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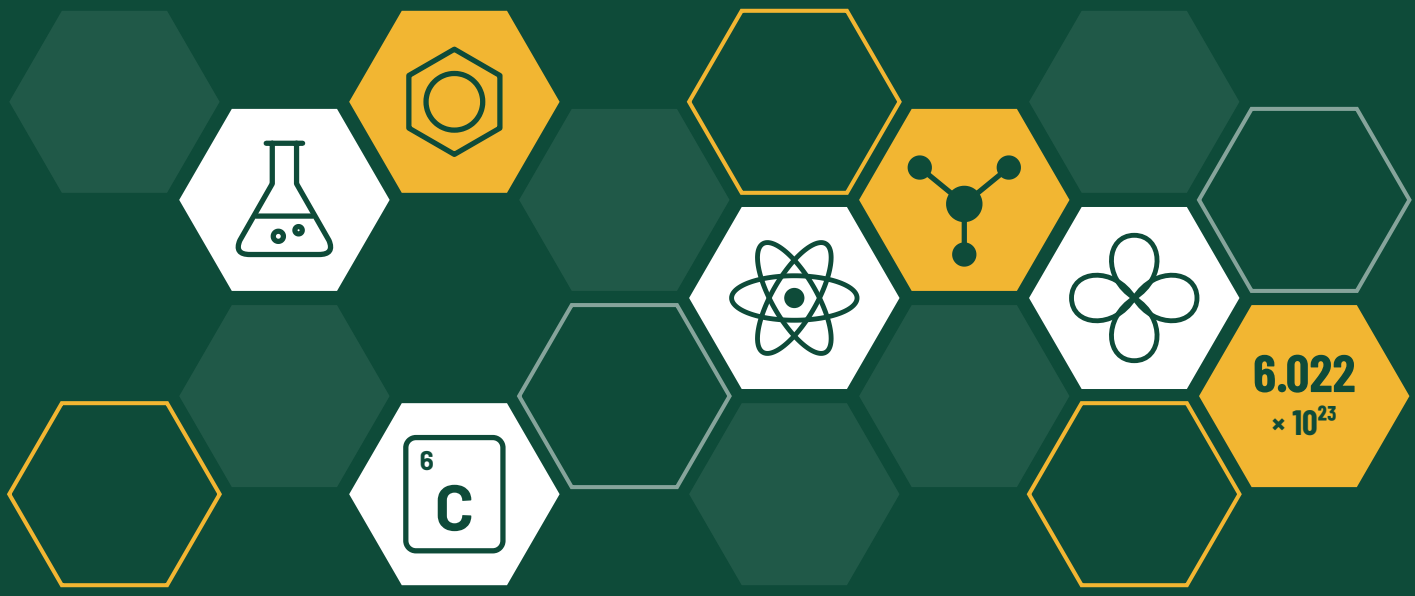

CHEMISTRY

CLASS 11 | FOR JEE Main & JEE Advanced

INCLUDES JEE MAIN 2026 & JEE ADVANCED QUESTIONS

Concepts • Formulas • Solved Questions • PYQs • Practice

1,800+ QUESTIONS WITH SOLUTIONS

540+ PREVIOUS YEAR QUESTIONS

18 CHAPTERS

Om Muruga Publication

How every chapter is organised

- Syllabus Map – where the chapter sits in CBSE, TN State Board, JEE Main and JEE Advanced
- A. Highlights – theory with definitions, tables, structures and worked illustrations
- B. Formula Overview – every key formula and fact in one table
- C. Solved IIT-Level Questions – “Formula used” and a complete solution
- D. Previous Year Questions – JEE Main, fully solved
- E. JEE Advanced Questions – fully solved
- F. Practice Questions – answer key with hints and worked solutions
- G. Revision Mind Map – the whole chapter on one page

Chapters in the full book

Chapter 1	**Some Basic Concepts of Chemistry**	**IN THIS SAMPLE**
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01
CHAPTER

Some Basic Concepts of Chemistry

Matter · Measurement and Significant Figures · Laws of Chemical Combination · Atomic and Molecular Masses · Mole Concept · Empirical and Molecular Formula · Stoichiometry and Limiting Reagent · Concentration Terms · Equivalent Concept

Syllabus Map

CBSE Class XI	Unit 1: Some Basic Concepts of Chemistry
TN Class XI	Unit 1: Basic Concepts of Chemistry and Chemical Calculations
JEE Main 2027	Unit 1: Some Basic Concepts in Chemistry
JEE Advanced	General Topics: mole concept, chemical formulae, balanced equations, stoichiometric calculations, concentration terms, equivalent concept

A. Highlights

1. Matter and its Classification

Matter is anything that has mass and occupies space. It exists in three physical states: solid (definite shape and volume), liquid (definite volume, no definite shape) and gas (neither definite shape nor volume).

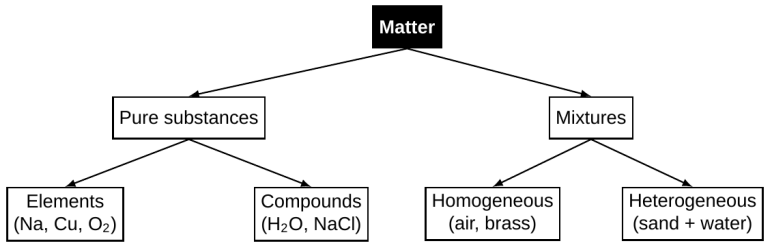


Fig. 1.1 Classification of matter

Type	Composition	Example
Element	One kind of atom	Na, Cu, O_2, S_8
Compound	Two or more elements in a fixed ratio by mass	H_2O, CO_2, $NaCl$
Homogeneous mixture	Uniform composition throughout	Air, sugar solution, brass
Heterogeneous mixture	Non-uniform composition	Sand + water, oil + water

Key Point

• Mass is the amount of matter in a body and is constant; weight is the force exerted by gravity on it and varies with place.

• Kelvin scale has no negative values: $T(K) = t(°C) + 273.15$.

2. Measurement, SI Units and Significant Figures

Base quantity	SI unit	Symbol
Mass	kilogram	kg
Length	metre	m
Time	second	s
Temperature	kelvin	K
Amount of substance	mole	mol

Base quantity	SI unit	Symbol
Electric current	ampere	A
Luminous intensity	candela	cd

Precision is the closeness of repeated measurements to one another; **accuracy** is the closeness of a measurement to the true value.

Rules for significant figures:

- All non-zero digits are significant (285 has 3).
- Zeros between non-zero digits are significant (2005 has 4).
- Leading zeros are not significant (0.0032 has 2).
- Trailing zeros after a decimal point are significant (2.500 has 4); in 100 they are ambiguous unless written as 1.00×10^2 (3).
- Exact numbers (counted objects, defined values) have infinite significant figures.

Operation	Rule for the result	Example
Addition / subtraction	Same number of decimal places as the least precise term	12.11 + 18.0 + 1.012 = 31.1
Multiplication / division	Same number of significant figures as the least precise term	$2.5 \times 1.25 = 3.1$
Rounding off a 5	Preceding digit unchanged if even, raised by one if odd	25.15 → 25.2; 25.25 → 25.2

Common Mistakes

• Counting leading zeros as significant: 0.00253 has only 3 significant figures.

• Rounding at every intermediate step. Keep one extra digit and round only the final answer.

3. Laws of Chemical Combination

Law	Statement	Illustration
Conservation of mass (Lavoisier)	Mass is neither created nor destroyed in a chemical reaction	10 g $CaCO_3$ → 5.6 g CaO + 4.4 g CO_2
Definite proportions (Proust)	A compound always contains the same elements in the same ratio by mass	C : O = 3 : 8 in all samples of CO_2
Multiple proportions (Dalton)	Masses of one element combining with a fixed mass of another are in a simple whole-number ratio	O in H_2O and H_2O_2 per 2 g H = 16 : 32 = 1 : 2
Gaseous volumes (Gay-Lussac)	Gases react in simple volume ratios at the same T and p	2 vol H_2 + 1 vol O_2 → 2 vol H_2O(g)
Avogadro's law	Equal volumes of all gases at the same T and p contain equal numbers of molecules	$V \propto n$ at constant T, p

Dalton's atomic theory (main postulates): matter consists of indivisible atoms; atoms of an element are identical in mass and properties; compounds form when atoms of different elements combine in a fixed ratio; chemical reactions involve only reorganisation of atoms.

4. Atomic Mass, Molecular Mass and the Mole

Atomic mass unit: 1 u (amu) $= \frac{1}{12}$ of the mass of one C-12 atom $= 1.66 \times 10^{-24}$ g.

Average atomic mass of an element with isotopes of masses m_i and percentage abundances x_i:

$$\acute{A} = \frac{\sum x_i m_i}{100}$$

Example: chlorine (75.77% Cl-35 of mass 34.969 u; 24.23% Cl-37 of mass 36.966 u) has $\acute{A} = 35.45$ u.

Mole: the amount of substance containing as many entities as there are atoms in exactly 12 g of C-12, i.e. $N_A = 6.022 \times 10^{23}$ entities.

$$n = \frac{m}{M} = \frac{N}{N_A} = \frac{V_{STP}}{22.7\ L\ mol^{-1}}$$

Note on molar volume

• At STP (273.15 K, 1 bar) the molar volume of an ideal gas is 22.7 L; at NTP / old STP (273.15 K, 1 atm) it is 22.4 L. Use whichever value the question gives.

JEE Extension

• Number of atoms = moles of molecules × atomicity × N_A; number of electrons = moles × (electrons per molecule) × N_A.

• Vapour density (VD) = molar mass / 2, so $M = 2 \times VD$.

5. Percentage Composition, Empirical and Molecular Formula

$$\text{Mass \% of element} = \frac{\text{mass of element in 1 mol}}{\text{molar mass}} \times 100$$

Steps to find the empirical formula: (1) take % as grams; (2) divide by atomic mass to get moles; (3) divide by the smallest value; (4) multiply by a small whole number to clear fractions.

$$\text{Molecular formula} = n \times (\text{empirical formula}),\ n = \frac{\text{molar mass}}{\text{empirical formula mass}}$$

Combustion analysis of an organic compound (mass w):

$$\%C = \frac{12}{44} \times \frac{m_{CO_2}}{w} \times 100,\ \%H = \frac{2}{18} \times \frac{m_{H_2O}}{w} \times 100$$

For a hydrocarbon C_xH_y: $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$.

6. Stoichiometry and Limiting Reagent

The coefficients of a balanced equation give the mole ratio (and, for gases at the same T and p, the volume ratio) of reactants and products.

- **Limiting reagent:** divide the moles of each reactant by its coefficient; the smallest quotient identifies the limiting reagent. It decides the amount of product.
- **Percentage yield** = (actual yield / theoretical yield) × 100.
- **Purity:** mass of pure substance = mass of sample × (% purity / 100).

Common Mistakes

• Comparing the given moles directly instead of dividing each by its stoichiometric coefficient.

• Using the mass of an impure sample without applying purity.

7. Concentration Terms

Term	Definition	Unit	T-dependent?
Mass % (w/w)	$\frac{w_B}{w_{soln}} \times 100$	—	No
Mass by volume % (w/v)	$\frac{w_B(g)}{V_{soln}(mL)} \times 100$	—	Yes
ppm	$\frac{w_B}{w_{soln}} \times 10^6$	—	No
Mole fraction	$x_B = \frac{n_B}{n_A + n_B}$	—	No
Molarity (M)	$\frac{n_B}{V_{soln}(L)}$	mol L^{-1}	Yes
Molality (m)	$\frac{n_B}{w_A(kg)}$	mol kg^{-1}	No
Normality (N)	$\frac{\text{g-equivalents}}{V(L)} = M \times n_f$	eq L^{-1}	Yes

Interconversion (density d in g mL^{-1}, molar mass of solute M_B in g mol^{-1}):

$$m = \frac{1000\,M}{1000\,d - M\,M_B}, \quad M = \frac{10 \times (\%\,w/w) \times d}{M_B}$$

Dilution and mixing: $M_1V_1 = M_2V_2$; on mixing, $M_{mix} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$.

Key Point
• Molality, mole fraction and mass % involve only masses, so they do not change with temperature; molarity and normality change because volume changes.
• Molarity of pure water = 1000/18 = 55.5 M.

8. Equivalent Concept [JEE Advanced]

$$\text{Equivalent mass} = \frac{\text{molar mass}}{n_f}, \quad \text{g-equivalents} = \frac{w}{E} = n \times n_f$$

Species	n_f (n-factor)	Example
Acid	Replaceable H^+ actually replaced	H_2SO_4 = 2; H_3PO_4 → Na_2HPO_4 = 2
Base	OH^- replaced	$Ca(OH)_2$ = 2
Oxidant / reductant	Change in oxidation number per formula unit	$KMnO_4$ (acidic) = 5; $H_2C_2O_4$ = 2
Salt (non-redox)	Total positive (or negative) charge	$Al_2(SO_4)_3$ = 6

Law of equivalence: in any reaction, equivalents of all reactants and products are equal, so $N_1V_1 = N_2V_2$ for a titration.

Experimental Skills

• A **primary standard** (e.g. oxalic acid dihydrate $H_2C_2O_4\cdot 2H_2O$, M = 126 g mol^{-1}) is weighed accurately to prepare a solution of known molarity: 3.150 g in 250.0 mL gives 0.100 M.

• In titration, take concordant readings and report the average titre with the correct number of significant figures.

B. Formula Overview

Topic	Formula / fact and conditions
Temperature	$T(K)=t(^\circ C)+273.15;\ ^\circ F=\frac{9}{5}(^\circ C)+32$
Atomic mass unit	1 u $=1.66\times10^{-24}$ g $=\frac{1}{12}$ mass of C-12 atom
Average atomic mass	$\acute{A}=\sum x_i m_i/100$
Mole	$n=m/M=N/N_A=V_{STP}/22.7$ L; $N_A=6.022\times10^{23}$ mol^{-1}
Mass of one molecule	M/N_A g
Vapour density	$M=2\times VD$
Mass %	(mass of element in 1 mol / molar mass) × 100
Molecular formula	$n\times$ empirical formula; $n=M/(\text{EF mass})$
Combustion analysis	%C $=\frac{12}{44}\frac{m_{CO_2}}{w}\times100$; %H $=\frac{2}{18}\frac{m_{H_2O}}{w}\times100$
Hydrocarbon combustion	$C_xH_y+\left(x+\frac{y}{4}\right)O_2\rightarrow xCO_2+\frac{y}{2}H_2O$
Limiting reagent	Smallest value of (moles / coefficient)
% yield	(actual / theoretical) × 100
Molarity	$M=n_B/V$ (L); $M=10\times(\%w/w)\times d/M_B$
Molality	$m=n_B/w_A$ (kg); $m=1000M/(1000d-MM_B)$
Mole fraction	$x_B=n_B/(n_A+n_B)$; $x_A+x_B=1$
ppm	$(w_B/w_{soln})\times10^6$
Dilution / mixing	$M_1V_1=M_2V_2$; $M_{mix}=(M_1V_1+M_2V_2)/(V_1+V_2)$
Normality [JEE Adv]	$N=M\times n_f$; $E=M/n_f$; $N_1V_1=N_2V_2$

C. Solved IIT-Level Questions

Matter, Measurement and Significant Figures

1. The number of significant figures in 0.050300 is *[Easy]*

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

Formula used: Leading zeros are not significant; trailing zeros after the decimal point are significant. **Solution:**

Given: the number 0.050300.

Rule 1: Zeros to the left of the first non-zero digit only locate the decimal point, so they are not significant. Here “0.0” before 5 is not counted.

Rule 2: Zeros between non-zero digits are significant. The 0 between 5 and 3 counts.

Rule 3: Zeros at the right end after the decimal point are significant. The two final zeros count.

Counting: 5, 0, 3, 0, 0 → 5 significant figures.

Check: in scientific notation, 0.050300 = 5.0300 × 10^{-2}, which shows five digits.

Ans: (c)

2. The sum 12.11 + 18.0 + 1.012, reported to the correct number of significant figures, is *[Easy]*

(a) 31.1 (b) 31.12 (c) 31.122 (d) 31

Formula used: In addition, the result has as many decimal places as the least precise term. **Solution:**

Given: 12.11 (2 decimal places), 18.0 (1 decimal place), 1.012 (3 decimal places).

Rule: in addition or subtraction, the answer keeps as many decimal places as the term with the fewest decimal places.

Step 1: Add the numbers: 12.11 + 18.0 + 1.012 = 31.122.

Step 2: The least precise term is 18.0 (1 decimal place), so round 31.122 to one decimal place.

Step 3: The digit after the first decimal place is 2 (< 5), so it is dropped: 31.1.

Hence the correctly reported sum is 31.1, option (a). **Ans: (a)**

3. Which of the following is a homogeneous mixture? *[Easy]*

(a) Sand and water
(b) Air
(c) Oil and water
(d) Iron filings and sulphur

Formula used: A homogeneous mixture has uniform composition throughout. **Solution:**

Concept: a homogeneous mixture has the same composition and properties throughout and shows no visible boundary between its components.

Air: a uniform mixture of N_2, O_2, Ar, CO_2 and water vapour; every sample has the same composition → homogeneous.

Sand and water: sand settles; two phases are seen → heterogeneous.

Oil and water: immiscible; two layers form → heterogeneous.

Iron filings and sulphur: particles can be seen and separated with a magnet → heterogeneous.

Hence air, option (b).

Ans: (b)

Laws of Chemical Combination

4. Two oxides of nitrogen contain 63.6% and 46.7% nitrogen by mass. The data illustrate the law of *[Medium]*

(a) constant proportions
(b) reciprocal proportions
(c) gaseous volumes
(d) multiple proportions

Formula used: Mass of O per gram of N in each oxide. **Solution:**

Given: oxide I has 63.6% N (so 36.4% O); oxide II has 46.7% N (so 53.3% O).

Concept: law of multiple proportions — when two elements form more than one compound, the masses of one element that combine with a fixed mass of the other are in a simple whole-number ratio.

Step 1: Fix the mass of nitrogen at 1 g.

Oxide I: mass of O per g of N = 36.4/63.6 = 0.572 g. Oxide II: mass of O per g of N = 53.3/46.7 = 1.141 g. **Step 2:** Ratio of oxygen masses = 0.572 : 1.141 ≈ 1 : 2, a simple whole-number ratio (oxides N_2O and NO). Hence the data illustrate the law of multiple proportions, option (d).

Ans: (d)

5. 60 mL of hydrogen reacts completely with oxygen to form water vapour at the same temperature and pressure. The volume of oxygen (in mL) required is _____. *[Easy]*

Formula used: Gay-Lussac's law: $2H_2 + O_2 \rightarrow 2H_2O$; volume ratio $H_2 : O_2 = 2 : 1$. **Solution:**

Given: $V(H_2)$ = 60 mL; all gases at the same temperature and pressure.

Concept: Gay-Lussac's law of gaseous volumes — at the same T and p, reacting gas volumes are in the ratio of the coefficients.

Step 1: Balanced equation: $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$. Volume ratio $H_2 : O_2 = 2 : 1$.

Step 2: $V(O_2) = 60 \times 1/2 = 30$ mL.

Hence 30 mL of oxygen is required.

Ans: 30

6. 10 g of calcium carbonate on strong heating leaves 5.6 g of calcium oxide. The mass of carbon dioxide evolved is *[Easy]*

(a) 4.4 g (b) 5.6 g (c) 10 g (d) 15.6 g

Formula used: Law of conservation of mass.
Solution:

Given: mass of $CaCO_3$ = 10 g; mass of CaO left = 5.6 g.

Concept: law of conservation of mass — total mass of products equals total mass of reactants.

Step 1: Reaction: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$.

Step 2: Mass of CO_2 = 10 − 5.6 = 4.4 g.

Check: 10 g $CaCO_3$ = 0.1 mol, giving 0.1 mol CO_2 = 0.1 × 44 = 4.4 g.

Hence 4.4 g, option (a).

Ans: (a)

Atomic and Molecular Masses, Mole Concept

7. The total number of atoms present in 4.25 g of ammonia is *[Medium]*

(a) 1.5×10^{23} (b) 6.022×10^{23}

(c) 1.2×10^{24} (d) 3.0×10^{23}

Formula used: Atoms = (m/M) × atomicity × N_A.
Solution:

Given: $m(NH_3)$ = 4.25 g; $M(NH_3)$ = 14 + 3 = 17 g mol^{-1}. **Step 1:** Moles of NH_3 = 4.25/17 = 0.25 mol.

Step 2: Molecules = $0.25 \times 6.022 \times 10^{23} = 1.5055 \times 10^{23}$.

Step 3: Each NH_3 molecule contains 1 N + 3 H = 4 atoms.

Step 4: Total atoms = $4 \times 1.5055 \times 10^{23} = 6.022 \times 10^{23}$.

Hence option (b).

Ans: (b)

8. Chlorine has two isotopes: Cl-35 (34.969 u, 75.77%) and Cl-37 (36.966 u, 24.23%). The average atomic mass of chlorine is *[Medium]*

(a) 35.00 u (b) 36.00 u (c) $\sum_{i} i$ (d) 35.45 u (d) 35.97 u

Formula used: $A = x\,m$ /100. **Solution:**

Given: Cl-35: mass 34.969 u, abundance 75.77%; Cl- 37: mass 36.966 u, abundance 24.23%.

Formula: average atomic mass = Σ(abundance × isotopic mass)/100.

Step 1: 75.77 × 34.969 = 2649.6.

Step 2: 24.23 × 36.966 = 895.7.

Step 3: Average = (2649.6 + 895.7)/100 = 3545.3/100 = 35.45 u.

Hence option (c).

