**	(B)
26.	(B)	**27.**	(A)	**28.**	(D)	**29.**	(D)	**30.**	(B)
31.	(B)	**32.**	(B)	**33.**	(B)	**34.**	(B)	**35.**	(C)
36.	(D)	**37.**	(C)	**38.**	(B)	**39.**	(B)	**40.**	(C)
41.	(C)	**42.**	(C)	**43.**	(D)	**44.**	(C)	**45.**	(A)
46.	(C)	**47.**	(B)	**48.**	(B)	**49.**	(AC)	**50.**	(BD)
51.	(ABCD)	**52.**	(ABC)	**53.**	(ABD)	**54.**	(C)	**55.**	(A)
56.	(B)	**57.**	(A)	**58.**	(C)	**59.**	(D)		

60. (A) - (p,r) ; (B) - (q,r) ; (C) - (q,s) ; (D) - (q,r)

SOLUTIONS OF INTRODUCTION TO CHEMISTRY

EXERCISE

PART - I

1. 10^{10} grains are distributed in 1 second

$\therefore$ 6.02×10^{23} grains are distributed in $\frac{6.02 \times 10^{23}}{10^{10}}$ sec = $\frac{6.02 \times 10^{23}}{10^{10} \times 60 \times 60 \times 24 \times 365}$ years

= 1.9×10^{6} years (approx.)

2. No. of atoms = mole × N_a

$1 = \frac{x}{238} \times N_a$ (x is wt. of uranium)

$x = \frac{238}{6} \times 10^{-23}$

$x = 3.95 \times 10^{-22}$

3. No. of moles of C = $\frac{12.044 \times 10^{23}}{6.022 \times 10^{23}}$ = 2.

Wt. of C atoms = 2 × 12 = 24 g.

4. mass of Si = mole × Atomic mass

= 35 × 28 = 980 g

8. We know that, 1 amu = $\frac{1}{12}$ × weight of one ^{12}C atom

or weight of one ^{12}C atom = 12 amu (at. wt. of C = 12 amu).
Similarly, as the atomic weight of He is 4 amu,
weight of one He atom = 4 amu.

Thus, the number of atoms in 100 amu of He = $\frac{100}{4}$ = 25.

9. 1 litre Hg metal
volume = 1000

$d = \frac{m}{v}$ mass = d × V = 13.6 × 1000

No of mole of Hg metal = $\frac{13.6 \times 1000}{200}$ = 68 mole

10. Fractional abundance of ^{35}Cl = 0.75, Molar mass = 35.0
Fractional abundance of ^{37}Cl = 0.25, Molar mass = 37.0

$\therefore$ Average atomic mass = (0.75) (35.0 amu) + (0.25) (37.0 amu) = 35.5

11. Let mole % of ^{26}Mg be x.

$\therefore$ $\frac{(21 - x)25 + x(26) + 79(24)}{100}$ = 24.31

x = 10%

12. No. of molecules = mole × N_a = $\frac{16}{16} \times N_a$

$N_a = 6.02 \times 10^{23}$

13. In 18 g, no. of molecules = N_A

so in 0.09 g no. of molecules = $\frac{N_A}{18} \times 0.09 = \frac{N_A}{2 \times 100}$ = 3.01×10^{21}.

14. Let the number of C_2H_6 molecules in the sample be n. As given, mass of C_2H_6 = mass of 10^7 molecules of CH_4

$$\frac{n}{\text{Av.constant}} \times \text{mol. wt. of } C_2H_6 = \frac{10^7}{\text{Av.constant}} \times \text{mol. wt. of } CH_4$$

$$\frac{n \times 30}{\text{Av.constant}} = \frac{10^7 \times 16}{\text{Av.constant}} = 5.34 \times 10^6.$$

16. No. of moles of $CaCO_3$ = $\frac{\text{no. of molecules}}{\text{Av. cons.}} = \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}} = 1$

Weight of $CaCO_3$ = 1 × 100 = 100 g.

17. Total no. of moles of CO_2 = $\frac{\text{wt. in g}}{\text{mol. wt.}} = \frac{0.2}{44} = 0.00454$.

No. of moles removed = $\frac{10^{21}}{6.022 \times 10^{23}} = 0.00166$.

No. of moles of CO_2 left = 0.00454 – 0.00166 = 0.00288.

18. **(a)** mole of $H_2SO_4 = \frac{\text{mass}}{\text{molar mass}} = \frac{196}{98} = 2$.

1 molecule H_2SO_4 contains 2 atom hydrogen, 1 atom sulphur and 4 atom of oxygen.
Hence, H = $4N_A$ atoms, S = $2N_A$ atoms, O = $8N_A$ atoms

(b) molecule of H_2SO_4 = $\frac{196}{98}$ = 2.

Hence, H = 4 atoms, S = 2 atoms, O = 8 atoms.
(c) 5 mole $H_2S_2O_8$ contains
H = $10N_A$ atoms, S = $10N_A$ atoms, O = 40 N_A atoms
(d) 3 molecules $H_2S_2O_6$ contains
H = 6 atoms, S = 6 atoms, O = 18 atoms.

19. 10 mole NH_3 have mole of 'H' atom = 10 × 3
5 mole of H_2SO_4 have mole of 'H' atom = 10
Total mole of 'H' atom = 40
mole of H_2 = 20
Hence: number of H_2 molecules = $20N_A$

20. no. of atoms = 3 × 11 × N_A
So no. of O_3 molecules formed = 11 N_A

21. Mol. wt. of air = $\frac{78 \times 28 + 21 \times 32 + 0.9 \times 40 + 0.1 \times 44}{78 + 21 + 0.9 + 0.1}$ = 28.964.
(N_2 = 28, O_2 = 32, Ar = 40 and CO_2 = 44)

22. From ideal gas equation, pV = nRT. In SI sytem the parameters of the gas are:
Pressure = p x 1000 (Pa); Volume = V x 10^{-6} (m^3); Temperature = t + 273 (K); moles = w/32

Therefore, R = $\frac{32pV}{1000 \times w \times (t + 273)}$

23. PV = nRT, N = n × N_A

24. PV = nRT,
n = W/M 16 AMU

25. Pressure = 7.6×10^{-10} mm
= 0.76×10^{-10} cm

$\frac{0.76 \times 10^{-10}}{76}$ = atm (1 atom = 76 cm) = 10^{-12} atm.

Volume = 1 litre, R = 0.0821 lit. atm/K/mole, temperature = 273 K.

We know that pV = nRT or $n = \frac{pV}{RT}$

$n = \frac{10^{-12} \times 1}{0.082 \times 273} = 0.44 \times 10^{-13}$.

No. of molecules = = $0.44 \times 10^{-13} \times 6.022 \times 10^{23} = 2.65 \times 10^{10}$.

PART - II

1. Atoms of an element are alike.

4. $\text{mole} = \frac{\text{mass}}{\text{at. wt.}} = \frac{46}{23}$ = 2 mole.

6. 4 g He = N_A atoms

7.

	A	B
Atomic mass	40	80
given weight	x gram	2x gram
No. of mole	$\frac{x}{40}$	$\frac{2x}{80}$
No. of Atom	$\frac{x}{40} \times N_A$	$\frac{x}{40} \times N_A$

But according to question = $\frac{x}{40} \times N_A = y$

8. Mole of Aluminium = $\frac{54}{27}$ = 2 mole.

Al and Mg have same number of atoms (given). Hence same moles also.

$\therefore$ Mass of magnesium = 2 × 24 = 48 g.

9. 558.5 g Fe = $\frac{558.5}{55.85}$ mole Fe = 10 mole Fe = 2 × 5 mole C = 2 × $\frac{60}{12}$ mole C

11. 12 g $_6C^{12}$ contains $6N_A$ electrons and 6 N_A neutrons.

12. $M_X = 2 \times 12 = 24$

$M_Y = \frac{M_X}{0.3} = 80.$

13. 1 gram ion = 1 mole
charge on 1 mole Al^{3+} is = 3 × e (N_A).

14. Number of protons in $_6C^{14}$ = 6 ;
Number of neutrons in $_6C^{14}$ = 8 ;
As per given new atomic mass of
$_6C^{14}$ = 12 + 4 = 16

(As the mass of electron negligible as compared to neutron and proton)

% increase in mass = $\frac{16-14}{14}$ × 100 = 14.28

15. Weight of C –14 isotope in 12g sample = $\frac{2\times12}{100}$

No. of isotopes = $\frac{2\times12\times N}{100\times14}$ = 1.032 × 10^{22} atom

17. 114.8 = 115 × 0.95 + M × 0.05
M = 111

19. 17 g NH_3 = N_A molecules

21. Gram mol. wt. of $C_{60}H_{22}$ = 742 gm
i.e. wt. of 6.023 × 10^{23} molecules = 742

so wt. of 1 molecules = $\frac{742}{6.023\times10^{23}}$ = 1.24 × 10^{-21} g.