Ans: (c)

9. The mass of one molecule of water is approximately *[Easy]*

(a) 2.99×10^{-23} g (b) 1.8×10^{-22} g

(c) 3.0×10^{-24} g (d) 1.66×10^{-24} g

Formula used: Mass of one molecule = M/N_A.
Solution:

Given: $M(H_2O) = 2 \times 1 + 16 = 18$ g mol^{-1}; one mole contains $N_A = 6.022 \times 10^{23}$ molecules.

Formula: mass of one molecule = M/N_A.

Step 1: $18/(6.022 \times 10^{23}) = 2.989 \times 10^{-23}$ g.

Hence about 2.99×10^{-23} g, option (a).

Ans: (a)

10. The number of moles of oxygen atoms present in 0.5 mol of $Al_2(SO_4)_3$ is _____. *[Easy]*

Formula used: Moles of atoms = moles of compound × number of that atom per formula unit. **Solution:**

Given: 0.5 mol of $Al_2(SO_4)_3$.

Step 1: Count O atoms per formula unit: each SO_4 has 4 O; there are 3 SO_4 groups → 3 × 4 = 12 O atoms. **Step 2:** Moles of O atoms = 0.5 × 12 = 6 mol.

Hence the answer is 6.

Ans: 6

11. Which of the following contains the largest number of molecules? *[Easy]*

(a) 1 g of H_2 (b) 16 g of O_2

(c) 22 g of CO_2 (d) 18 g of H_2O

Formula used: Number of molecules ∝ number of moles = m/M. **Solution:**

Concept: number of molecules = moles × N_A, so the sample with the most moles has the most molecules. 1 g H_2: n = 1/2 = 0.5 mol.

16 g O_2: n = 16/32 = 0.5 mol.

22 g CO_2: n = 22/44 = 0.5 mol.

18 g H_2O: n = 18/18 = 1.0 mol (largest).

Hence 18 g of water, option (d).

Ans: (d)

12. The volume occupied by 8.8 g of CO_2 at STP is $x \times 10^{-2}$ L. The value of x is _____. (Molar volume at STP = 22.7 L mol^{-1}) *[Medium]*

Formula used: V = n × 22.7 L. **Solution:**

Given: m(CO_2) = 8.8 g; M = 44 g mol^{-1}; molar volume at STP = 22.7 L mol^{-1}.

Step 1: n = 8.8/44 = 0.2 mol.

Step 2: V = n × 22.7 = 0.2 × 22.7 = 4.54 L.

Step 3: 4.54 L = 454 × 10^{-2} L, so x = 454.

Hence x = 454.

Ans: 454

Percentage Composition, Empirical and Molecular Formula

13. The percentage of nitrogen in urea, $CO(NH_2)_2$, is *[Easy]*

(a) 23.3% (b) 46.7% (c) 28.0% (d) 60.0%

Formula used: Mass % = (mass of element in 1 mol / molar mass) × 100. **Solution:**

Given: urea $CO(NH_2)_2$ contains 1 C, 1 O, 2 N and 4 H. **Step 1:** Molar mass = 12 + 16 + 2 × 14 + 4 × 1 = 60 g mol^{-1}.

Step 2: Mass of N per mole = 2 × 14 = 28 g.

Step 3: %N = (28/60) × 100 = 46.7%.

Hence option (b).

Ans: (b)

14. A compound contains 40.0% C, 6.67% H and 53.33% O. Its molar mass is 180 g mol^{-1}. Its molecular formula is *[Medium]*

(a) CH_2O (b) $C_2H_4O_2$ (c) $C_6H_{12}O_6$ (d) $C_6H_{10}O_5$

Formula used: Empirical formula from mole ratio; n = molar mass / EF mass. **Solution:**

Given: C 40.0%, H 6.67%, O 53.33%; molar mass 180 g mol^{-1}. Take 100 g of compound.

Step 1: Moles — C: 40.0/12 = 3.33; H: 6.67/1 = 6.67; O: 53.33/16 = 3.33.

Step 2: Divide by the smallest (3.33): C 1, H 2, O 1 → empirical formula CH_2O.

Step 3: Empirical formula mass = 12 + 2 + 16 = 30. **Step 4:** n = molar mass/EF mass = 180/30 = 6.

Step 5: Molecular formula = $(CH_2O)_6 = C_6H_{12}O_6$.

Hence option (c).

Ans: (c)

15. A hydrocarbon contains 80% carbon and 20% hydrogen. Its vapour density is 15. Its molecular formula is *[Medium]*

(a) CH_3 (b) C_2H_4 (c) C_3H_8 (d) C_2H_6

Formula used: M = 2 × VD; empirical formula from mole ratio. **Solution:**

Given: C 80%, H 20%; vapour density (VD) = 15.

Step 1: Molar mass = 2 × VD = 2 × 15 = 30 g mol^{-1}. **Step 2:** Moles in 100 g — C: 80/12 = 6.67; H: 20/1 = 20.

Step 3: Ratio C : H = 6.67 : 20 = 1 : 3 → empirical formula CH_3 (mass 15).

Step 4: n = 30/15 = 2 → molecular formula C_2H_6.

Hence ethane, option (d).

Ans: (d)

16. The percentage of water of crystallisation in $CuSO_4 \cdot 5H_2O$ is _____ (nearest integer). (Molar mass = 249.5 g mol^{-1}) *[Easy]*

Formula used: % water = (mass of water in 1 mol / molar mass) × 100. **Solution:**

Given: M($CuSO_4 \cdot 5H_2O$) = 249.5 g mol^{-1}.

Step 1: Mass of water of crystallisation per mole = 5 × 18 = 90 g.

Step 2: % water = (90/249.5) × 100 = 36.07%.

Hence the nearest integer is 36.

Ans: 36

Stoichiometry and Limiting Reagent

17. 28 g of N_2 and 9 g of H_2 react to form ammonia. The mass of ammonia formed is *[Medium]*

(a) 34 g (b) 51 g (c) 17 g (d) 25.5 g

Formula used: Limiting reagent: smallest value of moles/coefficient. **Solution:**

Given: 28 g N_2 (M = 28) and 9 g H_2 (M = 2).

Step 1: Balanced equation: $N_2 + 3H_2 \rightarrow 2NH_3$.

Step 2: Moles — N_2: 28/28 = 1 mol; H_2: 9/2 = 4.5 mol. **Step 3:** Limiting reagent: divide by coefficients — N_2: 1/1 = 1; H_2: 4.5/3 = 1.5. The smaller value (N_2) is limiting.

Step 4: 1 mol N_2 gives 2 mol NH_3 = 2 × 17 = 34 g. (H_2 used = 3 mol; 1.5 mol H_2 remains.)

Hence 34 g, option (a).

Ans: (a)

18. The mass of oxygen obtained on complete decomposition of 24.5 g of $KClO_3$ is *[Easy]*

(a) 4.8 g (b) 9.6 g (c) 19.2 g (d) 3.2 g

Formula used: $2KClO_3 \rightarrow 2KCl + 3O_2$. **Solution:**

Given: $m(KClO_3) = 24.5$ g; $M = 39 + 35.5 + 48 = 122.5$ g mol^{-1}.

Step 1: Balanced equation: $2KClO_3 \rightarrow 2KCl + 3O_2$. **Step 2:** $n(KClO_3) = 24.5/122.5 = 0.2$ mol.

Step 3: $n(O_2) = 0.2 \times 3/2 = 0.3$ mol.

Step 4: Mass of $O_2 = 0.3 \times 32 = 9.6$ g.

Hence option (b).

Ans: (b)

19. The mass of oxygen (in g) required for complete combustion of 4.4 g of propane is _____. *[Easy]*

Formula used: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$. **Solution:**

Given: $m(C_3H_8) = 4.4$ g; $M = 3 \times 12 + 8 = 44$ g mol^{-1}. **Step 1:** Balanced equation: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$.

Step 2: $n(C_3H_8) = 4.4/44 = 0.1$ mol.

Step 3: $n(O_2) = 5 \times 0.1 = 0.5$ mol.

Step 4: Mass of $O_2 = 0.5 \times 32 = 16$ g.

Hence 16 g.

Ans: 16

20. On heating, 10 g of $CaCO_3$ gives 3.3 g of CO_2. The percentage yield of the reaction is _____. *[Easy]*

Formula used: % yield = (actual/theoretical) × 100. **Solution:**

Given: 10 g $CaCO_3$ ($M = 100$); actual $CO_2 = 3.3$ g. **Step 1:** $CaCO_3 \rightarrow CaO + CO_2$; 1 mol $CaCO_3$ gives 1 mol CO_2.

Step 2: $n(CaCO_3) = 10/100 = 0.1$ mol → theoretical $CO_2 = 0.1 \times 44 = 4.4$ g.

Step 3: % yield = (actual/theoretical) × 100 = (3.3/4.4) × 100 = 75%.

Hence 75.

Ans: 75

21. 27 g of Al is heated with 160 g of Fe_2O_3 (thermite reaction: $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$). Which statement is correct? *[Hard]*

(a) Fe_2O_3 is the limiting reagent

(b) 112 g of iron is formed

(c) 80 g of Fe_2O_3 remains unreacted

(d) 102 g of Al_2O_3 is formed

Formula used: Limiting reagent: smallest value of moles/coefficient. **Solution:**

Given: 27 g Al ($M = 27$) and 160 g Fe_2O_3 ($M = 160$); $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$.

Step 1: Moles — Al: 1 mol; Fe_2O_3: 1 mol.

Step 2: Divide by coefficients — Al: 1/2 = 0.5; Fe_2O_3: 1/1 = 1. Al (smaller) is the limiting reagent, so (a) is wrong.

Step 3: Fe_2O_3 consumed = 1/2 × 1 = 0.5 mol; remaining = 0.5 mol = 0.5 × 160 = 80 g → (c) is correct.

Step 4: Fe formed = 1 mol = 56 g (not 112 g), so (b) is wrong; Al_2O_3 formed = 0.5 mol = 51 g (not 102 g), so (d) is wrong.

Hence option (c).

Ans: (c)

Concentration Terms

22. The molarity of a solution containing 4 g of NaOH in 250 mL of solution is *[Easy]*

(a) 0.1 M (b) 0.2 M (c) 0.4 M (d) 1.6 M

Formula used: M = n / V (L). **Solution:**

Given: m(NaOH) = 4 g; M = 40 g mol^{-1}; V = 250 mL = 0.250 L.

Step 1: n = 4/40 = 0.1 mol.

Step 2: Molarity = n/V(L) = 0.1/0.250 = 0.4 M.

Hence option (c).

Ans: (c)

23. The mole fraction of ethanol in a solution of 46 g ethanol and 36 g water is *[Easy]*

(a) 0.25 (b) 0.50 (c) 0.667 (d) 0.333

Formula used: $x_B = n_B/(n_A + n_B)$. **Solution:**

Given: ethanol 46 g (M = 46); water 36 g (M = 18). **Step 1:** n(ethanol) = 46/46 = 1 mol; n(water) = 36/18 = 2 mol.

Step 2: x(ethanol) = 1/(1 + 2) = 1/3 = 0.333.

Hence option (d).

Ans: (d)

24. The molality of a 20% (w/w) aqueous solution of NaOH is *[Medium]*

(a) 5.0 m (b) 6.25 m (c) 2.5 m (d) 4.0 m

Formula used: m = moles of solute / kg of solvent. **Solution:**

Given: 20% (w/w) means 20 g NaOH in 100 g solution. **Step 1:** Mass of solvent (water) = 100 − 20 = 80 g = 0.080 kg.

Step 2: n(NaOH) = 20/40 = 0.5 mol.

Step 3: Molality = 0.5/0.080 = 6.25 mol kg^{-1}.

Hence option (b).

Ans: (b)

25. Which of the following concentration terms does not change with temperature? *[Easy]*

(a) Molality (b) Molarity

(c) Normality (d) Mass by volume %

Formula used: Terms based only on mass do not depend on temperature. **Solution:**

Concept: volume of a solution changes with temperature (expansion/contraction), but mass does not.

Molality = moles of solute/kg of solvent — uses only masses → independent of temperature.

Molarity and normality divide by volume of solution → change with temperature.

Mass by volume % divides by volume → changes with temperature.

Hence molality, option (a).

Ans: (a)

26. The volume (in mL) of 12 M HCl required to prepare 600 mL of 0.5 M HCl is _____. *[Easy]*

Formula used: $M_1V_1 = M_2V_2$. **Solution:**

Given: M_1 = 12 M (stock); M_2 = 0.5 M; V_2 = 600 mL. **Concept:** on dilution, moles of solute stay the same: $M_1V_1 = M_2V_2$.

Step 1: $V_1 = M_2V_2/M_1 = (0.5 \times 600)/12 = 25$ mL.

Hence 25 mL of 12 M HCl is diluted to 600 mL.

Ans: 25

27. A 500 g water sample contains 2 mg of lead. The concentration of lead in ppm is _____. *[Medium]*

Formula used: ppm = $(w_B/w_{soln}) \times 10^6$. **Solution:**

Given: mass of lead = 2 mg = 0.002 g; mass of sample = 500 g.

Formula: ppm = (mass of solute/mass of solution) × 10^6.

Step 1: ppm = $(0.002/500) \times 10^6 = 4$ ppm.

Hence 4 ppm.

Ans: 4

Equivalent Concept [JEE Advanced]

28. The equivalent mass of H_3PO_4 in the reaction $H_3PO_4 + 2NaOH \rightarrow Na_2HPO_4 + 2H_2O$ is *[Medium]*

(a) 98 (b) 32.7 (c) 24.5 (d) 49

Formula used: E = M / n_f; n_f = number of H^+ actually replaced. **Solution:**

Given: $H_3PO_4 + 2NaOH \rightarrow Na_2HPO_4 + 2H_2O$; $M(H_3PO_4) = 98$.

Concept: for an acid, n-factor = number of H^+ actually replaced in the given reaction (not the total H present). **Step 1:** Na_2HPO_4 is formed, so 2 H^+ are replaced → n-factor = 2.

Step 2: Equivalent mass = 98/2 = 49.

Hence option (d).

Ans: (d)

29. The normality of 0.3 M H_2SO_4 (complete neutralisation) is *[Easy]*

(a) 0.15 N (b) 0.3 N (c) 0.9 N (d) 0.6 N

Formula used: N = M × n_f. **Solution:**

Given: 0.3 M H_2SO_4; complete neutralisation releases both H^+.

Step 1: n-factor of H_2SO_4 = 2.

Step 2: Normality = molarity × n-factor = 0.3 × 2 = 0.6 N.

Hence option (d).

Ans: (d)

30. The volume (in mL) of 0.1 N $KMnO_4$ required to react completely with 25 mL of 0.2 N oxalic acid is _____. *[Medium]*

Formula used: Law of equivalence: $N_1V_1 = N_2V_2$. **Solution:**

Given: N_1 = 0.1 N ($KMnO_4$); N_2 = 0.2 N (oxalic acid); V_2 = 25 mL.

Concept: law of equivalence — at the end point, equivalents of oxidant = equivalents of reductant: $N_1V_1 = N_2V_2$.

Step 1: $0.1 \times V_1 = 0.2 \times 25$.

Step 2: $V_1 = 5/0.1 = 50$ mL.

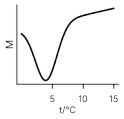
Hence 50 mL.

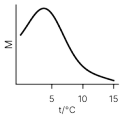
Ans: 50

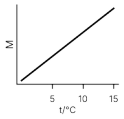
D. Previous Year Questions — JEE Main

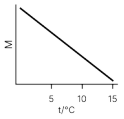
Basic Concepts and Significant Figures

1. x g of NaCl is dissolved in water in a beaker with a lid, and the temperature is raised from 1 °C to 25 °C (solubility of NaCl unchanged). Which plot best shows the molarity (M) of the solution against temperature? *JEE Main (2 Apr 2025 Shift 2)* | *Hard*

(a) 

(b) 

(c) 

(d) 

Formula used: M = n/V; water is densest at 4 °C.
Solution:

Given: the amount of NaCl (x g) and the mass of water stay fixed (lid prevents evaporation); only temperature changes from 1 °C to 25 °C.

Formula: Molarity M = moles of solute/volume of solution (L). Moles are constant, so M ∝ 1/V.

Step 1 (1 °C → 4 °C): water contracts and is densest at 4 °C, so the volume decreases and M increases, reaching a maximum at 4 °C.

Step 2 (4 °C → 25 °C): water expands, the volume increases and M decreases steadily.

Step 3: So the graph rises to a maximum at 4 °C and then falls — the shape shown in option (b).

Hence option (b).

Ans: (b)

2. Choose the correct statements. (A) Weight of a substance is the amount of matter present in it. (B) Mass is the force exerted by gravity on an object. (C) Volume is the amount of space occupied by a substance. (D) Temperatures below 0 °C are possible on the Celsius scale, but negative temperature is not possible on the Kelvin scale. (E) Precision refers to the closeness of various measurements for the same quantity. *JEE Main (29 Jan 2025 Shift 1)* | *Easy*

(a) (B), (C) and (D) only
(b) (C), (D) and (E) only
(c) (A), (B) and (C) only
(d) (A), (D) and (E) only

Formula used: Definitions of mass, weight, volume, temperature scales and precision.
Solution:

(A) False: the amount of matter present is mass, not weight.

(B) False: the force exerted by gravity on an object is weight, not mass. (A) and (B) have the two definitions interchanged.

(C) True: volume is the space occupied by a substance.

(D) True: Celsius temperatures below 0 °C exist, but 0 K is absolute zero, so negative Kelvin temperatures are not possible.

(E) True: precision is the closeness of repeated measurements of the same quantity to one another.

Correct statements: (C), (D) and (E). Hence option (b). **Ans: (b)**

3. If a substance A dissolves in a mixture of B and C with moles n_A, n_B and n_C, the mole fraction of C is *JEE Main (30 Jan 2024 Shift 2)* | *Easy*

(a) $n_C/(n_A - n_B - n_C)$ (b) $n_C/(n_A + n_B + n_C)$
(c) $n_C/(n_A n_B n_C)$ (d) $n_B/(n_A + n_B)$

Formula used: x = moles of component/total moles. **Solution:**

Concept: mole fraction of a component = its moles/- total moles of all components in the solution.

Step 1: Total moles = $n_A + n_B + n_C$.

Step 2: $x_C = n_C/(n_A + n_B + n_C)$.

Option (a) subtracts moles, (c) multiplies them and (d) is the mole fraction of B in a two-component mixture, so all are wrong.

Hence option (b).

Ans: (b)

4. The quantity that changes with temperature is *JEE Main (27 Jan 2024 Shift 2)* | *Easy*

(a) molality (b) mole fraction
(c) mass percentage (d) molarity

Formula used: Volume depends on T. **Solution:**

Concept: volume changes with temperature, mass does not.

Molality (mol per kg solvent), mole fraction (mol/mol) and mass percentage (g/g) use only masses or moles → temperature independent.

Molarity = mol/L of solution; the volume changes with temperature, so molarity changes.

Hence option (d).

Ans: (d)

5. Which of the following have the same number of significant figures? A. 0.00253; B. 1.0003; C. 15.0; D. 163 *JEE Main (8 Apr 2023 Shift 2)* | *Easy*

(a) B and C only (b) C and D only

(c) A, C and D only (d) A, B and C only

Formula used: Leading zeros are not significant; trailing zeros after a decimal point are. **Solution:**

A. 0.00253: leading zeros are not significant → digits 2, 5, 3 → 3 significant figures.

B. 1.0003: zeros between non-zero digits are significant → 1, 0, 0, 0, 3 → 5 significant figures.

C. 15.0: the trailing zero after the decimal point is significant → 3 significant figures.

D. 163: all non-zero digits → 3 significant figures.

A, C and D each have 3. Hence option (c).

Ans: (c)

6. Using the rules for significant figures, the answer for (0.02858 × 0.112)/0.5702 is *JEE Main (29 Jun 2022 Shift 2)* | *Easy*

(a) 0.005613 (b) 0.00561 (c) 0.0056 (d) 0.006

Formula used: Result has the fewest significant figures of the data (3). **Solution:**

Given: 0.02858 (4 s.f.), 0.112 (3 s.f.), 0.5702 (4 s.f.). **Rule:** in multiplication/division the result has as many significant figures as the least precise number (3 s.f. from 0.112).

Step 1: 0.02858 × 0.112 = 0.003201.

Step 2: 0.003201/0.5702 = 0.0056138.

Step 3: Round to 3 significant figures → 0.00561.

Hence option (b).

Ans: (b)

7. The number of significant figures in 0.00340 is _____. *JEE Main (25 Jul 2021 Shift 2)* | *Easy*

Formula used: Zeros before 3 are not significant; the final zero is. **Solution:**

Leading zeros (0.00) only fix the decimal point → not significant.

Non-zero digits 3 and 4 are significant.

The final 0 is a trailing zero after the decimal point → significant.

Total = 3 significant figures. Hence 3.

Ans: 3

8. The number of significant figures in 50000.020 × 10^{-3} is _____. *JEE Main (26 Feb 2021 Shift 1)* | *Medium*

Formula used: All zeros between non-zero digits and trailing zeros after the decimal count.

Solution:

Concept: the power of ten does not affect the count; count digits of 50000.020 only.

The first digit 5 is significant; zeros between non-zero digits (0000.0) are significant; the trailing zero after the decimal point is significant.

Digits: 5, 0, 0, 0, 0, 0, 2, 0 → 8 significant figures.

Hence 8.

Ans: 8

Laws of Chemical Combination and Dalton's Atomic Theory

9. The incorrect postulates of Dalton's atomic theory are: (A) atoms of different elements differ in mass; (B) matter consists of divisible atoms; (C) compounds form when atoms combine in a fixed ratio; (D) all atoms of an element have different properties including mass; (E) chemical reactions involve reorganisation of atoms. *JEE Main (5 Apr 2024 Shift 1)* | *Easy*

(a) (A), (B), (D) only (b) (B), (D) only

(c) (C), (D), (E) only (d) (B), (D), (E) only

Formula used: Compare with the postulates.