22. Number of electrons = $\frac{1.8\times10}{18}$ × N_A

23. 1 mole P_4 = N molecules of P_4 = 4 N atoms of P_4.

24. In $(NH_4)_3PO_4$

$\frac{\text{mole of Hatom}}{\text{mole of O atom}} = \frac{12}{4}$

mole of 'O' atom = $\frac{4}{12}$ (mole of H atom) = $\frac{1}{3}$ (3.18) = 1.06.

25. (B) 1 Torr = 1 mm.

27. This is the required relation in Centigrade and Fahrenheit scales.

28. $\frac{F-32}{9} = \frac{C}{5}$

Let temperature be t, same on two scale

∴ t – 32 = $\frac{9t}{5}$ or t = –40

30. R = 2 can K^{-1} mol^{-1} = 8.314 JK^{-1} mol^{-1} = 8.314 × 10^7 erg K^{-1} mol^{-1} = 0.0821 litre atm K^{-1} mol^{-1}.

31. Follow answer 1 in SI units.

33. P × 44.8 = 2 × 0.0821 × 540. ∴ P = 1.98 atm.

34. Molar volume, i.e. volume when n = 1 from PV = nRT is RT/P.

37.

	H_2	:	He	:	O_2	:	O_3
Ratio of total no. of molecules =	1	:	1	:	1	:	1
So ratio of total no. of atoms =	2	:	1	:	2	:	3

38. Statement of avogadro's hypothesis.

39. Mol. wt. of gas is = $\frac{16 \times 22.4}{5.6}$ = 64 g

32 + 16x = 64
x = 2

40. $\frac{\text{wt. of 1 litre gas at STP}}{\text{wt of 1 litre } O_2 \text{ at STP}} = \frac{\text{molar mass of gas}}{\text{molar mass of } O_2}$

2.22 = $\frac{M}{32}$
M = 71.

43. 9.108×10^{-21} kg is the wt. of 1 e^- = $\frac{1}{N_A}$ moles of e^-

So 1 kg is the wt. of 1 e^- = $\frac{1}{9.108 \times 10^{-31}} \times \frac{1}{N_A} = \frac{1}{9.108 \times 10^{-31} \times 6.023 \times 10^{23}} = \frac{10^8}{9.108 \times 6.023}$.

44. 560g of Fe No. of moles = $\frac{560\,g}{56\,g}$ = 10 mole

70 g of N
14g = 1 mole atom of N
70g = 5 moles of N
20g H = 20 moles of H-atoms.

45. (A) Moles of C = 24/12 = 2, So no. of atoms = $2N_A$
(B) Moles of Fe = 56/56 = 1, So no. of atoms = N_A
(C) Moles of Al = 27/27 = 1, So no. of atoms = N_A
(D) Moles of Fe = 108/108 = 1, So no. of atoms = N_A

46. The mass of one mole of a substance will remain unchanged.

47. 8 moles of O-atom are contained by 1 mole $Mg_3(PO_4)_2$.
Hence, 0.25 moles of O-atom = $\frac{1}{8} \times 0.25 = 3.125 \times 10^{-2}$ mole $Mg_3(PO_4)_2$.

48. $^{54}Fe \longrightarrow 5\%$
$^{56}Fe \longrightarrow 90\%$
$^{57}Fe \longrightarrow 5\%$
Av. atomic mass = $x_1A_1 + x_2A_2 + x_3A_3$ = 54 × 0.05 + 56 × 0.9 + 57 × 0.05 = **55.95**

51. Number of electron = mole of H × 1 = Mole of O × 8 = Mole of C × 6 = Mole of N × 7

52. Refer Notes.

53. Pressure is same when V/T is constant.

60. Use % by moles = $\frac{M_{avg} - M_1}{M_2 - M_1} \times 100$

% by mass = % by moles × $\frac{M_2}{M_{avg}}$