Solution:

Dalton's postulates: matter consists of indivisible atoms; atoms of an element are identical in all respects including mass; atoms of different elements differ in mass; compounds form when atoms combine in a fixed ratio; reactions involve reorganisation of atoms (atoms are neither created nor destroyed).

(A) Correct postulate.

(B) Incorrect: Dalton said atoms are indivisible, not divisible.

(C) Correct postulate.

(D) Incorrect: Dalton said all atoms of an element have identical properties including mass.

(E) Correct postulate.

Incorrect ones: (B) and (D). Hence option (b).

Ans: (b)

10. The incorrect statement about Dalton's atomic theory is *JEE Main (4 Apr 2024 Shift 2)* | *Easy*

(a) Chemical reactions involve reorganisation of atoms.

(b) Matter consists of indivisible atoms.

(c) Compounds are formed when atoms of different elements combine in any ratio.

(d) All atoms of a given element have identical properties including identical mass.

Formula used: Dalton: fixed ratio of atoms.
Solution: Dalton stated that compounds form when atoms of different elements combine in a fixed (simple wholenumber) ratio.

Option (c) says "in any ratio", which contradicts the law of definite proportions and Dalton's theory.

Options (a), (b) and (d) are genuine postulates.

Hence option (c).

Ans: (c)

11. The statement NOT proposed by Dalton was *JEE Main (7 Jan 2020 Shift 1)* | *Easy*

(a) all atoms of a given element have identical properties including mass; atoms of different elements differ in mass

(b) matter consists of indivisible atoms

(c) gases combine or are produced in a simple ratio by volume at the same T and P

(d) chemical reactions involve reorganisation of atoms, which are neither created nor destroyed

Formula used: This is Gay-Lussac's law.
Solution: Options (a), (b) and (d) are Dalton's postulates.

Option (c), that gases combine or are produced in a simple ratio by volume, is Gay-Lussac's law of gaseous volumes (1808), not Dalton's.

Hence option (c).

Ans: (c)

Mole Concept, Composition, Empirical and Molecular Formulae

12. Match the mass of substance (List-I) with the number of atoms (List-II): A. 1.8 mg water; B. 9.8 mg sulphuric acid; C. 1.8 mg carbon; D. 5.85 mg NaCl. I. $2 \times 10^{-4} N_A$; II. $1.5 \times 10^{-4} N_A$; III. $3 \times 10^{-4} N_A$; IV. $7 \times 10^{-4} N_A$ *JEE Main (8 Apr 2026 Shift 2)* | *Medium*

(a) A-IV, B-III, C-I, D-II

(b) A-III, B-II, C-IV, D-I

(c) A-III, B-IV, C-II, D-I

(d) A-III, B-IV, C-I, D-II

Formula used: Atoms = (mass/M) × atomicity × N_A. **Solution:**

Method: moles = mass/molar mass; atoms = moles × atoms per formula unit × N_A.

A. 1.8 mg H_2O: $1.8 \times 10^{-3}/18 = 10^{-4}$ mol; 3 atoms each → 3×10^{-4} N_A (III).

B. 9.8 mg H_2SO_4: $9.8 \times 10^{-3}/98 = 10^{-4}$ mol; 7 atoms each → 7×10^{-4} N_A (IV).

C. 1.8 mg C: $1.8 \times 10^{-3}/12 = 1.5 \times 10^{-4}$ mol of atoms → 1.5×10^{-4} N_A (II).

D. 5.85 mg NaCl: $5.85 \times 10^{-3}/58.5 = 10^{-4}$ mol; 2 ions (Na^+, Cl^-) each → 2×10^{-4} N_A (I).

Match: A-III, B-IV, C-II, D-I. Hence option (c).

Ans: (c)

13. An oxide of iron contains 69.9% iron. Its empirical formula is (Fe = 56, O = 16) *JEE Main (6 Apr 2026 Shift 1)* | *Easy*

(a) FeO (b) Fe_2O_3 (c) Fe_3O_4 (d) FeO_3

Formula used: Empirical formula from the simplest mole ratio. **Solution:**

Given: Fe 69.9%, so O = 100 − 69.9 = 30.1%. Take 100 g.

Step 1: Moles — Fe: 69.9/56 = 1.248; O: 30.1/16 = 1.881.

Step 2: Divide by smaller: Fe 1, O 1.881/1.248 = 1.507 ≈ 1.5.

Step 3: Multiply by 2 for whole numbers: Fe 2, O 3 → Fe_2O_3.

Hence option (b).

Ans: (b)

14. Which of the following contain the same number of atoms? A. 2 g of O_2 gas; B. 4 g of SO_2 gas; C. 1400 mL of O_2 at STP; D. 0.05 L of He at STP; E. 0.0625 mol of H_2 gas *JEE Main (6 Apr 2026 Shift 2)* | *Medium*

(a) A and B only (b) B and C only
(c) C and D only (d) A, C and E only

Formula used: Moles of atoms = moles of molecules × atomicity. **Solution:**

Compare moles of atoms in each sample (molar volume at STP = 22.4 L).

A. 2 g O_2: 2/32 = 0.0625 mol molecules × 2 = 0.125 mol atoms.

B. 4 g SO_2: 4/64 = 0.0625 mol × 3 = 0.1875 mol atoms. C. 1400 mL O_2: 1.4/22.4 = 0.0625 mol × 2 = 0.125 mol atoms.

D. 0.05 L He: 0.05/22.4 = 0.00223 mol atoms (monoatomic).

E. 0.0625 mol H_2 × 2 = 0.125 mol atoms.

A, C and E each have 0.125 mol atoms. Hence option (d).

Ans: (d)

15. The number of moles and number of molecules in 1.4187 L of SO_2 at STP are respectively *JEE Main (4 Apr 2026 Shift 1)* | *Easy*

(a) 0.1266; 3.812×10^{22} (b) 0.0633; 3.812×10^{22}
(c) 0.1266; 7.6238×10^{22} (d) 0.0633; 7.6238×10^{22}

Formula used: n = V/22.4 L; N = n × N_A.
Solution: Given: V(SO_2) = 1.4187 L at STP (22.4 L mol^{-1}).

Step 1: n = 1.4187/22.4 = 0.0633 mol.

Step 2: Molecules = $0.0633 \times 6.022 \times 10^{23} = 3.812 \times 10^{22}$ (each SO_2 molecule is one molecule; 7.62×10^{22}would be the number of O atoms).

Hence option (b).

Ans: (b)

16. The correct order of total number of atoms present in (A) 2 moles of cyclohexane, (B) 684 g of sucrose, (C) 90.8 L of dihydrogen at STP is *JEE Main (4 Apr 2026 Shift 2)* | *Medium*

(a) C > A > B (b) C > B > A
(c) B > C > A (d) B > A > C

Formula used: Moles of atoms = moles × atomicity; n(gas) = V/22.7 L. **Solution:**

A. Cyclohexane C_6H_{12} has 6 + 12 = 18 atoms per molecule: 2 × 18 = 36 mol atoms.

B. Sucrose $C_{12}H_{22}O_{11}$: M = 342; 684/342 = 2 mol; atoms per molecule = 12 + 22 + 11 = 45 → 90 mol atoms. C. H_2: 90.8/22.7 = 4 mol molecules × 2 = 8 mol atoms. Order: B (90) > A (36) > C (8). Hence option (d).

Ans: (d)

17. Among 10^{-9} g (each) of the elements Pb, Po, Pr and Pt, which has the highest number of atoms? *JEE Main (3 Apr 2025 Shift 1)* | *Easy*

(a) Pr (b) Pb (c) Pt (d) Po

Formula used: For equal mass, number of atoms ∝ 1/atomic mass. **Solution:**

Concept: for equal masses, number of atoms = (m/atomic mass) × N_A, so the element with the smallest atomic mass has the most atoms.

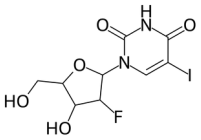
Atomic masses: Pr 140.9, Pt 195.1, Pb 207.2, Po ≈ 209.

Pr has the smallest atomic mass → highest number of atoms.

Hence option (a).

Ans: (a)

18. 0.1 mol of the antiviral compound P shown below weighs _____ × 10^{-1} g (H 1, C 12, N 14, O 16, F 19, I 127). *JEE Main (2 Apr 2025 Shift 1)* | *Medium*



Formula used: Count atoms: $C_9H_{10}FIN_2O_5$.
Solution:

Step 1: From the structure in the paper, the molar mass of P is 372 g mol^{-1} (sum of atomic masses of all its C, H, N, O, F and I atoms).

Step 2: Mass of 0.1 mol = 0.1 × 372 = 37.2 g = 372×10^{-1} g.

Hence 372.

Ans: 372

19. Compound X has C 14.5%, Cl 64.46%, H 1.8% (rest O). Its empirical formula mass is _____ × 10^{-1} (C 12, H 1, O 16, Cl 35.5). *JEE Main (28 Jan 2025 Shift 1)* | *Medium*

Formula used: Mole ratio. **Solution:**

Given: C 14.5%, Cl 64.46%, H 1.8%; O = 100 − 80.76 = 19.24%.

Step 1: Moles — C: 14.5/12 = 1.208; Cl: 64.46/35.5 = 1.816; H: 1.8/1 = 1.8; O: 19.24/16 = 1.203.

Step 2: Divide by smallest (1.203): C 1.0, Cl 1.5, H 1.5, O 1.0.

Step 3: Multiply by 2: $C_2H_3Cl_3O_2$.

Step 4: EF mass = 2(12) + 3(1) + 3(35.5) + 2(16) = 24 + 3 + 106.5 + 32 = 165.5 = 1655 × 10^{-1}.

Hence 1655.

Ans: 1655

20. A compound contains 54.2% C, 9.2% H and 36.6% O. If its molar mass is 132 g mol^{-1}, the molecular formula is *JEE Main (24 Jan 2025 Shift 2)* | *Medium*

(a) $C_6H_{12}O_3$ (b) $C_4H_8O_2$ (c) $C_4H_9O_3$ (d) $C_6H_{12}O_6$

Formula used: Empirical formula, then n = M/EF mass. **Solution:**

Step 1: Moles in 100 g — C: 54.2/12 = 4.52; H: 9.2/1 = 9.2; O: 36.6/16 = 2.29.

Step 2: Divide by 2.29: C 1.97 ≈ 2; H 4.02 ≈ 4; O 1 → EF C_2H_4O (mass 44).

Step 3: n = 132/44 = 3.

Step 4: Molecular formula = $(C_2H_4O)_3 = C_6H_{12}O_3$.

Hence option (a).

Ans: (a)

21. 2.8×10^{-3} mol of CO_2 is left after removing 10^{21} molecules from its x mg sample. The mass of CO_2 taken initially is ($N_A = 6.02 \times 10^{23}$) *JEE Main (23 Jan 2025 Shift 1)* | *Medium*

(a) 48.2 mg (b) 98.3 mg (c) 150.4 mg (d) 196.2 mg

Formula used: n = N/N_A; m = n × M. **Solution:**

Given: molecules removed = 10^{21}; moles left = 2.8 × 10^{-3} mol; N_A = 6.02 × 10^{23}.

Step 1: Moles removed = 10^{21}/(6.02 × 10^{23}) = 1.661 × 10^{-3} mol.

Step 2: Initial moles = 2.8 × 10^{-3} + 1.661 × 10^{-3} = 4.461 × 10^{-3} mol.

Step 3: Initial mass = 4.461 × 10^{-3} × 44 = 0.1963 g = 196.3 mg ≈ 196.2 mg.

Hence option (d).

Ans: (d)

22. An organic compound has 42.1% carbon, 6.4% hydrogen and the rest oxygen. If its molecular weight is 342, its molecular formula is *JEE Main (5 Apr 2024 Shift 1)* | *Medium*

(a) $C_{11}H_{18}O_{12}$ (b) $C_{12}H_{20}O_{12}$

(c) $C_{12}H_{22}O_{11}$ (d) $C_{14}H_{20}O_{10}$

Formula used: Mole ratio; check molar mass. **Solution:**

Given: C 42.1%, H 6.4%, O = 51.5%; molecular weight 342.

Step 1: Moles — C: 42.1/12 = 3.51; H: 6.4/1 = 6.4; O: 51.5/16 = 3.22.

Step 2: Atoms in one molecule = (% × M)/(100 × atomic mass): C = 42.1 × 342/1200 = 12.0; H = 6.4 × 342/100 = 21.9 ≈ 22; O = 51.5 × 342/1600 = 11.0.

Step 3: Formula $C_{12}H_{22}O_{11}$. Check: 144 + 22 + 176 = 342.

Hence option (c).

Ans: (c)

23. A metal chloride contains 55.0% chlorine by weight. 100 mL vapours of the metal chloride at STP weigh 0.57 g. Its molecular formula is (Cl = 35.5) *JEE Main (12 Apr 2023 Shift 1)* | *Medium*

(a) MCl_4 (b) MCl_3 (c) MCl_2 (d) MCl

Formula used: M = mass × 22400/V (mL). **Solution: Given:** 100 mL vapour at STP weighs 0.57 g; Cl = 55.0% by mass.

Step 1: Molar mass = 0.57 × 22400/100 = 127.7 g mol^{-1}.

Step 2: Mass of Cl per mole = 0.55 × 127.7 = 70.2 g. **Step 3:** Number of Cl atoms = 70.2/35.5 ≈ 2.

Hence the formula is MCl_2, option (c).

Ans: (c)

24. A solution is prepared by adding 2 g of 'X' to 1 mole of water. The mass percent of X in the solution is *JEE Main (11 Apr 2023 Shift 2)* | *Easy*

(a) 5% (b) 20% (c) 2% (d) 10%

Formula used: Mass % = mass of solute / mass of solution × 100. **Solution:**

Given: mass of X = 2 g; 1 mole of water = 18 g.

Step 1: Mass of solution = 2 + 18 = 20 g.

Step 2: Mass % of X = (2/20) × 100 = 10%.

Hence option (d).

Ans: (d)

25. A sugar solution is obtained by mixing 200 g of its 25% solution and 500 g of its 40% solution (both by mass). The mass percentage of the resulting solution is _____ (nearest integer). *JEE Main (11 Apr 2023 Shift 1)* | *Easy*

Formula used: Total solute / total solution × 100. **Solution:**

Given: 200 g of 25% solution and 500 g of 40% solution (w/w).

Step 1: Sugar in first = 0.25 × 200 = 50 g; in second = 0.40 × 500 = 200 g.

Step 2: Total sugar = 250 g; total solution = 200 + 500 = 700 g.

Step 3: Mass % = (250/700) × 100 = 35.7% ≈ 36.

Hence 36.

Ans: 36

26. The number of molecules and moles in 2.8375 L of O_2 at STP are respectively *JEE Main (10 Apr 2023 Shift 1)* | *Easy*

(a) 7.527×10^{23} and 0.125 mol

(b) 7.527×10^{22} and 0.250 mol

(c) 1.505×10^{23} and 0.250 mol

(d) 7.527×10^{22} and 0.125 mol

Formula used: n = V/22.7 L; N = n × N_A. **Solution: Given:** V = 2.8375 L at STP (molar volume 22.7 L mol^{-1}).

Step 1: n = 2.8375/22.7 = 0.125 mol.

Step 2: Molecules = $0.125 \times 6.022 \times 10^{23} = 7.527 \times 10^{22}$.

Hence option (d).

Ans: (d)

27. Match: A. 16 g CH_4(g); B. 1 g H_2(g); C. 1 mol N_2(g); D. 0.5 mol SO_2(g) with I. weighs 28 g; II. 60.2×10^{23} electrons; III. weighs 32 g; IV. occupies 11.4 L at STP. *JEE Main (10 Apr 2023 Shift 2)* | *Easy*

(a) A-II, B-III, C-IV, D-I

(b) A-I, B-III, C-II, D-IV

(c) A-II, B-IV, C-III, D-I

(d) A-II, B-IV, C-I, D-III

Formula used: Moles, electrons, mass, volume. **Solution:**

A. 16 g CH_4 = 1 mol; electrons per molecule = 6 + 4 = 10 → 10 mol e^- = 60.2×10^{23} electrons (II).

B. 1 g H_2 = 0.5 mol → volume at STP = 0.5 × 22.7 ≈ 11.4 L (IV).

C. 1 mol N_2 weighs 28 g (I).

D. 0.5 mol SO_2 weighs 0.5 × 64 = 32 g (III).

Match: A-II, B-IV, C-I, D-III. Hence option (d).

Ans: (d)

28. 0.5 g of an organic compound with 60% carbon produces _____ × 10^{-1} g of CO_2 on complete combustion. *JEE Main (8 Apr 2023 Shift 1)* | *Easy*

Formula used: C → CO_2. **Solution:**

Given: mass of compound = 0.5 g; C = 60%.

Step 1: Mass of carbon = 0.60 × 0.5 = 0.3 g = 0.3/12 = 0.025 mol.

Step 2: Each C atom gives one CO_2 → 0.025 mol CO_2 = 0.025 × 44 = 1.1 g = 11×10^{-1} g.

Hence 11.

Ans: 11

29. A hydrocarbon A on complete combustion requires 11 equivalents of oxygen and produces 4 equivalents of water. The molecular formula of A is *JEE Main (31 Jan 2023 Shift 2)* | *Medium*

(a) $C_{11}H_8$ (b) $C_{11}H_4$ (c) C_5H_8 (d) C_9H_8

Formula used: C_xH_y needs (x + y/4) O_2 and gives y/2 H_2O. **Solution:**

General equation: $C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$.

Step 1: Water formed = y/2 = 4 → y = 8.

Step 2: O_2 needed = x + y/4 = 11 → x + 2 = 11 → x = 9.

Formula: C_9H_8. Hence option (d).

Ans: (d)

30. A hydrocarbon A requires 9.5 equivalents of oxygen for combustion and produces 3 equivalents of water. The molecular formula of A is *JEE Main (29 Jan 2023 Shift 2)* | *Medium*

(a) C_8H_6 (b) C_9H_9 (c) C_6H_6 (d) C_9H_6

Formula used: C_xH_y needs (x + y/4) O_2 and gives y/2 H_2O. **Solution:**

General equation: $C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$.

Step 1: y/2 = 3 → y = 6.

Step 2: x + y/4 = 9.5 → x + 1.5 = 9.5 → x = 8.

Formula: C_8H_6. Hence option (a).

Ans: (a)

31. The number of hydrogen atoms per molecule of a hydrocarbon A (85.8% C, M = 84 g mol^{-1}) is _____. *JEE Main (25 Jan 2023 Shift 2)* | *Easy*

Formula used: Mass of C = 72. **Solution:**

Given: C = 85.8%, so H = 14.2%; M = 84 g mol^{-1}.

Step 1: Mass of C per mole = 0.858 × 84 = 72 g → 72/12 = 6 C atoms.

Step 2: Mass of H per mole = 84 − 72 = 12 g → 12 H atoms (C_6H_{12}).

Hence 12.

Ans: 12

32. 0.492 g of an organic compound (C, H, O) gave 0.7938 g CO_2 and 0.4428 g H_2O. The percentage of oxygen is _____ (nearest integer). *JEE Main (28 Jul 2022 Shift 2)* | *Medium*

Formula used: C = 12/44 of CO_2; H = 2/18 of H_2O. **Solution:**

Step 1: Mass of C = (12/44) × 0.7938 = 0.2165 g.

Step 2: Mass of H = (2/18) × 0.4428 = 0.0492 g.

Step 3: Mass of O = 0.492 − (0.2165 + 0.0492) = 0.2263 g.

Step 4: %O = (0.2263/0.492) × 100 = 46.0%.

Hence 46.

Ans: 46

33. Haemoglobin contains 0.34% of iron by mass. The number of Fe atoms in 3.3 g of haemoglobin is (Fe = 56 u, N_A = 6.022 × 10^{23} mol^{-1}) *JEE Main (26 Jul 2022 Shift 2)* | *Easy*

(a) 1.21 × 10^5 (b) 12.0 × 10^{16}

(c) 1.21 × 10^{20} (d) 3.4 × 10^{22}

Formula used: N = (m/M) × N_A. **Solution:**

Step 1: Mass of Fe in 3.3 g = 0.0034 × 3.3 = 0.01122 g.

Step 2: Moles of Fe = 0.01122/56 = 2.0 × 10^{-4} mol. **Step 3:** Atoms = 2.0 × 10^{-4} × 6.022 × 10^{23} = 1.21 × 10^{20}.

Hence option (c).

Ans: (c)

34. Compound A contains 8.7% H, 74% C and 17.3% N; its molar mass is 162 g mol^{-1}. Its molecular formula is *JEE Main (28 Jun 2022 Shift 2)* | *Easy*

(a) $C_4H_6N_2$ (b) C_2H_3N (c) C_5H_7N (d) $C_{10}H_{14}N_2$

Formula used: Mole ratio → empirical formula → n = M/EF mass. **Solution:**

Step 1: Moles in 100 g — C: 74/12 = 6.17; H: 8.7/1 = 8.7; N: 17.3/14 = 1.24.

Step 2: Divide by 1.24: C 4.98 ≈ 5; H 7.0; N 1 → EF C_5H_7N (mass 60 + 7 + 14 = 81).

Step 3: n = 162/81 = 2 → $C_{10}H_{14}N_2$ (nicotine).

Hence option (d).

Ans: (d)

35. In the estimation of bromine, 0.5 g of an organic compound gave 0.40 g of AgBr. The percentage of bromine is _____ (Ag 108, Br 80). *JEE Main (28 Jun 2022 Shift 1)* | *Easy*

Formula used: % Br = (80/188) × mass AgBr/mass × 100. **Solution:**

Given: mass of compound = 0.5 g; mass of AgBr = 0.40 g; M(AgBr) = 108 + 80 = 188.

Formula (Carius): %Br = (80/188) × (mass of AgBr/- mass of compound) × 100.

Step 1: %Br = (80/188) × (0.40/0.5) × 100 = 0.4255 × 0.8 × 100 = 34.0%.

Hence 34.

Ans: 34

36. Elements A and B form 0.15 mol each of A_2B and AB_3, which weigh equally. The atomic weight of A is _____ times that of B. *JEE Main (27 Jun 2022 Shift 1)* | *Easy*

Formula used: Equal molar masses. **Solution:**

Let the atomic masses be A and B.

Step 1: Mass of 0.15 mol A_2B = 0.15(2A + B); mass of 0.15 mol AB_3 = 0.15(A + 3B).

Step 2: Equal masses: 2A + B = A + 3B → A = 2B. Hence the atomic weight of A is 2 times that of B.

Ans: 2

37. The number of N atoms in 681 g of $C_7H_5N_3O_6$ is x × 10^{21} (N_A = 6.02 × 10^{23}). x = _____ (nearest integer). *JEE Main (25 Jun 2022 Shift 2)* | *Easy*

Formula used: M = 227. **Solution:**

Step 1: M($C_7H_5N_3O_6$) = 7(12) + 5(1) + 3(14) + 6(16) = 84 + 5 + 42 + 96 = 227 g mol^{-1} (TNT).

Step 2: Moles = 681/227 = 3 mol.

Step 3: N atoms = 3 × 3 = 9 mol = 9 × 6.02 × 10^{23} = 5.418 × 10^{24} = 5418 × 10^{21}.

Hence x = 5418.

Ans: 5418

38. Protein A contains 0.30% glycine (M = 75). Its minimum molecular weight is _____ × 10^3 g mol^{-1}. *JEE Main (25 Jun 2022 Shift 2)* | *Easy*

Formula used: At least one glycine unit.

Solution: Concept: minimum molecular weight corresponds to one glycine unit per molecule.

Step 1: 75 g is 0.30% of M → M = 75/0.0030 = 25 000 g mol^{-1}.

Step 2: 25 000 = 25 × 10^3.

Hence 25.

Ans: 25

39. The number of atoms in 8 g of sodium is x × 10^{23} (Na = 23.0). x = _____ (nearest integer). *JEE Main (1 Sep 2021 Shift 2)* | *Easy*

Formula used: n × N_A. **Solution:**

Step 1: Moles of Na = 8/23 = 0.348 mol.

Step 2: Atoms = 0.348 × 6.02 × 10^{23} = 2.09 × 10^{23}. Hence x ≈ 2.

Ans: 2

40. The average molar mass of chlorine is 35.5 g mol^{-1}. The ratio of ^{35}Cl to ^{37}Cl in natural chlorine is close to *JEE Main (6 Sep 2020 Shift 2)* | *Easy*

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

Formula used: Weighted average. **Solution:**

Let fraction of ^{35}Cl = x; then ^{37}Cl = 1 − x.

Step 1: 35x + 37(1 − x) = 35.5.

Step 2: 37 − 2x = 35.5 → x = 0.75; ^{37}Cl = 0.25.

Step 3: Ratio ^{35}Cl : ^{37}Cl = 0.75 : 0.25 = 3 : 1.

Hence option (b).

Ans: (b)

41. 5 moles of AB_2 weigh 125 × 10^{-3} kg and 10 moles of A_2B_2 weigh 300 × 10^{-3} kg. The molar masses of A and B (kg mol^{-1}) are *JEE Main (12 Apr 2019 Shift 1)* | *Medium*

(a) M_A = 25 × 10^{-3}, M_B = 50 × 10^{-3}

(b) M_A = 5 × 10^{-3}, M_B = 10 × 10^{-3}

(c) M_A = 10 × 10^{-3}, M_B = 5 × 10^{-3}

(d) M_A = 50 × 10^{-3}, M_B = 25 × 10^{-3}

Formula used: Set up two equations. **Solution:**

Step 1: Molar mass of AB_2 = 125 × 10^{-3}/5 = 25 × 10^{-3}kg mol^{-1} → M_A + 2M_B = 25 × 10^{-3}.

Step 2: Molar mass of A_2B_2 = 300 × 10^{-3}/10 = 30 × 10^{-3} kg mol^{-1} → 2M_A + 2M_B = 30 × 10^{-3}.

Step 3: Subtract: M_A = 5 × 10^{-3} kg mol^{-1}.

Step 4: 2M_B = 25 × 10^{-3} − 5 × 10^{-3} → M_B = 10 × 10^{-3}kg mol^{-1}.

Hence option (b).

Ans: (b)

42. The percentage composition of carbon by mole in methane is *JEE Main (8 Apr 2019 Shift 2)* | *Easy*

(a) 80% (b) 25% (c) 75% (d) 20%

Formula used: Mole % of atoms. **Solution:**

Concept: "by mole" means the fraction of atoms (moles of atoms), not mass.

Step 1: One CH_4 has 1 C and 4 H = 5 atoms.

Step 2: Mole % of C = (1/5) × 100 = 20% (by mass it would be 75%).

Hence option (d).

Ans: (d)

43. The mass ratio of C and H in a compound $CxHyOz$ is 6 : 1. One molecule contains half as much oxygen as needed to burn one molecule of $CxHy$ completely. The empirical formula of $CxHyOz$ is *JEE Main (2018)* | *Medium*

(a) $C_3H_6O_3$ (b) C_2H_4O (c) $C_3H_4O_2$ (d) $C_2H_4O_3$

Formula used: 12x : y = 6 : 1 → y = 2x; CxHy needs (x + y/4) O_2. **Solution:**

Step 1: C : H mass = 6 : 1 → mole ratio = 6/12 : 1/1 = 1 : 2, so y = 2x.

Step 2: Combustion of C_xH_y needs (x + y/4) O_2 = x + x/2 = 1.5x molecules of O_2 = 3x oxygen atoms.

Step 3: The compound contains half of this: z = 1.5x. **Step 4:** Smallest whole numbers: x = 2, y = 4, z = 3 → $C_2H_4O_3$.

Hence option (d).

Ans: (d)

44. A chlorohydrocarbon has 3.55% Cl and one Cl atom per molecule. The number of Cl atoms in 1 g of it is (Cl = 35.5 u) *JEE Main (Online 2018)* | *Easy*

(a) 6.023×10^{21} (b) 6.023×10^{23}

(c) 6.023×10^{20} (d) 6.023×10^{9}

Formula used: M = 35.5/0.0355 = 1000. **Solution: Step 1:** One Cl (35.5 g) is 3.55% of the molar mass: M = 35.5/0.0355 = 1000 g mol^{-1}.

Step 2: 1 g = 10^{-3} mol of compound = 10^{-3} mol of Cl atoms.

Step 3: Cl atoms = $10^{-3} \times 6.023 \times 10^{23} = 6.023 \times 10^{20}$. Hence option (c).

Ans: (c)

45. A 75 kg person contains 10.0% hydrogen by mass. The mass gained if all ^1H atoms are replaced by ^2H atoms is *JEE Main (2017)* | *Easy*

(a) 7.5 kg (b) 10 kg (c) 15 kg (d) 37.5 kg

Formula used: Mass of H doubles. **Solution:**

Step 1: Mass of ^1H in the body = 0.10 × 75 = 7.5 kg. **Step 2:** Replacing ^1H (mass 1) by ^2H (mass 2) doubles this mass: 7.5 → 15 kg.

Step 3: Mass gained = 15 − 7.5 = 7.5 kg.

Hence option (a).

Ans: (a)

46. An organic compound of C, H and S contains 8% sulphur. Its minimum molecular weight is (S = 32) *JEE Main (Online 2016)* | *Easy*

(a) 600 g mol^{-1} (b) 200 g mol^{-1}

(c) 400 g mol^{-1} (d) 300 g mol^{-1}

Formula used: At least one S atom. **Solution:**

Concept: minimum molecular weight when the molecule has only one S atom.

Step 1: 32 g of S = 8% of M → M = 32/0.08 = 400 g mol^{-1}.

Hence option (c).

Ans: (c)

47. The mass ratio of oxygen to nitrogen in a gaseous mixture is 1 : 4. The ratio of their numbers of molecules is *JEE Main (2014)* | *Easy*

(a) 3 : 16 (b) 1 : 4 (c) 7 : 32 (d) 1 : 8

Formula used: n = m/M. **Solution:**

Take 1 g O_2 and 4 g N_2.

Step 1: Moles — O_2: 1/32; N_2: 4/28 = 1/7.

Step 2: Ratio of molecules = (1/32) : (1/7) = 7 : 32. Hence option (c).

Ans: (c)

48. The moles of $Mg_3(PO_4)_2$ containing 0.25 mol of oxygen atoms are *AIEEE (2006)* | *Easy*

(a) 0.02 (b) 3.125×10^{-2}

(c) 1.25×10^{-2} (d) 2.5×10^{-2}

Formula used: 8 O per formula unit. **Solution:**

Step 1: Oxygen atoms per formula unit = 2 × 4 = 8. **Step 2:** Moles of $Mg_3(PO_4)_2$ = 0.25/8 = 0.03125 = 3.125×10^{-2} mol.

Hence option (b).

Ans: (b)

49. If 1/6 (instead of 1/12) of the mass of a carbon atom is taken as the atomic mass unit, the mass of one mole of a substance will *AIEEE (2005)* | *Medium*

(a) decrease twice

(b) increase two-fold

(c) remain unchanged

(d) be a function of the molecular mass of the substance

Formula used: Mole is defined by 12 g of C-12. **Solution:**

Concept: the mole is a fixed number of particles (6.022×10^{23}); the actual mass of one mole of a substance does not depend on which unit is used to express atomic masses.

Changing the amu to 1/6 of a C-12 atom halves all relative atomic masses, but the mass of 6.022×10^{23} particles in grams is unchanged.

Hence the mass of one mole remains unchanged, option (c).

Ans: (c)

50. The number of atoms in 558.5 g Fe (Fe = 55.85) is *AIEEE (2002)* | *Easy*

(a) twice that in 60 g carbon

(b) 6.023×10^{22}

(c) half that in 8 g He

(d) $558.5 \times 6.023 \times 10^{23}$

Formula used: Compare moles. **Solution:**

Step 1: Moles of Fe = 558.5/55.85 = 10 mol.

Step 2: Compare: 60 g C = 60/12 = 5 mol, so Fe has twice the atoms in 60 g C → (a) is correct.

Check other options: (b) 10 mol gives 6.023×10^{24}, not 10^{22}; (c) 8 g He = 2 mol, half of which is 1 mol — not 10 mol; (d) multiplies mass, not moles.

Hence option (a).

Ans: (a)

Stoichiometry and Concentration Terms

51. The mass of residue obtained by heating 2.76 g of silver carbonate is (C = 12, O = 16, Ag = 108) *JEE Main (5 Apr 2026 Shift 1)* | *Medium*

(a) 1.08 g (b) 2.16 g (c) 3.24 g (d) 4.32 g

Formula used: $2Ag_2CO_3 \rightarrow 4Ag + 2CO_2 + O_2$ (residue is Ag). **Solution:**

Concept: on strong heating silver carbonate decomposes completely to silver metal: $2Ag_2CO_3 \rightarrow 4Ag + 2CO_2 + O_2$ (Ag_2O itself decomposes above 300 °C). **Step 1:** $M(Ag_2CO_3) = 2(108) + 12 + 48 = 276$ g mol^{-1}; n = 2.76/276 = 0.01 mol.

Step 2: Each Ag_2CO_3 gives 2 Ag → 0.02 mol Ag.

Step 3: Mass of residue = 0.02 × 108 = 2.16 g.

Hence option (b).

Ans: (b)

52. What volume of hydrogen at STP is liberated by the action of 50 mL of H_2SO_4 of 50% purity (density 1.3 g mL^{-1}) on 20 g of zinc? (H = 1, O = 16, S = 32, Zn = 65) *JEE Main (5 Apr 2026 Shift 2)* | *Hard*

(a) 5.824 L (b) 7.428 L (c) 6.892 L (d) 8.375 L

Formula used: $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$; limiting reagent; V = n × 22.4 L. **Solution:**

Reaction: $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ (1 : 1 : 1).

Step 1: Mass of solution = 50 × 1.3 = 65 g; pure H_2SO_4 = 0.5 × 65 = 32.5 g = 32.5/98 = 0.332 mol.

Step 2: Zn = 20/65 = 0.308 mol.

Step 3: Zn (0.308 < 0.332) is the limiting reagent → H_2 = 0.308 mol.

Step 4: Volume at STP = 0.308 × 22.4 = 6.89 L.

Hence option (c).

Ans: (c)

53. The mass of iron converted into Fe_3O_4 by the action of 18 g of steam is (H = 1, O = 16, Fe = 56; iron in excess) *JEE Main (2 Apr 2026 Shift 1)* | *Medium*

(a) 2.1 g (b) 4.2 g (c) 21 g (d) 42 g

Formula used: $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$. **Solution:** Reaction: $3Fe + 4H_2O(g) \rightarrow Fe_3O_4 + 4H_2$.

Step 1: Steam = 18/18 = 1 mol (iron in excess, so steam is limiting).

Step 2: Fe used = (3/4) × 1 = 0.75 mol.

Step 3: Mass of Fe = 0.75 × 56 = 42 g.

Hence option (d).

Ans: (d)

54. For $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$, 90 g $CaCO_3$ is added to 300 mL of HCl that is 38.55% HCl by mass with density 1.13 g mL^{-1}. Which is correct? (H = 1, Cl = 35.5, Ca = 40, O = 16) *JEE Main (28 Jan 2026 Shift 2)* | *Hard*

(a) 32.85 g of $CaCO_3$ remains unreacted

(b) 97.30 g of HCl reacted

(c) 64.97 g of HCl remains unreacted

(d) 60.32 g of HCl remains unreacted

Formula used: Purity and limiting reagent. **Solution: Step 1:** Mass of HCl solution = 300 × 1.13 = 339 g; HCl = 0.3855 × 339 = 130.68 g = 130.68/36.5 = 3.58 mol. **Step 2:** $CaCO_3$ = 90/100 = 0.9 mol; it needs 2 × 0.9 = 1.8 mol HCl = 65.7 g.

Step 3: HCl available (3.58 mol) > needed (1.8 mol), so $CaCO_3$ is limiting and is consumed completely → (a) wrong.

Step 4: HCl reacted = 65.7 g → (b) wrong; HCl left = 130.68 − 65.7 = 64.98 g ≈ 64.97 g → (c) correct, (d) wrong.

Hence option (c).

Ans: (c)

55. One mole of Cl_2 is passed into 2 L of cold 2 M KOH. After the reaction, the concentrations of Cl^-, ClO^- and OH^- are respectively (volume constant) *JEE Main (24 Jan 2026 Shift 2)* | *Medium*

(a) 1 M, 1 M, 1 M (b) 0.5 M, 0.5 M, 0.5 M

(c) 0.75 M, 0.75 M, 1 M (d) 0.5 M, 0.5 M, 1 M

Formula used: $Cl_2 + 2KOH$ (cold) → $KCl + KClO + H_2O$. **Solution:**

Reaction (cold, dilute alkali): $Cl_2 + 2KOH \rightarrow KCl + KClO + H_2O$.

Step 1: KOH taken = 2 × 2 = 4 mol.

Step 2: 1 mol Cl_2 consumes 2 mol KOH and gives 1 mol Cl^- and 1 mol ClO^-.

Step 3: OH^- left = 4 − 2 = 2 mol.

Step 4: In 2 L: $[Cl^-]$ = 0.5 M, $[ClO^-]$ = 0.5 M, $[OH^-]$ = 1 M.

Hence option (d).

Ans: (d)

56. In the reaction $2Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$, which statement is correct? *JEE Main (22 Jan 2026 Shift 1)* | *Medium*

(a) 67.2 L H_2 at STP is produced for every mole of Al

(b) 33.6 L H_2 is produced regardless of T and p for every mole of Al

(c) 12 L HCl(aq) is consumed for every 6 L H_2 produced

(d) 11.2 L H_2 at STP is produced for every mole of HCl consumed

Formula used: Mole ratio Al : HCl : H_2 = 2 : 6 : 3; 1 mol gas = 22.4 L at STP. **Solution:**

Mole ratio Al : HCl : H_2 = 2 : 6 : 3.

(a) 1 mol Al gives 1.5 mol H_2 = 1.5 × 22.4 = 33.6 L at STP, not 67.2 L → wrong.

(b) 33.6 L is true only at STP; gas volume depends on T and p → wrong.

(c) HCl is an aqueous solution, so its volume is not related to the gas volume of H_2 by Gay-Lussac's law → wrong.

(d) 1 mol HCl gives 3/6 = 0.5 mol H_2 = 11.2 L at STP → correct.

Hence option (d).

Ans: (d)

57. A + 2B → AB_2. 36.0 g of A (M = 60 g mol^{-1}) and 56.0 g of B (M = 80 g mol^{-1}) are allowed to react. Correct statements: A. A is the limiting reagent; B. 77.0 g of AB_2 is formed; C. Molar mass of AB_2 is 140 g mol^{-1}; D. 15.0 g of A is left unreacted. *JEE Main (22 Jan 2026 Shift 2)* | *Hard*

(a) A and B only (b) C and D only

(c) B and D only (d) A and C only

Formula used: Limiting reagent: smallest value of moles/coefficient. **Solution:**

Step 1: Moles — A: 36/60 = 0.6 mol; B: 56/80 = 0.7 mol.

Step 2: Divide by coefficients — A: 0.6/1 = 0.6; B: 0.7/2 = 0.35. B is limiting, so statement A is false.

Step 3: AB_2 formed = 0.35 mol; M(AB_2) = 60 + 2 × 80 = 220 g mol^{-1} (statement C false); mass = 0.35 × 220 = 77.0 g (B true).

Step 4: A used = 0.35 mol; left = 0.25 mol = 0.25 × 60 = 15.0 g (D true).

Correct: B and D. Hence option (c).

Ans: (c)

58. 14.0 g of calcium is allowed to react with excess HCl at 1.0 atm and 273 K. Which statement is incorrect? (Ca = 40, Cl = 35.5, H = 1) *JEE Main (21 Jan 2026 Shift 1)* | *Medium*

(a) 33.3 g of $CaCl_2$ is produced

(b) 0.35 mol of H_2 is evolved

(c) The limiting reagent is calcium

(d) 7.84 L of H_2 is evolved

Formula used: $Ca + 2HCl \rightarrow CaCl_2 + H_2$. **Solution:** Reaction: $Ca + 2HCl \rightarrow CaCl_2 + H_2$.

Step 1: Ca = 14.0/40 = 0.35 mol; HCl is in excess, so Ca is limiting (c true).

Step 2: H_2 = 0.35 mol (b true); volume at 273 K and 1 atm = 0.35 × 22.4 = 7.84 L (d true).

Step 3: $CaCl_2$ = 0.35 mol × 111 = 38.85 g, not 33.3 g → (a) is incorrect.

Hence option (a).

Ans: (a)

59. 80 mL of a hydrocarbon mixed with 264 mL of oxygen in a closed U-tube undergoes complete combustion. The residual gases after cooling to 273 K occupy 224 mL. On treatment with KOH solution the volume decreases to 64 mL. The formula of the hydrocarbon is *JEE Main (21 Jan 2026 Shift 1)* | *Hard*

(a) C_2H_2 (b) C_2H_4 (c) C_2H_6 (d) C_4H_{10}

Formula used: $C_xH_y + (x + y/4)\ O_2 \rightarrow x\ CO_2 + (y/2)\ H_2O(l)$; KOH absorbs CO_2. **Solution:**

$C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O(l)$. On cooling, water condenses; residual gas = CO_2 + unused O_2.

Step 1: KOH absorbs CO_2: $CO_2 = 224 - 64 = 160$ mL; unused $O_2 = 64$ mL.

Step 2: $x = 160/80 = 2$.

Step 3: O_2 used $= 264 - 64 = 200$ mL $\rightarrow (x + y/4) = 200/80 = 2.5 \rightarrow 2 + y/4 = 2.5 \rightarrow y = 2$.

Formula C_2H_2. Hence option (a).

Ans: (a)

60. Aqueous HCl reacts with MnO_2 to form $MnCl_2$, Cl_2 and water. The mass of Cl_2 liberated when 8.7 g of MnO_2 reacts with excess HCl is (Mn = 55, Cl = 35.5, O = 16) *JEE Main (21 Jan 2026 Shift 2)* | *Easy*

(a) 21.3 g (b) 71 g (c) 7.1 g (d) 14.2 g

Formula used: $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$. **Solution:**

Reaction: $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$.

Step 1: $M(MnO_2) = 55 + 32 = 87$; $n = 8.7/87 = 0.1$ mol. **Step 2:** $Cl_2 = 0.1$ mol $= 0.1 \times 71 = 7.1$ g.

Hence option (c).

Ans: (c)

61. 20 mL of NaI solution gives 4.74 g of AgI with excess $AgNO_3$. The molarity of NaI is _____ M (nearest integer). *JEE Main (8 Apr 2025 Shift 2)* | *Easy*

Formula used: AgI = 235. **Solution:**

Reaction: $NaI + AgNO_3 \rightarrow AgI + NaNO_3$ (1 : 1).

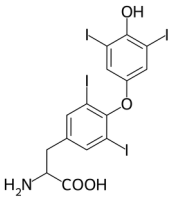
Step 1: $M(AgI) = 108 + 127 = 235$; $n(AgI) = 4.74/235 = 0.0202$ mol = n(NaI).

Step 2: Molarity $= 0.0202/0.020 = 1.01\ M \approx 1\ M$.

Hence 1.

Ans: 1

62. The percentage of iodine in thyroxine ($C_{15}H_{11}I_4NO_4$, structure below) is _____ (nearest integer). *JEE Main (7 Apr 2025 Shift 1)* | *Easy*



Formula used: M = 777. **Solution:**

Step 1: $M = 15(12) + 11(1) + 4(127) + 14 + 4(16) = 180 + 11 + 508 + 14 + 64 = 777\ g\ mol^{-1}$.

Step 2: %I $= (508/777) \times 100 = 65.4\%$.

Hence 65.

Ans: 65

63. $C_4H_{10} + 13/2\ O_2 \rightarrow 4CO_2 + 5H_2O$. If 174.0 kg butane is mixed with 320.0 kg O_2, the volume of water formed is _____ L (density 1 g mL^{-1}). *JEE Main (7 Apr 2025 Shift 1)* | *Medium*

Formula used: Oxygen is limiting. **Solution:**

Step 1: Butane $= 174/58 = 3$ kmol; $O_2 = 320/32 = 10$ kmol.

Step 2: O_2 needed for 3 kmol butane $= 3 \times 6.5 = 19.5$ kmol > 10, so O_2 is limiting.

Step 3: Butane burned $= 10/6.5 = 1.538$ kmol; water formed $= 5 \times 1.538 = 7.69$ kmol $= 7.69 \times 18 = 138.5$ kg. **Step 4:** Density 1 g $mL^{-1} \rightarrow 138.5$ kg ≈ 138 L.

Hence 138.

Ans: 138

64. The mass of calcium oxide from heating 150 kg of 75% pure limestone is _____ kg (nearest integer). *JEE Main (4 Apr 2025 Shift 2)* | *Easy*

Formula used: $CaCO_3 \rightarrow CaO$. **Solution:**

Reaction: $CaCO_3 \rightarrow CaO + CO_2$ (100 g $\rightarrow$ 56 g).

Step 1: Pure $CaCO_3 = 0.75 \times 150 = 112.5$ kg.

Step 2: $CaO = 112.5 \times 56/100 = 63$ kg.

Hence 63.

Ans: 63

65. The mass of magnesium needed to produce 220 mL of hydrogen at STP with excess dilute HCl is (Mg = 24) *JEE Main (3 Apr 2025 Shift 2)* | *Easy*

(a) 0.24 mg (b) 236 mg (c) 2.444 g (d) 235.7 g

Formula used: Mg → H_2 (1 : 1). **Solution:**

Reaction: Mg + 2HCl → $MgCl_2$ + H_2 (1 mol Mg → 1 mol H_2).

Step 1: H_2 = 0.220/22.4 = 9.82 × 10^{-3} mol.

Step 2: Mg = 9.82 × 10^{-3} × 24 = 0.236 g = 236 mg. Hence option (b).

Ans: (b)

66. For $CaCO_3$(s) + $2HCl$(aq) → $CaCl_2$(aq) + CO_2(g) + H_2O(l), what mass of $CaCl_2$ is formed if 250 mL of 0.76 M HCl reacts with 1000 g of $CaCO_3$? (Ca = 40, C = 12, O = 16, H = 1, Cl = 35.5) *JEE Main (2 Apr 2025 Shift 1)* | *Medium*

(a) 3.908 g (b) 10.545 g (c) 2.636 g (d) 5.272 g

Formula used: n = M × V; HCl is limiting.

Solution: Step 1: HCl = 0.76 × 0.250 = 0.19 mol; $CaCO_3$ = 1000/100 = 10 mol.

Step 2: HCl is limiting (it needs only 0.095 mol $CaCO_3$).

Step 3: $CaCl_2$ = 0.19/2 = 0.095 mol; M($CaCl_2$) = 40 + 71 = 111.

Step 4: Mass = 0.095 × 111 = 10.545 g.

Hence option (b).

Ans: (b)

67. x g of benzoic acid with aqueous $NaHCO_3$ releases CO_2 occupying 11.2 L at STP. x is _____ g. *JEE Main (24 Jan 2025 Shift 1)* | *Easy*

Formula used: 1 : 1. **Solution:**

Reaction: C_6H_5COOH + $NaHCO_3$ → C_6H_5COONa + H_2O + CO_2 (1 : 1).

Step 1: CO_2 = 11.2/22.4 = 0.5 mol = moles of benzoic acid.

Step 2: M(C_6H_5COOH) = 122 → x = 0.5 × 122 = 61 g. Hence 61.

Ans: 61

68. Fe_3O_4 + 4CO → 3Fe + 4CO_2. x kg of iron is produced from 2.32 × 10^3 kg Fe_3O_4 and 2.8 × 10^2 kg CO. x = _____. *JEE Main (24 Jan 2025 Shift 2)* | *Medium*

Formula used: CO is limiting. **Solution:**

Step 1: Fe_3O_4 (M = 232) = 2320/232 = 10 kmol; CO = 280/28 = 10 kmol.

Step 2: 10 kmol Fe_3O_4 needs 40 kmol CO; only 10 kmol available → CO is limiting.

Step 3: Fe = (3/4) × 10 = 7.5 kmol = 7.5 × 56 = 420 kg. Hence 420.

Ans: 420

69. The mass of bromine needed to convert 2 g of phenol into 2,4,6-tribromophenol is (C 12, H 1, O 16, Br 80) *JEE Main (23 Jan 2025 Shift 1)* | *Easy*

(a) 6.0 g (b) 20.44 g (c) 10.22 g (d) 4.0 g

Formula used: 3 Br_2 per phenol. **Solution:**

Reaction: C_6H_5OH + 3Br_2 → $C_6H_2Br_3OH$ + 3HBr.

Step 1: Phenol (M = 94) = 2/94 = 0.02128 mol.

Step 2: Br_2 = 3 × 0.02128 = 0.0638 mol × 160 = 10.21 g.

Hence option (c).

Ans: (c)

70. 81.0 g Al reacts with 128.0 g O_2. The mass of Al_2O_3 formed is _____ g. *JEE Main (23 Jan 2025 Shift 2)* | *Easy*

Formula used: 4Al + 3O_2 → 2Al_2O_3. **Solution:**

Reaction: 4Al + 3O_2 → 2Al_2O_3.

Step 1: Al = 81/27 = 3 mol (3/4 = 0.75); O_2 = 128/32 = 4 mol (4/3 = 1.33). Al is limiting.

Step 2: Al_2O_3 = 3/2 = 1.5 mol × 102 = 153 g.

Hence 153.

Ans: 153

71. The molarity of an aqueous solution containing x g of anhydrous $CuSO_4$ in 500 mL at 32 °C is 2×10^{-1} M. Its molality will be _____ $\times 10^{-3}$ m (nearest integer). (Density of solution = 1.25 g mL^{-1}) *JEE Main (9 Apr 2024 Shift 1)* | *Medium*

Formula used: m = n(solute) / mass of solvent (kg). **Solution:**

Take 1 L of solution: n($CuSO_4$) = 0.2 mol; M($CuSO_4$) = 159.5 → mass = 31.9 g.

Step 1: Mass of solution = 1000 × 1.25 = 1250 g.

Step 2: Mass of water = 1250 − 31.9 = 1218.1 g = 1.2181 kg.

Step 3: Molality = 0.2/1.2181 = 0.164 m = 164 × 10^{-3}m.

Hence 164.

Ans: 164

72. Combustion of glucose ($C_6H_{12}O_6$) produces CO_2 and water. The mass of oxygen required for complete combustion of 900 g of glucose is *JEE Main (8 Apr 2024 Shift 1)* | *Easy*

(a) 480 g (b) 800 g (c) 960 g (d) 32 g

Formula used: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$. **Solution:**

Reaction: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.

Step 1: Glucose = 900/180 = 5 mol.

Step 2: O_2 = 6 × 5 = 30 mol = 30 × 32 = 960 g.

Hence option (c).

Ans: (c)

73. The molality of a 3 M aqueous solution of NaCl (density 1.25 g mL^{-1}; Na = 23, Cl = 35.5) is *JEE Main (6 Apr 2024 Shift 2)* | *Medium*

(a) 1.9 m (b) 3.85 m (c) 2.79 m (d) 2.90 m

Formula used: Solvent mass = solution mass − solute mass. **Solution:**

Take 1 L solution: mass = 1000 × 1.25 = 1250 g.

Step 1: NaCl = 3 mol × 58.5 = 175.5 g.

Step 2: Water = 1250 − 175.5 = 1074.5 g = 1.0745 kg. **Step 3:** Molality = 3/1.0745 = 2.79 m.

Hence option (c).

Ans: (c)

74. The density of an 'x' M NaOH solution is 1.12 g mL^{-1} and its molality is 3 m. The value of x is (NaOH = 40) *JEE Main (6 Apr 2024 Shift 1)* | *Medium*

(a) 3.5 (b) 3.8 (c) 2.8 (d) 3.0

Formula used: Molality to molarity using density. **Solution:**

Molality 3 m: 3 mol NaOH (120 g) in 1000 g water.

Step 1: Mass of solution = 1000 + 120 = 1120 g.

Step 2: Volume = 1120/1.12 = 1000 mL = 1 L.

Step 3: Molarity = 3/1 = 3.0 M.

Hence option (d).

Ans: (d)

75. 9.3 g of pure aniline is treated with bromine water to give a white precipitate of product 'P'. The mass of P obtained is 26.4 g. The percentage yield is _____%. *JEE Main (5 Apr 2024 Shift 1)* | *Medium*

Formula used: $C_6H_5NH_2 + 3Br_2 \rightarrow$ 2,4,6-tribromoaniline + 3HBr; % yield. **Solution:**

Reaction: $C_6H_5NH_2 + 3Br_2 \rightarrow$ 2,4,6-tribromoaniline (P) + 3HBr.

Step 1: Aniline (M = 93) = 9.3/93 = 0.1 mol → theoretical P = 0.1 mol.

Step 2: M($C_6H_4Br_3N$) = 72 + 4 + 240 + 14 = 330 → theoretical mass = 33.0 g.

Step 3: % yield = (26.4/33.0) × 100 = 80%.

Hence 80.

Ans: 80

76. The number of moles of methane required to produce 11 g of CO_2 after complete combustion is *JEE Main (5 Apr 2024 Shift 2)* | *Easy*

(a) 0.35 (b) 0.5 (c) 0.75 (d) 0.25

Formula used: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. **Solution:** Reaction: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ (1 mol CH_4 → 1 mol CO_2).

Step 1: CO_2 = 11/44 = 0.25 mol → CH_4 = 0.25 mol. Hence option (d).

Ans: (d)

77. $3PbCl_2 + 2(NH_4)_3PO_4 \rightarrow Pb_3(PO_4)_2 + 6NH_4Cl$. If 72 mmol $PbCl_2$ is mixed with 50 mmol of $(NH_4)_3PO_4$, the amount of $Pb_3(PO_4)_2$ formed is _____ mmol. *JEE Main (1 Feb 2024 Shift 1)* | *Medium*

Formula used: Limiting reagent: smallest value of moles/coefficient. **Solution:**

Step 1: Divide moles by coefficients — $PbCl_2$: 72/3 = 24; $(NH_4)_3PO_4$: 50/2 = 25. $PbCl_2$ is limiting.

Step 2: $Pb_3(PO_4)_2$ formed = 72/3 = 24 mmol.

Hence 24.

Ans: 24

78. 10 mL of a gaseous hydrocarbon on combustion gives 40 mL of CO_2(g) and 50 mL of water vapour. The total number of carbon and hydrogen atoms in the hydrocarbon is _____. *JEE Main (1 Feb 2024 Shift 2)* | *Medium*

Formula used: C_xH_y gives x vol CO_2 and y/2 vol H_2O. **Solution:**

$C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$(g); volumes ∝ moles.

Step 1: x = 40/10 = 4.

Step 2: y/2 = 50/10 = 5 → y = 10. Formula C_4H_{10}.

Step 3: Total C and H atoms = 4 + 10 = 14.

Hence 14.

Ans: 14

79. The number of moles of methane required to produce 22 g of CO_2 after combustion is x × 10^{-2}. The value of x is _____. *JEE Main (31 Jan 2024 Shift 1)* | *Easy*

Formula used: 1 mol CH_4 gives 1 mol CO_2. **Solution: Step 1:** CO_2 = 22/44 = 0.5 mol.

Step 2: $CH_4 : CO_2 = 1 : 1 \rightarrow CH_4$ = 0.5 mol = 50 × 10^{-2} mol.

Hence 50.

Ans: 50

80. A sample of $CaCO_3$ and $MgCO_3$ weighing 2.21 g is ignited to a constant weight of 1.152 g. The composition of the mixture is ($CaCO_3$ = 100, $MgCO_3$ = 84) *JEE Main (31 Jan 2024 Shift 2)* | *Hard*

(a) 1.187 g $CaCO_3$ + 1.023 g $MgCO_3$

(b) 1.023 g $CaCO_3$ + 1.023 g $MgCO_3$

(c) 1.187 g $CaCO_3$ + 1.187 g $MgCO_3$

(d) 1.023 g $CaCO_3$ + 1.187 g $MgCO_3$

Formula used: Residue = CaO (56/100 of $CaCO_3$) + MgO (40/84 of $MgCO_3$). **Solution:**

On ignition: $CaCO_3 \rightarrow CaO$ (100 → 56); $MgCO_3 \rightarrow MgO$ (84 → 40).

Step 1: Let $CaCO_3$ = x g, $MgCO_3$ = (2.21 − x) g.

Step 2: Residue: (56/100)x + (40/84)(2.21 − x) = 1.152 → 0.56x + 0.4762(2.21 − x) = 1.152.

Step 3: 0.56x − 0.4762x = 1.152 − 1.0524 → 0.0838x = 0.0996 → x = 1.187 g.

Step 4: $MgCO_3$ = 2.21 − 1.187 = 1.023 g.

Hence option (a).

Ans: (a)

81. The molarity of 1 L orthophosphoric acid (H_3PO_4) of 70% purity by weight (specific gravity 1.54 g cm^{-3}) is _____ M. (H_3PO_4 = 98) *JEE Main (31 Jan 2024 Shift 2)* | *Medium*

Formula used: M = 10 × (% w/w) × d / M_B. **Solution: Formula:** M = (10 × % w/w × density)/molar mass.

Step 1: Mass of 1 L = 1540 g; H_3PO_4 = 0.70 × 1540 = 1078 g.

Step 2: Moles = 1078/98 = 11 → molarity = 11 M.

Hence 11.

Ans: 11

82. A 0.05 cm thick coating of silver is deposited on a plate of 0.05 m^2 area. The number of silver atoms deposited is _____ × 10^{23}. (Ag = 108, d = 7.9 g cm^{-3}) *JEE Main (30 Jan 2024 Shift 1)* | *Hard*

Formula used: Mass = volume × density; atoms = (m/M) × N_A. **Solution:**

Step 1: Area = 0.05 m^2 = 0.05 × 10^4 cm^2 = 500 cm^2. **Step 2:** Volume of Ag = 500 × 0.05 = 25 cm^3.

Step 3: Mass = 25 × 7.9 = 197.5 g; moles = 197.5/108 = 1.829 mol.

Step 4: Atoms = 1.829 × 6.022 × 10^{23} = 11.0 × 10^{23}. Hence 11.

Ans: 11

83. 31.4% H_2SO_4 by mass has density 1.25 g mL^{-1}. Its molarity is _____ M (nearest integer). *JEE Main (29 Jan 2024 Shift 1)* | *Easy*

Formula used: M = 10d(%)/M. **Solution:**

Take 1 L solution: mass = 1250 g.

Step 1: H_2SO_4 = 0.314 × 1250 = 392.5 g = 392.5/98 = 4.0 mol.

Step 2: Molarity = 4.0 M.

Hence 4.

Ans: 4

84. 50 mL of 0.5 M oxalic acid neutralises 25 mL of NaOH solution. The NaOH in 50 mL of this solution is _____ g. *JEE Main (29 Jan 2024 Shift 2)* | *Easy*

Formula used: Oxalic acid is dibasic. **Solution:**

Reaction: $H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$.

Step 1: Oxalic acid = 50 × 0.5 = 25 mmol → NaOH needed = 50 mmol in 25 mL.

Step 2: Molarity of NaOH = 50/25 = 2 M.

Step 3: NaOH in 50 mL = 2 × 0.050 = 0.1 mol = 4 g. Hence 4.

Ans: 4

85. The volume of 3 M NaOH (formula weight 40 g mol^{-1}) which can be prepared from 84 g of NaOH is _____ $\times 10^{-1}$ dm^3. *JEE Main (27 Jan 2024 Shift 2)* | *Easy*

Formula used: V = n / M. **Solution:**

Step 1: n = 84/40 = 2.1 mol.

Step 2: V = n/M = 2.1/3 = 0.7 dm^3 = 7 × 10^{-1} dm^3. Hence 7.

Ans: 7

86. The mass of methane required to produce 22 g of CO_2 after complete combustion is _____ g. (C = 12, H = 1, O = 16) *JEE Main (27 Jan 2024 Shift 1)* | *Easy*

Formula used: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$.
Solution: Step 1: CO_2 = 22/44 = 0.5 mol → CH_4 = 0.5 mol (1 : 1).

Step 2: Mass = 0.5 × 16 = 8 g.

Hence 8.

Ans: 8

87. 9.3 g of aniline is reacted with excess acetic anhydride to prepare acetanilide. The mass of acetanilide produced at 100% conversion is _____ $\times 10^{-1}$ g. (N = 14, O = 16, C = 12, H = 1) *JEE Main (27 Jan 2024 Shift 2)* | *Easy*

Formula used: 1 mol aniline gives 1 mol acetanilide (C_8H_9NO, M = 135). **Solution:**

Reaction: $C_6H_5NH_2 + (CH_3CO)_2O \rightarrow C_6H_5NHCOCH_3 + CH_3COOH$ (1 : 1).

Step 1: Aniline = 9.3/93 = 0.1 mol.

Step 2: M(acetanilide) = 135 → mass = 13.5 g = 135 × 10^{-1} g.

Hence 135.

Ans: 135

88. 1 mole of PbS is oxidised by X moles of O_3 to get Y moles of O_2. X + Y = _____. *JEE Main (27 Jan 2024 Shift 2)* | *Medium*

Formula used: $PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$.
Solution: Reaction: $PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$.

Step 1: S goes from −2 (PbS) to +6 ($PbSO_4$): 8 electrons lost per PbS.

Step 2: Each $O_3 \rightarrow O_2$ transfers one O atom ($O^0 \rightarrow O^{-2}$ in sulphate), accepting 2 electrons; X = 8/2 = 4 mol O_3.

Step 3: Each O_3 releases one O_2 → Y = 4.

Step 4: X + Y = 8.

Hence 8.

Ans: 8

89. 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01 mol of CO_2. The molar mass of M_2CO_3 is _____ g mol^{-1}. *JEE Main (13 Apr 2023 Shift 2)* | *Easy*

Formula used: 1 mol M_2CO_3 gives 1 mol CO_2.
Solution:

Reaction: $M_2CO_3 + 2HCl \rightarrow 2MCl + H_2O + CO_2$ (1 mol carbonate → 1 mol CO_2).

Step 1: Moles of M_2CO_3 = 0.01 mol.

Step 2: Molar mass = 1/0.01 = 100 g mol^{-1}.

Hence 100.

Ans: 100

90. The volume of hydrogen liberated at STP by treating 2.4 g of magnesium with excess HCl is _____ $\times 10^{-2}$ L. (Molar volume = 22.4 L; Mg = 24) *JEE Main (11 Apr 2023 Shift 2)* | *Easy*

Formula used: $Mg + 2HCl \rightarrow MgCl_2 + H_2$.
Solution: Step 1: Mg = 2.4/24 = 0.1 mol; $Mg + 2HCl \rightarrow MgCl_2 + H_2$ → H_2 = 0.1 mol.

Step 2: V = 0.1 × 22.4 = 2.24 L = 224 × 10^{-2} L.

Hence 224.

Ans: 224

91. If 5 moles of $BaCl_2$ is mixed with 2 moles of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ formed is _____. *JEE Main (6 Apr 2023 Shift 1)* | *Medium*

Formula used: $3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$. **Solution:**

Reaction: $3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$. **Step 1:** $BaCl_2$: 5/3 = 1.67; Na_3PO_4: 2/2 = 1. Na_3PO_4 is limiting.

Step 2: $Ba_3(PO_4)_2$ = 2/2 = 1 mol.

Hence 1.

Ans: 1

92. The volume of 0.02 M HBr needed to neutralise 10.0 mL of 0.01 M $Ba(OH)_2$ is *JEE Main (6 Apr 2023 Shift 2)* | *Easy*

(a) 10.0 mL (b) 5.0 mL (c) 7.5 mL (d) 2.5 mL

Formula used: Equivalents. **Solution:**

OH^- = 10.0 × 0.01 × 2 = 0.2 mmol.

HBr volume = 0.2/0.02 = 10.0 mL.

Hence option (c).

Ans: (a)

93. The molality of a 10% (v/v) solution of bromine in CCl_4 is x. x = _____ × 10^{-2} M (densities: Br_2 3.2, CCl_4 1.6 g cm^{-3}). *JEE Main (1 Feb 2023 Shift 2)* | *Medium*

Formula used: Use 100 mL solution. **Solution:**

Take 100 mL solution: 10 mL Br_2 and 90 mL CCl_4.

Step 1: Br_2 = 10 × 3.2 = 32 g = 32/160 = 0.2 mol.

Step 2: CCl_4 = 90 × 1.6 = 144 g = 0.144 kg.

Step 3: Molality = 0.2/0.144 = 1.39 m = 139 × 10^{-2}. Hence 139.

Ans: 139

94. The volume of hydrogen gas produced at STP from 11.5 g of zinc with excess HCl is _____ L (nearest integer). (Zn = 65.4; molar volume = 22.7 L) *JEE Main (31 Jan 2023 Shift 1)* | *Easy*

Formula used: Zn + 2HCl → $ZnCl_2$ + H_2.

Solution: Step 1: Zn = 11.5/65.4 = 0.176 mol; Zn + 2HCl → $ZnCl_2$ + H_2 → H_2 = 0.176 mol.

Step 2: V = 0.176 × 22.7 = 3.99 L ≈ 4 L.

Hence 4.

Ans: 4

95. 2C + O_2 → 2CO. When 12 g carbon burns in 48 g oxygen, the volume of CO produced at STP (22.7 L mol^{-1}) is _____ × 10^{-1} L. *JEE Main (31 Jan 2023 Shift 2)* | *Easy*

Formula used: Carbon is limiting. **Solution:**

Step 1: C = 12/12 = 1 mol; O_2 = 48/32 = 1.5 mol.

Step 2: 1 mol C needs 0.5 mol O_2 → C is limiting (O_2 in excess).

Step 3: CO formed = 1 mol = 22.7 L = 227 × 10^{-1} L. Hence 227.

Ans: 227

96. 0.01 mol of an organic compound with 60% carbon gives 4.4 g CO_2 on combustion. Its molar mass is _____ g mol^{-1}. *JEE Main (29 Jan 2023 Shift 2)* | *Easy*

Formula used: 0.1 mol C → 10 C atoms.

Solution: Step 1: CO_2 = 4.4/44 = 0.1 mol → carbon = 0.1 mol = 1.2 g in 0.01 mol compound.

Step 2: Carbon per mole of compound = 1.2/0.01 = 120 g.

Step 3: 120 g is 60% of M → M = 120/0.60 = 200 g mol^{-1}.

Hence 200.

Ans: 200

97. A monobasic strong acid (M = 24.2) has density 1.21 kg L^{-1}. The volume needed to neutralise 25 mL of 0.24 M NaOH is _____ × 10^{-2} mL. *JEE Main (25 Jan 2023 Shift 1)* | *Medium*

Formula used: Pure acid molarity = 1210/24.2 = 50 M. **Solution:**

Step 1: Molarity of pure acid = (1210 g L^{-1})/(24.2 g mol^{-1}) = 50 M.

Step 2: NaOH = 25 × 0.24 = 6 mmol → acid needed = 6 mmol (monobasic).

Step 3: Volume = 6/50 = 0.12 mL = 12 × 10^{-2} mL.

Hence 12.

Ans: 12

98. $N_2 + 3H_2 \rightleftharpoons 2NH_3$ with 20 g N_2 and 5 g H_2. The limiting reagent and moles of NH_3 formed are *JEE Main (29 Jul 2022 Shift 1)* | *Easy*

(a) H_2, 1.42 mol (b) H_2, 0.71 mol

(c) N_2, 1.42 mol (d) N_2, 0.71 mol

Formula used: Compare mole ratio. **Solution:**

Step 1: N_2 = 20/28 = 0.714 mol; H_2 = 5/2 = 2.5 mol. **Step 2:** 0.714 mol N_2 needs 3 × 0.714 = 2.14 mol H_2 < 2.5 mol available → N_2 is limiting.

Step 3: NH_3 = 2 × 0.714 = 1.43 mol.

Hence N_2 and 1.42 mol, option (c).

Ans: (c)

99. $4\,HNO_3 + 3\,KCl \rightarrow Cl_2 + \text{NOCl} + 2\,H_2O + 3\,KNO_3$. The mass of HNO_3 needed to make 110.0 g KNO_3 is (K 39) *JEE Main (29 Jul 2022 Shift 2)* | *Easy*

(a) 32.2 g (b) 69.4 g (c) 91.5 g (d) 162.5 g

Formula used: 4 : 3 ratio. **Solution:**

Step 1: M(KNO_3) = 39 + 14 + 48 = 101; n = 110/101 = 1.089 mol.

Step 2: HNO_3 : KNO_3 = 4 : 3 → HNO_3 = 1.089 × 4/3 = 1.452 mol.

Step 3: Mass = 1.452 × 63 = 91.5 g.

Hence option (c).

Ans: (c)

100. X + Y + 3Z ⇌ XYZ_3. With 1 mol each of X and Y and 0.05 mol Z (atomic masses 10, 20, 30), the yield of XYZ_3 is _____ g. *JEE Main (28 Jul 2022 Shift 1)* | *Easy*

Formula used: Z limiting. **Solution:**

Step 1: Divide by coefficients — X: 1; Y: 1; Z: 0.05/3 = 0.0167. Z is limiting.

Step 2: XYZ_3 = 0.0167 mol; M = 10 + 20 + 3 × 30 = 120 g mol^{-1}.

Step 3: Mass = 0.0167 × 120 = 2 g.

Hence 2.

Ans: 2

101. 2 L of 0.2 M H_2SO_4 reacts with 2 L of 0.1 M NaOH. The molarity of Na_2SO_4 formed is _____ mM. *JEE Main (28 Jul 2022 Shift 2)* | *Easy*

Formula used: NaOH limiting. **Solution:**

Reaction: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$.

Step 1: H_2SO_4 = 0.4 mol; NaOH = 0.2 mol (limiting). **Step 2:** Na_2SO_4 = 0.2/2 = 0.1 mol in total volume 4 L. **Step 3:** Molarity = 0.1/4 = 0.025 M = 25 mM.

Hence 25.

Ans: 25

102. Benzene → (oleum) benzenesulphonic acid → (NaOH, then H^+) phenol. Yields are 60% and 50%. The overall yield is _____ %. *JEE Main (27 Jul 2022 Shift 1)* | *Easy*

Formula used: Multiply yields. **Solution:**

Concept: the overall yield of consecutive steps is the product of the individual fractional yields.

Step 1: Overall = 0.60 × 0.50 = 0.30 = 30%.

Hence 30.

Ans: 30

103. The normality of H_2SO_4 in the solution from 100 mL of 0.1 M H_2SO_4 and 50 mL of 0.1 M NaOH is _____ × 10^{-1} N. *JEE Main (27 Jul 2022 Shift 2)* | *Easy*

Formula used: Excess equivalents/volume.

Solution: Step 1: Equivalents of acid = 100 × 0.1 × 2 = 20 meq. **Step 2:** Equivalents of base = 50 × 0.1 × 1 = 5 meq. **Step 3:** Acid left = 15 meq in 150 mL → N = 15/150 = 0.1 N = 1 × 10^{-1} N.

Hence 1.

Ans: 1

104. 5 g of toluene is converted to benzaldehyde in 92% yield. The benzaldehyde produced is _____ × 10^{-2} g. *JEE Main (27 Jul 2022 Shift 2)* | *Easy*

Formula used: 1 : 1. **Solution:**

Step 1: Toluene (M = 92) = 5/92 = 0.05435 mol.

Step 2: Benzaldehyde at 92% = 0.05435 × 0.92 = 0.05 mol.

Step 3: Mass = 0.05 × 106 = 5.30 g = 530 × 10^{-2} g. Hence 530.

Ans: 530

105. Chlorophyll extract gives 2 L of solution with 48 ppm Mg. The number of Mg atoms is x × 10^{20} (Mg 24, N_A 6.02 × 10^{23}). x = _____. *JEE Main (26 Jul 2022 Shift 1)* | *Medium*

Formula used: ppm ≈ mg L^{-1}. **Solution:**

Step 1: 2 L ≈ 2000 g solution; 48 ppm → Mg = 48 × 2000/10^6 = 0.096 g.

Step 2: Moles = 0.096/24 = 0.004 mol.

Step 3: Atoms = 0.004 × 6.02 × 10^{23} = 2.41 × 10^{21} = 24 × 10^{20}.

Hence 24.

Ans: 24

106. 800 mL of 0.5 M nitric acid is heated until its volume halves and 11.5 g of acid evaporates. The molarity of the remaining acid is x × 10^{-2} M. x = _____. *JEE Main (26 Jul 2022 Shift 1)* | *Medium*

Formula used: Moles left/volume. **Solution:**

Step 1: HNO_3 initially = 0.8 × 0.5 = 0.4 mol = 0.4 × 63 = 25.2 g.

Step 2: After loss of 11.5 g: 13.7 g = 13.7/63 = 0.2175 mol.

Step 3: New volume = 400 mL → M = 0.2175/0.4 = 0.544 M = 54 × 10^{-2} M.

Hence 54.

Ans: 54

107. $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4$ + 2HCl. 16 mol of NaOH neutralise the acids completely. The moles of SO_2Cl_2 used are *JEE Main (25 Jul 2022 Shift 1)* | *Easy*

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

Formula used: 4 H^+ per SO_2Cl_2. **Solution:**

Step 1: 1 mol SO_2Cl_2 gives 1 H_2SO_4 (2 H^+) + 2 HCl (2 H^+) = 4 mol H^+.

Step 2: 16 mol NaOH neutralise 16 mol H^+ → SO_2Cl_2 = 16/4 = 4 mol.

Hence option (c).

Ans: (c)

108. 56.0 L of nitrogen is mixed with excess hydrogen and 20 L of ammonia is produced. The unused nitrogen is _____ L. *JEE Main (25 Jul 2022 Shift 2)* | *Easy*

Formula used: N_2 : NH_3 = 1 : 2. **Solution:**

Reaction: $N_2 + 3H_2 \rightarrow 2NH_3$ (volume ratio 1 : 3 : 2). **Step 1:** N_2 used to give 20 L NH_3 = 20/2 = 10 L.

Step 2: Unused N_2 = 56 − 10 = 46 L.

Hence 46.

Ans: 46

109. $2Cu_2O + Cu_2S \rightarrow$ 6Cu + SO_2. With 2.86 × 10^3 g Cu_2O and 4.77 × 10^3 g Cu_2S, the copper formed is _____ g (Cu 63.5, S 32). *JEE Main (30 Jun 2022 Shift 1)* | *Medium*

Formula used: Cu_2O limiting. **Solution:**

Step 1: M(Cu_2O) = 143 → 2860/143 = 20 mol; M(Cu_2S) = 159 → 4770/159 = 30 mol.

Step 2: Divide by coefficients — Cu_2O: 20/2 = 10; Cu_2S: 30/1 = 30. Cu_2O is limiting.

Step 3: Cu = (6/2) × 20 = 60 mol = 60 × 63.5 = 3810 g.

Hence 3810.

Ans: 3810

110. 100 mL of 0.3 M acetic acid shaken with 0.8 g charcoal becomes 0.125 M. The acid adsorbed per gram of carbon is _____ × 10^{-4} g. *JEE Main (30 Jun 2022 Shift 1)* | *Medium*

Formula used: Moles removed. **Solution:**

Step 1: Acetic acid adsorbed = (0.3 − 0.125) × 0.1 = 0.0175 mol = 0.0175 × 60 = 1.05 g.

Step 2: Per gram of charcoal = 1.05/0.8 = 1.3125 g = 13125 × 10^{-4} g.

Hence 13125.

Ans: 13125

111. Fe_3O_4 + 4CO → 3Fe + 4CO_2. When 4.640 kg Fe_3O_4 and 2.520 kg CO react, the amount of iron produced (in g) is *JEE Main (29 Jun 2022 Shift 1)* | *Medium*

(a) 1400 (b) 2200 (c) 3360 (d) 4200

Formula used: Limiting reagent. **Solution:**

Step 1: Fe_3O_4 = 4640/232 = 20 mol; CO = 2520/28 = 90 mol.

Step 2: 20 mol Fe_3O_4 needs 80 mol CO; 90 available → Fe_3O_4 is limiting.

Step 3: Fe = 3 × 20 = 60 mol = 60 × 56 = 3360 g.

Hence option (c).

Ans: (c)

112. 0.01 M $KMnO_4$ from a 50 mL burette is added to 20.0 mL of 0.05 M Mohr's salt. The volume left in the burette at the end point is _____ mL. *JEE Main (28 Jun 2022 Shift 2)* | *Easy*

Formula used: 1 MnO^- : 5 Fe^{2+}. **Solution:**

Concept: MnO_4^- + 5Fe^{2+} + 8H^+ → Mn^{2+} + 5Fe^{3+} + 4H_2O (1 : 5).

Step 1: Fe^{2+} = 20 × 0.05 = 1 mmol → MnO_4^- = 1/5 = 0.2 mmol.

Step 2: Volume of $KMnO_4$ = 0.2/0.01 = 20 mL.

Step 3: Left in burette = 50 − 20 = 30 mL.

Hence 30.

Ans: 30

113. Assertion A: At 10 °C the density of 5 M KCl is x g mL^{-1}; on cooling to −21 °C, its molality remains unchanged. Reason R: Molality does not change with temperature as mass is unaffected. *JEE Main (27 Jun 2022 Shift 1)* | *Easy*

(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) A is false but R is true

Formula used: Mass-based concentration. **Solution:** Molality = moles of solute/kg of solvent — both depend only on mass.

Cooling changes volume (and density) but not masses, so molality is unchanged → A is true.

R gives the correct reason for A.

Hence option (a).

Ans: (a)

114. Commercial conc. HCl is 35% HCl by mass with density 1.46 g mL^{-1}. Its molarity is *JEE Main (26 Jun 2022 Shift 1)* | *Easy*

(a) 10.2 M (b) 12.5 M (c) 14.0 M (d) 18.2 M

Formula used: M = 10 × d × %/M. **Solution:**

Take 1 L: mass = 1460 g; HCl = 0.35 × 1460 = 511 g. **Step 1:** Moles = 511/36.5 = 14.0 → molarity = 14.0 M. Hence option (c).

Ans: (c)

115. 100 g of methane (CNG) is mixed with 208 g oxygen and burnt. The mass of CO_2 formed is _____ g. *JEE Main (26 Jun 2022 Shift 2)* | *Medium*

Formula used: Oxygen limiting. **Solution:**

Reaction: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$.

Step 1: CH_4 = 100/16 = 6.25 mol; O_2 = 208/32 = 6.5 mol.

Step 2: 6.25 mol CH_4 needs 12.5 mol O_2 → O_2 is limiting.

Step 3: CO_2 = 6.5/2 = 3.25 mol = 3.25 × 44 = 143 g. Hence 143.

Ans: 143

116. The moles of methane needed to produce 81 g of water by complete combustion are _____ × 10^{-2}. *JEE Main (26 Jun 2022 Shift 2)* | *Easy*

Formula used: 1 CH_4 → 2 H_2O. **Solution:**

Step 1: Water = 81/18 = 4.5 mol.

Step 2: $CH_4 : H_2O = 1 : 2 \rightarrow CH_4$ = 2.25 mol = 225 × 10^{-2}.

Hence 225.

Ans: 225

117. The mass of bromine reacting completely with 5.0 g pent-1-ene is _____ × 10^{-2} g (Br 80). *JEE Main (25 Jun 2022 Shift 1)* | *Easy*

Formula used: 1 Br_2 per C=C. **Solution:**

Step 1: Pent-1-ene C_5H_{10} (M = 70) = 5/70 = 0.0714 mol; one C=C adds one Br_2.

Step 2: Br_2 = 0.0714 × 160 = 11.43 g = 1143 × 10^{-2} g. Hence 1143.

Ans: 1143

118. 10 mL of 0.1 M acid A reacts with 30 mL of 0.05 M base $M(OH)_2$. The basicity of A is _____. *JEE Main (25 Jun 2022 Shift 2)* | *Easy*

Formula used: Equivalents equal. **Solution:**

Step 1: OH^- from $M(OH)_2$ = 30 × 0.05 × 2 = 3 mmol. **Step 2:** Acid = 10 × 0.1 = 1 mmol; it neutralises 3 mmol OH^- → basicity = 3.

Hence 3.

Ans: 3

119. A rocket uses fuel $C_{15}H_{30}$ (density 0.756 g mL^{-1}) with liquid oxygen. The mass of O_2 required and CO_2 released per litre of fuel are *JEE Main (24 Jun 2022 Shift 1)* | *Medium*

(a) 1188 g and 1296 g (b) 2376 g and 2592 g
(c) 2592 g and 2376 g (d) 3429 g and 3142 g

Formula used: $C_{15}H_{30} + 22.5\ O_2 \rightarrow 15\ CO_2 + 15\ H_2O$. **Solution:**

Step 1: Mass of 1 L fuel = 756 g; $M(C_{15}H_{30})$ = 210 → 3.6 mol.

Step 2: $C_{15}H_{30} + 22.5O_2 \rightarrow 15CO_2 + 15H_2O$.

Step 3: O_2 = 22.5 × 3.6 = 81 mol = 2592 g.

Step 4: CO_2 = 15 × 3.6 = 54 mol = 2376 g.

Hence option (c).

Ans: (c)

120. 20.0 g Na_2O dissolved in 500 mL water gives NaOH of concentration _____ × 10^{-1} M. *JEE Main (31 Aug 2021 Shift 2)* | *Easy*

Formula used: 1 Na_2O → 2 NaOH. **Solution:**

Reaction: $Na_2O + H_2O \rightarrow 2NaOH$.

Step 1: Na_2O (M = 62) = 20/62 = 0.3226 mol → NaOH = 0.645 mol.

Step 2: Molarity = 0.645/0.5 = 1.29 M ≈ 13 × 10^{-1} M. Hence 13.

Ans: 13

121. 100 g propane reacts completely with 1000 g oxygen. The mole fraction of CO_2 in the resulting mixture is x × 10^{-2}. x = _____. *JEE Main (27 Aug 2021 Shift 2)* | *Hard*

Formula used: Count all gases including excess $O_2$and water. **Solution:**

Reaction: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$.

Step 1: C_3H_8 = 100/44 = 2.273 mol; O_2 = 1000/32 = 31.25 mol (excess).

Step 2: O_2 used = 11.36 mol; left = 19.89 mol. CO_2 = 6.82 mol; H_2O = 9.09 mol.

Step 3: Total moles = 19.89 + 6.82 + 9.09 = 35.8.

Step 4: x(CO_2) = 6.82/35.8 = 0.19 = 19 × 10^{-2}.

Hence 19.

Ans: 19

122. 100 mL of Na_3PO_4 solution contains 3.45 g of sodium. Its molarity is _____ × 10^{-2} mol L^{-1}. *JEE Main (26 Aug 2021 Shift 2)* | *Easy*

Formula used: 3 Na per formula. **Solution:**

Step 1: Na = 3.45/23 = 0.15 mol → Na_3PO_4 = 0.15/3 = 0.05 mol.

Step 2: Molarity = 0.05/0.1 = 0.5 M = 50 × 10^{-2} M. Hence 50.

Ans: 50

123. $2SO_2 + O_2 \rightarrow 2SO_3$ starting with 250 mbar SO_2, 750 mbar O_2. The total pressure after complete reaction is _____ mbar. *JEE Main (27 Jul 2021 Shift 2)* | *Easy*

Formula used: Pressure ∝ moles. **Solution:**

Concept: at constant V and T, partial pressure ∝ moles.

Step 1: SO_2 (250 mbar) reacts completely, using 125 mbar O_2 and forming 250 mbar SO_3.

Step 2: O_2 left = 750 − 125 = 625 mbar.

Step 3: Total = 250 + 625 = 875 mbar.

Hence 875.

Ans: 875

124. The butane needed to produce 72.0 g of water by complete combustion is _____ × 10^{-1} g. *JEE Main (25 Jul 2021 Shift 1)* | *Easy*

Formula used: 1 butane → 5 H_2O. **Solution:**

Reaction: $C_4H_{10} \rightarrow 5H_2O$ (per mole).

Step 1: Water = 72/18 = 4 mol → butane = 4/5 = 0.8 mol.

Step 2: Mass = 0.8 × 58 = 46.4 g = 464 × 10^{-1} g.

Hence 464.

Ans: 464

125. Methylation of 10 g benzene gave 9.2 g toluene. The percentage yield is _____. *JEE Main (22 Jul 2021 Shift 2)* | *Easy*

Formula used: Theoretical toluene 11.8 g.

Solution: Step 1: Benzene = 10/78 = 0.1282 mol → theoretical toluene = 0.1282 × 92 = 11.79 g.

Step 2: % yield = (9.2/11.79) × 100 = 78%.

Hence 78.

Ans: 78

126. 250 mL of 0.5 M NaOH was added to 500 mL of 1 M HCl. The number of unreacted HCl molecules is _____ × 10^{21}. *JEE Main (20 Jul 2021 Shift 1)* | *Easy*

Formula used: Excess moles × N_A. **Solution:**

Step 1: NaOH = 0.125 mol; HCl = 0.5 mol.

Step 2: HCl left = 0.375 mol.

Step 3: Molecules = 0.375 × 6.022 × 10^{23} = 2.26 × 10^{23} = 226 × 10^{21}.

Hence 226.

Ans: 226

127. A person needs 10000 kJ per day. The glucose needed (ΔcH = −2700 kJ mol^{-1}) is _____ g. *JEE Main (20 Jul 2021 Shift 1)* | *Easy*

Formula used: Energy/ΔH × M. **Solution:**

Step 1: Moles of glucose = 10000/2700 = 3.704 mol. **Step 2:** Mass = 3.704 × 180 = 666.7 g ≈ 667 g.

Hence 667.

Ans: 667

128. 4 g of an equimolar mixture of NaOH and Na_2CO_3 contains x g NaOH. x = _____. *JEE Main (20 Jul 2021 Shift 2)* | *Easy*

Formula used: n(40 + 106) = 4. **Solution:**

Let n mol of each.

Step 1: 40n + 106n = 4 → 146n = 4 → n = 0.0274 mol. **Step 2:** NaOH = 0.0274 × 40 = 1.096 g ≈ 1 g.

Hence 1.

Ans: 1

129. Complete combustion of 3 g ethane gives x × 10^{22} molecules of water. x = _____. *JEE Main (18 Mar 2021 Shift 1)* | *Easy*

Formula used: 3 H_2O per ethane. **Solution:**

Reaction: $C_2H_6 + 3.5O_2 \rightarrow 2CO_2 + 3H_2O$.

Step 1: Ethane = 3/30 = 0.1 mol → H_2O = 0.3 mol.

Step 2: Molecules = 0.3 × 6.022 × 10^{23} = 1.81 × 10^{23}= 18 × 10^{22}.

Hence 18.

Ans: 18

130. 0.1 mol benzylamine with bromomethane gave 23 g of benzyltrimethylammonium bromide. The moles of bromomethane consumed are n × 10^{-1}. n = _____. *JEE Main (18 Mar 2021 Shift 1)* | *Easy*

Formula used: Three methylations. **Solution:**

Reaction: $C_6H_5CH_2NH_2 + 3CH_3Br \rightarrow C_6H_5CH_2N^+(CH_3)_3 + 2HBr$ (two H replaced, then quaternisation).

Step 1: M(product $C_{10}H_{16}NBr$) = 120 + 16 + 14 + 80 = 230 → 23 g = 0.1 mol.

Step 2: CH_3Br used = 3 × 0.1 = 0.3 mol = 3 × 10^{-1}. Hence 3.

Ans: 3

131. _____ g of 3-hydroxypropanal (M = 74) must be dehydrated to give 7.8 g of acrolein (M = 56) at 64% yield. *JEE Main (18 Mar 2021 Shift 1)* | *Easy*

Formula used: Divide by yield. **Solution:**

Reaction: $HOCH_2CH_2CHO \rightarrow CH_2{=}CHCHO + H_2O$ (1 : 1).

Step 1: Acrolein = 7.8/56 = 0.1393 mol.

Step 2: At 64% yield, required = 0.1393/0.64 = 0.2176 mol.

Step 3: Mass = 0.2176 × 74 = 16.1 g ≈ 16.

Hence 16.

Ans: 16

132. 6.1 g of benzoic acid gives 7.8 g of m-bromobenzoic acid with $Br_2/FeBr_3$. The percentage yield is _____. *JEE Main (18 Mar 2021 Shift 2)* | *Easy*

Formula used: 1 : 1. **Solution:**

Step 1: Benzoic acid = 6.1/122 = 0.05 mol.

Step 2: Theoretical m-bromobenzoic acid (M = 201) = 0.05 × 201 = 10.05 g.

Step 3: % yield = (7.8/10.05) × 100 = 77.6 ≈ 78.

Hence 78.

Ans: 78

133. 15 mL of acidic Fe^{2+} reacts completely with 20 mL of 0.03 M $Cr_2O_7^{2-}$. The molarity of Fe^{2+} is _____ × 10^{-2} M. *JEE Main (17 Mar 2021 Shift 1)* | *Easy*

Formula used: 1 : 6. **Solution:**

Reaction: $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$.

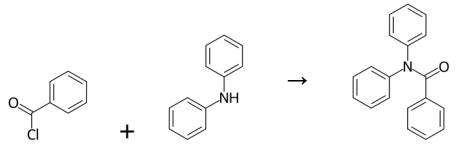
Step 1: $Cr_2O_7^{2-}$ = 20 × 0.03 = 0.6 mmol → Fe^{2+} = 6 × 0.6 = 3.6 mmol.

Step 2: [Fe^{2+}] = 3.6/15 = 0.24 M = 24 × 10^{-2} M.

Hence 24.

Ans: 24

134. 0.140 g benzoyl chloride reacts with 0.388 g diphenylamine to give 0.210 g of the amide. The percentage yield is _____ (nearest integer). *JEE Main (17 Mar 2021 Shift 2)* | *Medium*



Formula used: Benzoyl chloride limiting; product M = 273. **Solution:**

Reaction: $C_6H_5COCl + (C_6H_5)_2NH \rightarrow C_6H_5CON(C_6H_5)_2 + HCl$.

Br^-**Step 1:** C_6H_5COCl (140.5) = 0.140/140.5 = 9.96 × 10^{-4}mol (limiting); diphenylamine (169) = 2.30 × 10^{-3} mol. **Step 2:** Amide (M = 273) theoretical = 9.96 × 10^{-4} × 273 = 0.272 g.

Step 3: % yield = (0.210/0.272) × 100 = 77%.

Hence 77.

Ans: 77

135. The volumes of 1 M NaOH needed to neutralise 50 mL of 1 M H_3PO_3 and 100 mL of 2 M H_3PO_2 are *JEE Main (16 Mar 2021 Shift 2)* | *Medium*

(a) 100 mL and 100 mL (b) 100 mL and 200 mL

(c) 100 mL and 50 mL (d) 50 mL and 50 mL

Formula used: H_3PO_3 dibasic; H_3PO_2 monobasic. **Solution:**

Concept: H_3PO_3 is dibasic (two P–OH); H_3PO_2 is monobasic (one P–OH).

Step 1: H_3PO_3 = 50 mmol × 2 = 100 mmol OH^- → 100 mL of 1 M NaOH.

Step 2: H_3PO_2 = 100 × 2 = 200 mmol × 1 = 200 mmol OH^- → 200 mL.

Hence option (b).

Ans: (b)

136. 35 mL of 0.15 M lead nitrate is mixed with 20 mL of 0.12 M chromic sulphate. The lead sulphate precipitated is _____ × 10^{-5} mol. *JEE Main (16 Mar 2021 Shift 2)* | *Medium*

Formula used: $Cr_2(SO_4)_3$ gives 3 $SO^2{}_4^-$. **Solution:** Reaction: $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$.

Step 1: Pb^{2+} = 35 × 0.15 = 5.25 mmol.

Step 2: $Cr_2(SO_4)_3$ = 20 × 0.12 = 2.4 mmol → SO_4^{2-} = 7.2 mmol.

Step 3: Pb^{2+} is limiting → $PbSO_4$ = 5.25 mmol = 525 × 10^{-5} mol.

Hence 525.

Ans: 525

137. The $NaNO_3$ to be weighed to make 50 mL of solution with 70.0 mg Na^+ per mL is _____ g. *JEE Main (26 Feb 2021 Shift 2)* | *Easy*

Formula used: Na → $NaNO_3$. **Solution:**

Step 1: Na^+ needed = 70.0 mg × 50 = 3500 mg = 3.5 g.

Step 2: Moles of Na = 3.5/23 = 0.152 mol = moles of $NaNO_3$.

Step 3: Mass of $NaNO_3$ (M = 85) = 0.152 × 85 = 12.9 g ≈ 13 g.

Hence 13.

Ans: 13

138. In basic medium CrO_4^{2-} oxidises $S_2O_3^{2-}$ to SO_4^{2-} and becomes $Cr(OH)_4^-$. The volume of 0.154 M CrO_4^{2-} needed for 40 mL of 0.25 M $S_2O_3^{2-}$ is _____ mL. *JEE Main (25 Feb 2021 Shift 1)* | *Hard*

Formula used: Electrons: 8 per $S_2O^2{}_3^-$, 3 per $CrO^2{}_4^-$. **Solution:**

Step 1: Cr: +6 (CrO_4^{2-}) → +3 ($Cr(OH)_4^-$) → 3 electrons gained per CrO_4^{2-}.

Step 2: S: +2 ($S_2O_3^{2-}$) → +6 (SO_4^{2-}): 4 electrons per S × 2 S = 8 electrons per $S_2O_3^{2-}$.

Step 3: Electrons from thiosulphate = 40 × 0.25 × 8 = 80 mmol.

Step 4: CrO_4^{2-} needed = 80/3 = 26.67 mmol → V = 26.67/0.154 = 173 mL.

Hence 173.

Ans: 173

139. A gaseous hydrocarbon $CxHy$ needs 6 volumes of O_2 and gives 4 volumes of CO_2. y = _____. *JEE Main (24 Feb 2021 Shift 2)* | *Easy*

Formula used: x + y/4 = 6. **Solution:**

$C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$.

Step 1: CO_2 = 4 volumes → x = 4.

Step 2: x + y/4 = 6 → y/4 = 2 → y = 8 (C_4H_8).

Hence 8.

Ans: 8

140. 1.86 g aniline gives acetanilide; 10% is lost in purification. The acetanilide obtained is _____ × 10^{-2} g. *JEE Main (24 Feb 2021 Shift 2)* | *Easy*

Formula used: 1 : 1. **Solution:**

Step 1: Aniline = 1.86/93 = 0.02 mol → acetanilide (M = 135) theoretical = 0.02 × 135 = 2.70 g.

Step 2: After 10% loss: 2.70 × 0.9 = 2.43 g = 243 × 10^{-2} g.

Hence 243.

Ans: 243

141. Potassium chlorate is made by electrolysis of KCl in base (6 e^- per ClO_3^-). With 60% current efficiency and 2 A, the time to make 10 g $KClO_3$ is _____ h. *JEE Main (6 Sep 2020 Shift 1)* | *Medium*

Formula used: Q = nFz/efficiency. **Solution:**

Step 1: $KClO_3$ (M = 122.5) = 10/122.5 = 0.0816 mol. **Step 2:** Charge needed = 0.0816 × 6 × 96 500 = 47 250 C.

Step 3: At 60% efficiency, charge passed = 47 250/0.6 = 78 750 C.

Step 4: Time = 78 750/2 = 39 375 s = 10.9 h ≈ 11 h. Hence 11.

Ans: 11

142. The ammonia formed from 2.8 kg dinitrogen and 1 kg dihydrogen is _____ g. *JEE Main (4 Sep 2020 Shift 1)* | *Easy*

Formula used: N_2 limiting. **Solution:**

Step 1: N_2 = 2800/28 = 100 mol; H_2 = 1000/2 = 500 mol.

Step 2: 100 mol N_2 needs 300 mol H_2 (available 500) → N_2 is limiting.

Step 3: NH_3 = 200 mol = 200 × 17 = 3400 g.

Hence 3400.

Ans: 3400

143. 1.43 g of $Na_2CO_3 \cdot xH_2O$ in 100 mL gives a 0.1 N solution. x = _____. *JEE Main (4 Sep 2020 Shift 2)* | *Easy*

Formula used: n-factor 2. **Solution:**

Step 1: Na_2CO_3 has n-factor 2, so 0.1 N = 0.05 M.

Step 2: Moles in 100 mL = 0.05 × 0.1 = 0.005 mol → M = 1.43/0.005 = 286 g mol^{-1}.

Step 3: 106 + 18x = 286 → x = 10.

Hence 10.

Ans: 10

144. The mole fraction of glucose in an aqueous binary solution is 0.1. The mass percentage of water is _____. *JEE Main (3 Sep 2020 Shift 1)* | *Easy*

Formula used: Use 1 mol total. **Solution:**

Take 0.1 mol glucose and 0.9 mol water.

Step 1: Glucose = 0.1 × 180 = 18 g; water = 0.9 × 18 = 16.2 g.

Step 2: Mass % of water = 16.2/(18 + 16.2) × 100 = 47.4% ≈ 47.

Hence 47.

Ans: 47

145. 6.023 × 10^{22} molecules are in 10 g of substance X. The molarity of 5 g of X in 2 L is _____ × 10^{-3}. *JEE Main (3 Sep 2020 Shift 2)* | *Easy*

Formula used: M = 100. **Solution:**

Step 1: 6.023 × 10^{22} molecules = 0.1 mol weighs 10 g → M = 100 g mol^{-1}.

Step 2: 5 g = 0.05 mol in 2 L → molarity = 0.025 M = 25 × 10^{-3}.

Hence 25.

Ans: 25

146. In an acyclic organic compound X, the mass ratios C : H and C : O are 4 : 1 and 3 : 4. The moles of O_2 needed to burn two moles of X are _____. *JEE Main (2 Sep 2020 Shift 2)* | *Medium*

Formula used: Empirical formula CH_3O → X = $C_2H_6O_2$. **Solution:**

Step 1: Take C = 12 g → H = 3 g, O = 16 g → mole ratio C : H : O = 1 : 3 : 1 → EF CH_3O.

Step 2: Acyclic stable compound: $(CH_3O)_2$ = $C_2H_6O_2$ (ethylene glycol).

Step 3: $C_2H_6O_2$ + 5/2 O_2 → 2CO_2 + 3H_2O.

Step 4: For 2 mol X, O_2 = 2 × 5/2 = 5 mol.

Hence 5.

Ans: 5

147. 5 g of zinc is treated separately with excess dilute HCl and aqueous NaOH. The ratio of volumes of H_2 evolved is *JEE Main (9 Jan 2020 Shift 2)* | *Easy*

(a) 1 : 2 (b) 1 : 4 (c) 1 : 1 (d) 2 : 1

Formula used: Zn gives 1 H_2 either way.

Solution: Zn + 2HCl → $ZnCl_2$ + H_2; Zn + 2NaOH → Na_2ZnO_2 + H_2.

In both reactions 1 mol Zn gives 1 mol H_2, so equal masses of Zn give equal volumes of H_2.

Ratio 1 : 1. Hence option (c).

Ans: (c)

148. 10.30 mg of O_2 dissolved in a litre of sea water (density 1.03 g mL^{-1}). The concentration in ppm is _____. *JEE Main (9 Jan 2020 Shift 2)* | *Easy*

Formula used: Mass ratio × 10^6. **Solution:**

Step 1: Mass of 1 L sea water = 1000 × 1.03 = 1030 g.

Step 2: ppm = (10.30 × 10^{-3}/1030) × 10^6 = 10 ppm. Hence 10.

Ans: 10

149. Ferrous sulphate heptahydrate fortifies food. The salt needed for 10 ppm of iron in 100 kg wheat is _____ g (Fe 55.85). *JEE Main (8 Jan 2020 Shift 1)* | *Medium*

Formula used: 1 g Fe needed. **Solution:**

Step 1: 10 ppm of iron in 100 kg (10^5 g) wheat = 10 × 10^5/10^6 = 1 g Fe.

Step 2: M($FeSO_4 \cdot 7H_2O$) = 55.85 + 96 + 126 = 277.85 g mol^{-1}.

Step 3: Salt = 1 × 277.85/55.85 = 4.97 g.

Hence 4.97.

Ans: 4.97

150. The ammonia from 0.6 g urea (NH_2CONH_2) with NaOH can be neutralised by *JEE Main (7 Jan 2020 Shift 2)* | *Easy*

(a) 100 mL of 0.2 N HCl (b) 200 mL of 0.4 N HCl

(c) 200 mL of 0.2 N HCl (d) 100 mL of 0.1 N HCl

Formula used: 2 NH_3 per urea. **Solution:**

Step 1: Urea (M = 60) = 0.6/60 = 0.01 mol → NH_3 = 0.02 mol (2 N per urea).

Step 2: HCl needed = 0.02 eq. Check options: (a) 0.100 × 0.2 = 0.02 eq ✓; (b) 0.08; (c) 0.04; (d) 0.01.

Hence option (a).

Ans: (a)

151. 25 g of a hydrocarbon on combustion gives 88 g CO_2 and 9 g H_2O. The hydrocarbon contains *JEE Main (12 Apr 2019 Shift 2)* | *Easy*

(a) 20 g C and 5 g H (b) 22 g C and 3 g H

(c) 24 g C and 1 g H (d) 18 g C and 7 g H

Formula used: C = 12/44, H = 2/18. **Solution:**

Step 1: C = 88 × 12/44 = 24 g.

Step 2: H = 9 × 2/18 = 1 g. Check: 24 + 1 = 25 g. Hence option (c).

Ans: (c)

152. At 300 K and 1 atm, 10 mL of a hydrocarbon needed 55 mL of O_2 for complete combustion and formed 40 mL of CO_2. The hydrocarbon is *JEE Main (10 Apr 2019 Shift 1)* | *Easy*

(a) C H (b) C H (c) C H Cl (d) C H

Formula used: x + y/4 = 5.5, x = 4. **Solution:**

Step 1: CO_2 = 40 mL from 10 mL → x = 4.

Step 2: O_2 per volume = 55/10 = 5.5 = x + y/4 → y/4 = 1.5 → y = 6.

Formula C_4H_6. Hence option (d).

Ans: (d)

153. For $N_2 + 3H_2 \rightarrow 2NH_3$, H_2 is the limiting reagent in *JEE Main (9 Apr 2019 Shift 1)* | *Easy*

(a) 28 g N_2 + 6 g H_2 (b) 14 g N_2 + 4 g H_2

(c) 56 g N_2 + 10 g H_2 (d) 35 g N_2 + 8 g H_2

Formula used: Needs 3 mol H_2 per mol N_2. **Solution:** Check moles H_2 needed = 3 × moles N_2.

(a) 1 mol N_2 needs 3 mol H_2; 3 available → exact. (b) 0.5 mol N_2 needs 1.5 mol; 2 available → N_2 limiting. (c) 2 mol N_2 needs 6 mol; only 5 available → H_2 limiting. (d) 1.25 mol N_2 needs 3.75 mol; 4 available → N_2 limiting.

Hence option (c).

Ans: (c)

154. 100 mmol $Ca(OH)_2$ and 2 g Na_2SO_4 were dissolved and made up to 100 mL. The mass of $CaSO_4$ formed and [OH^-] are (Ksp of $Ca(OH)_2$ = 5.5 × 10^{-6}) *JEE Main (12 Jan 2019 Shift 1)* | *Medium*

(a) 1.9 g, 0.28 mol L^{-1} (b) 13.6 g, 0.28 mol L^{-1}

(c) 1.9 g, 0.14 mol L^{-1} (d) 13.6 g, 0.14 mol L^{-1}

Formula used: Na_2SO_4 is limiting; NaOH forms. **Solution:**

Reaction: $Ca(OH)_2 + Na_2SO_4 \rightarrow CaSO_4 + 2NaOH$.

Step 1: Na_2SO_4 (M = 142) = 2/142 = 14.1 mmol (limiting).

Step 2: $CaSO_4$ = 14.1 mmol × 136 = 1.92 g ≈ 1.9 g. **Step 3:** NaOH = 28.2 mmol in 0.1 L → $[OH^-]$ = 0.28 M (excess $Ca(OH)_2$ is sparingly soluble, Ksp small, so its OH^- contribution is negligible).

Hence option (a).

Ans: (a)

155. A 10 mg effervescent tablet with sodium bicarbonate and oxalic acid releases 0.25 mL of CO_2 at 298.15 K and 1 bar (molar volume 25.0 L). The percentage of $NaHCO_3$ in the tablet is *JEE Main (11 Jan 2019 Shift 1)* | *Medium*

(a) 0.84 (b) 8.4 (c) 33.6 (d) 16.8

Formula used: 1 CO_2 per $NaHCO_3$. **Solution:**

Step 1: CO_2 = 0.25 mL/25 000 mL mol^{-1} = 1 × 10^{-5}mol.

Step 2: $NaHCO_3 : CO_2 = 1 : 1 \rightarrow NaHCO_3 = 10^{-5} \times 84 = 8.4 \times 10^{-4}$ g = 0.84 mg.

Step 3: % = (0.84/10) × 100 = 8.4%.

Hence option (b).

Ans: (b)

156. 25 mL of an HCl solution needs 30 mL of 0.1 M Na_2CO_3. The volume of this HCl needed to titrate 30 mL of 0.2 M NaOH is *JEE Main (11 Jan 2019 Shift 2)* | *Easy*

(a) 50 mL (b) 75 mL (c) 12.5 mL (d) 25 mL

Formula used: Find [HCl]. **Solution:**

Step 1: Na_2CO_3 = 3 mmol → HCl = 2 × 3 = 6 mmol in 25 mL → [HCl] = 0.24 M.

Step 2: NaOH = 30 × 0.2 = 6 mmol → HCl volume = 6/0.24 = 25 mL.

Hence option (d).

Ans: (d)

157. The amount of sugar ($C_{12}H_{22}O_{11}$) needed to prepare 2 L of its 0.1 M aqueous solution is *JEE Main (10 Jan 2019 Shift 2)* | *Easy*

(a) 136.8 g (b) 34.2 g (c) 68.4 g (d) 17.1 g

Formula used: n = MV. **Solution:**

Step 1: Moles = 0.1 × 2 = 0.2 mol.

Step 2: Mass = 0.2 × 342 = 68.4 g.

Hence option (c).

Ans: (c)

158. $2C_{57}H_{110}O_6 + 163O_2 \rightarrow 114CO_2 + 110H_2O$. The mass of water from 445 g of the fat is *JEE Main (9 Jan 2019 Shift 2)* | *Easy*

(a) 490 g (b) 495 g (c) 445 g (d) 890 g

Formula used: M = 890. **Solution:**

Step 1: $M(C_{57}H_{110}O_6)$ = 684 + 110 + 96 = 890 → 445 g = 0.5 mol.

Step 2: Water = 0.5 × 110/2 = 27.5 mol = 27.5 × 18 = 495 g.

Hence option (b).

Ans: (b)

159. A sample of $NaClO_3$ is heated to NaCl with loss of 0.16 g of oxygen. The residue precipitated as AgCl weighs (AgCl = 143.5) *JEE Main (Online 2018)* | *Easy*

(a) 0.54 g (b) 0.35 g (c) 0.48 g (d) 0.41 g

Formula used: $NaClO_3 \rightarrow NaCl + 3/2\ O_2$.

Solution: Reaction: $2NaClO_3 \rightarrow 2NaCl + 3O_2$.

Step 1: O_2 = 0.16/32 = 0.005 mol → NaCl = 0.005 × 2/3 = 0.00333 mol.

Step 2: AgCl = 0.00333 × 143.5 = 0.478 g ≈ 0.48 g. Hence option (c).

Ans: (c)

160. Per gram of reactant, the maximum N_2 is produced by *JEE Main (Online 2018)* | *Easy*

(a) $2NH_4NO_3 \rightarrow 2N_2 + 4H_2O + O_2$

(b) $Ba(N_3)_2 \rightarrow Ba + 3N_2$

(c) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$

(d) $2NH_3 \rightarrow N_2 + 3H_2$

Formula used: Moles N_2 per gram. **Solution:**

(a) $2NH_4NO_3$ (160 g) → $2N_2$: 2/160 = 1/80 mol per g. (b) $Ba(N_3)_2$ (221 g) → $3N_2$: 3/221 = 1/73.7 mol per g. (c) $(NH_4)_2Cr_2O_7$ (252 g) → $1N_2$: 1/252 mol per g.

(d) $2NH_3$ (34 g) → $1N_2$: 1/34 mol per g (largest).

Hence option (d).

Ans: (d)

161. 1 g of a carbonate M_2CO_3 with excess HCl gives 0.01186 mol CO_2. The molar mass of M_2CO_3 is *JEE Main (2017)* | *Easy*

(a) 118.6 (b) 11.86 (c) 1186 (d) 84.3

Formula used: Moles carbonate = moles CO_2.

Solution:

Step 1: 1 mol M_2CO_3 gives 1 mol CO_2 → moles of carbonate = 0.01186.

Step 2: Molar mass = 1/0.01186 = 84.3 g mol^{-1}.

Hence option (d).

Ans: (d)

162. Excess NaOH added to 100 mL of $FeCl_3$ solution gives 2.14 g $Fe(OH)_3$. The molarity of $FeCl_3$ is *JEE Main (Online 2017)* | *Easy*

(a) 0.2 M (b) 1.8 M (c) 0.3 M (d) 0.6 M

Formula used: 1 : 1. **Solution:**

Step 1: $Fe(OH)_3$ (M = 107) = 2.14/107 = 0.02 mol = moles of $FeCl_3$.

Step 2: Molarity = 0.02/0.1 = 0.2 M.

Hence option (a).

Ans: (a)

163. The volume of 45% acid to be mixed with 20% acid to make 800 mL of 29.875% acid is *JEE Main (Online 2017)* | *Easy*

(a) 330 mL (b) 316 mL (c) 320 mL (d) 325 mL

Formula used: Mixing balance. **Solution:**

Let x mL of 45% acid; (800 − x) mL of 20% acid.

Step 1: 0.45x + 0.20(800 − x) = 0.29875 × 800 = 239. **Step 2:** 0.25x = 239 − 160 = 79 → x = 316 mL.

Hence option (b).

Ans: (b)

164. 5 L of an alkane needs 25 L of oxygen for complete combustion (same T and P). The alkane is *JEE Main (Online 2016)* | *Easy*

(a) isobutane (b) ethane

(c) butane (d) propane

Formula used: (3n + 1)/2 = 5. **Solution:**

$C_nH_{2n+2} + (3n + 1)/2\ O_2 \rightarrow nCO_2 + (n + 1)H_2O$.

Step 1: O_2 per volume = 25/5 = 5 = (3n + 1)/2 → n = 3 (propane).

Hence option (d).

Ans: (d)

165. The amount of arsenic pentasulphide obtained when 35.5 g arsenic acid (H_3AsO_4) is treated with excess H_2S in conc. HCl is *JEE Main (Online 2016)* | *Easy*

(a) 0.25 mol (b) 0.50 mol

(c) 0.333 mol (d) 0.125 mol

Formula used: $2\ H_3AsO_4 \rightarrow As_2S_5$. **Solution:**

Reaction: $2H_3AsO_4 + 5H_2S \rightarrow As_2S_5 + 8H_2O$.

Step 1: H_3AsO_4 (M = 142) = 35.5/142 = 0.25 mol.

Step 2: As_2S_5 = 0.25/2 = 0.125 mol.

Hence option (d).

Ans: (d)

166. The volume of 0.1 N dibasic acid sufficient to neutralise 1 g of a base that furnishes 0.04 mol OH^- is *JEE Main (Online 2016)* | *Easy*

(a) 400 mL (b) 600 mL (c) 200 mL (d) 800 mL

Formula used: Equivalents. **Solution:**

Step 1: The base furnishes 0.04 mol OH^- = 0.04 equivalents.

Step 2: Volume of 0.1 N acid = 0.04/0.1 = 0.4 L = 400 mL.

Hence option (a).

Ans: (a)

167. 3 g activated charcoal was added to 50 mL of 0.06 N acetic acid; afterwards the filtrate was 0.042 N. The acetic acid adsorbed per gram of charcoal is *JEE Main (2015)* | *Easy*

(a) 42 mg (b) 54 mg (c) 18 mg (d) 36 mg

Formula used: Moles removed. **Solution:**

Step 1: Acid adsorbed = (0.06 − 0.042) × 50 = 0.9 meq = 0.9 mmol (monobasic).

Step 2: Mass = 0.9 × 60 = 54 mg.

Step 3: Per gram of charcoal = 54/3 = 18 mg.

Hence option (c).

Ans: (c)

168. A hydrate of barium chloride weighing 61 g gave 52 g of anhydrous salt (Ba 137, Cl 35.5). The formula is *JEE Main (Online 2015)* | *Easy*

(a) $BaCl_2 \cdot H_2O$ (b) $BaCl_2 \cdot 2H_2O$

(c) $BaCl_2 \cdot 3H_2O$ (d) $BaCl_2 \cdot 4H_2O$

Formula used: Moles of water per salt. **Solution:**

Step 1: $BaCl_2$ (M = 208) = 52/208 = 0.25 mol.

Step 2: Water lost = 61 − 52 = 9 g = 0.5 mol.

Step 3: H_2O per $BaCl_2$ = 0.5/0.25 = 2 → $BaCl_2 \cdot 2H_2O$. Hence option (b).

Ans: (b)

169. A + 2B + 3C ⇌ AB_2C_3: 6.0 g A, 6.0 × 10^{23} atoms of B and 0.036 mol C give 4.8 g of product. Atomic masses of A and C are 60 and 80. The atomic mass of B is (N_A = 6 × 10^{23}) *JEE Main (Online 2015)* | *Medium*

(a) 70 amu (b) 60 amu (c) 50 amu (d) 40 amu

Formula used: C is limiting. **Solution:**

Step 1: A = 6/60 = 0.1 mol; B = 1 mol; C = 0.036 mol. **Step 2:** Divide by coefficients: A 0.1, B 0.5, C 0.012 → C is limiting; product = 0.012 mol.

Step 3: M(AB_2C_3) = 4.8/0.012 = 400 g mol^{-1}.

Step 4: 60 + 2B + 3 × 80 = 400 → 2B = 100 → B = 50 amu.

Hence option (c).

Ans: (c)

170. The $BaSO_4$ formed on mixing 100 mL of 20.8% $BaCl_2$ with 50 mL of 9.8% H_2SO_4 is *JEE Main (Online 2014)* | *Easy*

(a) 23.3 g (b) 11.65 g (c) 30.6 g (d) 33.2 g

Formula used: Limiting reagent. **Solution:**

Step 1: $BaCl_2$ = 20.8 g (in 100 mL) = 20.8/208 = 0.1 mol.

Step 2: H_2SO_4 = 9.8% of 50 mL = 4.9 g = 0.05 mol (limiting).

Step 3: $BaSO_4$ = 0.05 × 233 = 11.65 g.

Hence option (b).

Ans: (b)

171. The molarity of a mixture of 750 mL of 0.5 M HCl and 250 mL of 2 M HCl is *JEE Main (2013)* | *Easy*

(a) 0.975 M (b) 0.875 M (c) 1.00 M (d) 1.75 M

Formula used: Total moles/total volume.

Solution: Step 1: Moles = 0.75 × 0.5 + 0.25 × 2 = 0.375 + 0.5 = 0.875 mol.

Step 2: Volume = 1 L → molarity = 0.875 M.

Hence option (b).

Ans: (b)

172. CO_2 passed over red-hot coke is partly reduced to CO. 0.5 L of CO_2 becomes 700 mL of gases. The composition at STP is *AIEEE (Online 2012)* | *Easy*

(a) CO_2 300 mL; CO 400 mL

(b) CO_2 0 mL; CO 700 mL

(c) CO_2 200 mL; CO 500 mL

(d) CO_2 350 mL; CO 350 mL

Formula used: CO_2 + C → 2CO. **Solution:**

Reaction: CO_2 + C → 2CO (1 volume gives 2 volumes). **Step 1:** Let x mL CO_2 react → forms 2x mL CO.

Step 2: Total = (500 − x) + 2x = 700 → x = 200 mL. **Step 3:** CO_2 = 300 mL; CO = 400 mL.

Hence option (a).

Ans: (a)

173. The mass of potassium dichromate (294) needed to oxidise 750 mL of 0.6 M Mohr's salt solution is *AIEEE (2011)* | *Easy*

(a) 0.45 g (b) 22.05 g (c) 2.2 g (d) 0.49 g

Formula used: 1 $Cr_2O_7^{2-}$: 6 Fe^{2+}. **Solution:**

Reaction: $Cr_2O_7^{2-}$ + 6Fe^{2+} + 14H^+ → 2Cr^{3+} + 6Fe^{3+} + 7H_2O.

Step 1: Fe^{2+} = 0.75 × 0.6 = 0.45 mol.

Step 2: $K_2Cr_2O_7$ = 0.45/6 = 0.075 mol = 0.075 × 294 = 22.05 g.

Hence option (b).

Ans: (b)

174. In 2Al(s) + 6HCl(aq) → $2Al^{3+}$ + $6Cl^-$ + $3H_2$(g), *AIEEE (2007)* | *Easy*

(a) 11.2 L H_2 at STP is produced for every mole of HCl consumed

(b) 6 L HCl(aq) is consumed for every 3 L H_2 produced

(c) 33.6 L H_2 is produced regardless of T and P for every mole of Al

(d) 67.2 L H_2 at STP is produced for every mole of Al

Formula used: 3 H_2 per 6 HCl. **Solution:**

(a) 6 mol HCl give 3 mol H_2 → 1 mol HCl gives 0.5 mol H_2 = 11.2 L at STP → correct.

(b) HCl is an aqueous solution; its volume cannot be compared with gas volumes → wrong.

(c) 1 mol Al gives 1.5 mol H_2 = 33.6 L only at STP → wrong.

(d) 67.2 L per mole of Al is double the correct value → wrong.

Hence option (a).

Ans: (a)

175. The volume of hydrogen at 273 K and 1 atm needed to obtain 21.6 g of boron from BCl_3 is (B = 10.8) *AIEEE (2003)* | *Easy*

(a) 89.6 L (b) 67.2 L (c) 44.8 L (d) 22.4 L

Formula used: $2BCl_3 + 3H_2 \rightarrow 2B + 6HCl$.

Solution: Reaction: $2BCl_3 + 3H_2 \rightarrow 2B + 6HCl$.

Step 1: B = 21.6/10.8 = 2 mol → H_2 = 3 mol.

Step 2: Volume = 3 × 22.4 = 67.2 L.

Hence option (b).

Ans: (b)

176. With increase of temperature, which changes? *AIEEE (2002)* | *Medium*

(a) molality

(b) weight fraction of solute

(c) fraction of solute present in water

(d) mole fraction

Formula used: Volume-based quantities change.

Solution:

Molality, weight fraction and mole fraction are based on masses or moles only, which do not change with temperature.

The fraction of solute present per unit volume of water (a volume-based quantity) changes because volume changes with temperature.

Hence option (c) (official answer).

Ans: (c)

E. JEE Advanced Questions

Single Correct Option

1. The abundances of ^{54}Fe, ^{56}Fe and ^{57}Fe are 5%, 90% and 5%. The atomic mass of Fe is *IIT-JEE (2009)* | *Easy*

(a) 55.85 (b) 55.95 (c) 55.75 (d) 56.05

Formula used: Weighted average. **Solution:**

Formula: average atomic mass = Σ(fraction × isotopic mass).

Step 1: 0.05 × 54 = 2.70; 0.90 × 56 = 50.40; 0.05 × 57 = 2.85.

Step 2: Sum = 2.70 + 50.40 + 2.85 = 55.95.

Hence option (b).

Ans: (b)

2. The maximum number of atoms is in *IIT-JEE (2003)* | *Easy*

(a) 24 g of C (12) (b) 56 g of Fe (56)

(c) 27 g of Al (27) (d) 108 g of Ag (108)

Formula used: Moles of atoms. **Solution:**

Number of atoms ∝ moles = mass/atomic mass.

(a) 24/12 = 2 mol; (b) 56/56 = 1 mol; (c) 27/27 = 1 mol; (d) 108/108 = 1 mol.

Carbon has the most moles of atoms. Hence option (a).

Ans: (a)

3. 2 L of a solution contains 0.02 mol $\left[Co\left(NH_3\right)_5SO_4\right)Br$ and 0.02 mol $\left[Co\left(NH_3\right)_5Br\right)SO_4$. 1 L + excess $AgNO_3$ → Y; 1 L + excess $BaCl_2$ → Z. The moles of Y and Z are *IIT-JEE (2003)* | *Medium*

(a) 0.01, 0.01 (b) 0.02, 0.01

(c) 0.01, 0.02 (d) 0.02, 0.02

Formula used: Only ions outside the sphere react. **Solution:**

Concept: only ions outside the coordination sphere (counter-ions) are precipitated.

Step 1: Each litre contains 0.01 mol of each complex. **Step 2:** With $AgNO_3$, only $[Co(NH_3)_5SO_4]Br$ gives free Br^- → 0.01 mol AgBr (Y).

Step 3: With $BaCl_2$, only $[Co(NH_3)_5Br]SO_4$ gives free SO_4^{2-} → 0.01 mol $BaSO_4$ (Z).

Hence option (a).

Ans: (a)

4. The moles of electrons weighing one kilogram are (electron mass 9.108×10^{-31} kg) *IIT-JEE (2001)* | *Medium*

(a) 6.023×10^{23}

(b) $(1/9.108) \times 10^{31}$

(c) $(6.023/9.108) \times 10^{54}$

(d) $1/(9.108 \times 6.023) \times 10^{8}$

Formula used: $n = (1\ kg/m_e)/N_A$. **Solution:**

Step 1: Number of electrons in 1 kg = $1/(9.108 \times 10^{-31}) = 10^{31}/9.108$.

Step 2: Moles = $(10^{31}/9.108)/(6.023 \times 10^{23}) = 10^{8}/(9.108 \times 6.023)$.

Hence option (d).

Ans: (d)

5. An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH needed to neutralise 10 mL of it is *IIT-JEE (2001)* | *Easy*

(a) 40 mL (b) 20 mL (c) 10 mL (d) 4 mL

Formula used: Dibasic acid. **Solution:**

Step 1: $H_2C_2O_4 \cdot 2H_2O$ (M = 126) = 6.3/126 = 0.05 mol in 0.25 L → 0.2 M = 0.4 N (dibasic).

Step 2: 10 mL contains 10 × 0.4 = 4 meq.

Step 3: Volume of 0.1 N NaOH = 4/0.1 = 40 mL.

Hence option (a).

Ans: (a)

6. The normality of 0.3 M phosphorous acid (H_3PO_3) is *IIT-JEE (1999)* | *Easy*

(a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6

Formula used: H_3PO_3 is dibasic. **Solution:**

Concept: H_3PO_3 has structure $HP(O)(OH)_2$ — only two ionisable H (P–OH); it is dibasic.

Step 1: n-factor = 2 → N = 0.3 × 2 = 0.6.

Hence option (d).

Ans: (d)

7. The moles of $KMnO_4$ needed to react with one mole of ferrous oxalate in acid are *IIT-JEE (1997)* | *Medium*

(a) 3/5 (b) 2/5 (c) 4/5 (d) 1

Formula used: Fe^{2+} (1 e^-) + $C_2O_4^{2-}$ (2 e^-) = 3 e^-; MnO_4^- takes 5. **Solution:**

Step 1: FeC_2O_4 is oxidised at two sites: $Fe^{2+} \rightarrow Fe^{3+}$(1 e^-) and $C_2O_4^{2-} \rightarrow 2CO_2$ (2 e^-) → 3 e^- per formula unit.

Step 2: $MnO_4^- \rightarrow Mn^{2+}$ accepts 5 e^-.

Step 3: Moles of $KMnO_4$ = 3/5.

Hence option (a).

Ans: (a)

8. The equivalent weight of $MnSO_4$ is half its molecular weight when it is converted to *IIT-JEE (1988)* | *Medium*

(a) Mn_2O_3 (b) MnO_2 (c) MnO^-_4 (d) MnO^{2-}_4

Formula used: n-factor = 2. **Solution:**

Concept: equivalent weight = M/n-factor; half means n-factor = 2.

Mn is +2 in $MnSO_4$; it must go to +4 → MnO_2.

Check: Mn_2O_3 (+3) gives 1; MnO_4^- (+7) gives 5; MnO_4^{2-} (+6) gives 4.

Hence option (b).

Ans: (b)

9. The concentration expression independent of temperature is *IIT-JEE (1988)* | *Easy*

(a) molarity (b) normality

(c) formality (d) molality

Formula used: Mass-based. **Solution:**

Molarity, normality and formality are per litre of solution — volume changes with temperature.

Molality = moles per kg of solvent — masses do not change with temperature.

Hence option (d).

Ans: (d)

10. A molal solution contains one mole of solute in *IIT-JEE (1986)* | *Easy*

(a) 1000 g of the solvent

(b) one litre of the solvent

(c) one litre of the solution

(d) 22.4 litres of the solution

Formula used: Definition. **Solution:**

Definition: molality = moles of solute per kg (1000 g) of solvent.

So a 1 molal solution has 1 mol solute in 1000 g solvent.

Hence option (a).

Ans: (a)

11. If 0.50 mol $BaCl_2$ is mixed with 0.20 mol Na_3PO_4, the maximum moles of $Ba_3(PO_4)_2$ formed are *IIT-JEE (1981)* | *Easy*

(a) 0.70 (b) 0.50 (c) 0.20 (d) 0.10

Formula used: Phosphate limiting. **Solution:**

Reaction: $3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$. **Step 1:** $BaCl_2$: 0.50/3 = 0.167; Na_3PO_4: 0.20/2 = 0.10 → Na_3PO_4 is limiting.

Step 2: $Ba_3(PO_4)_2$ = 0.20/2 = 0.10 mol.

Hence option (d).

Ans: (d)

12. The total number of electrons in one molecule of carbon dioxide is *IIT-JEE (1979)* | *Easy*

(a) 22 (b) 44 (c) 66 (d) 88

Formula used: Sum of atomic numbers.

Solution:

Electrons = sum of atomic numbers: C (6) + 2 × O (8) = 6 + 16 = 22.

Hence option (a).

Ans: (a)

13. The largest number of molecules is in *IIT-JEE (1979)* | *Easy*

(a) 36 g of water

(b) 28 g of carbon monoxide

(c) 46 g of ethyl alcohol

(d) 54 g of nitrogen pentoxide

Formula used: Moles. **Solution:**

(a) 36 g H_2O = 2 mol; (b) 28 g CO = 1 mol; (c) 46 g C_2H_5OH = 1 mol; (d) 54 g N_2O_5 = 0.5 mol.

Water has the most molecules. Hence option (a).

Ans: (a)

14. Equal amounts of zinc are treated separately with excess sulphuric acid and excess sodium hydroxide. The ratio of volumes of hydrogen is *IIT-JEE (1979)* | *Easy*

(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 9 : 4

Formula used: Zn → H_2 in both. **Solution:**

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$; $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$.

Both give 1 mol H_2 per mol Zn, so the volumes are equal: 1 : 1.

Hence option (a).

Ans: (a)

15. 2.76 g of silver carbonate on being strongly heated yields a residue weighing *IIT-JEE (1979)* | *Medium*

(a) 2.16 g (b) 2.48 g (c) 2.32 g (d) 2.64 g

Formula used: Strong heating: $Ag_2CO_3 \rightarrow Ag_2O \rightarrow Ag$. **Solution:**

Concept: on strong heating $Ag_2CO_3 \rightarrow Ag_2O + CO_2$, and Ag_2O further decomposes: $2Ag_2O \rightarrow 4Ag + O_2$. The residue is silver metal.

Step 1: Ag_2CO_3 (M = 276) = 2.76/276 = 0.01 mol → Ag = 0.02 mol.

Step 2: Residue = 0.02 × 108 = 2.16 g.

Note: if heating stopped at Ag_2O, the residue would be 0.01 × 232 = 2.32 g.

Hence option (a).

Ans: (a)

One or More Correct Options

16. Binary compounds P_mQ_n have weight % of P and Q: compound 1 (50, 50), 2 (44.4, 55.6), 3 (40, 60). The correct option(s) is(are) *JEE Advanced (2022)* | *Hard*

(a) If compound 3 is P_3Q_4, compound 2 is P_3Q_5

(b) If compound 3 is P_3Q_2 and P = 20, then Q = 45

(c) If compound 2 is PQ, compound 1 is P_5Q_4

(d) If P = 70 and Q = 35, compound 1 is P_2Q

Formula used: Compare Q : P mass ratios (1.00, 1.25, 1.50). **Solution:**

Method: compare mass of Q per gram of P — compound 1: 50/50 = 1.00; compound 2: 55.6/44.4 = 1.25; compound 3: 60/40 = 1.50.

(a) If compound 3 is P_3Q_4 (Q/P atom ratio 4/3 for mass ratio 1.5), compound 2 has Q/P atoms = (4/3)(1.25/1.5) = 10/9 → P_9Q_{10}, not P_3Q_5 → wrong.

(b) Compound 3 as P_3Q_2 with P = 20: mass 60 g P per 3 atoms; Q: 1.5 × 60 = 90 g for 2 atoms → Q = 45 → correct.

(c) If compound 2 is PQ, compound 1 has Q/P atoms = 1.00/1.25 = 4/5 → P_5Q_4 → correct.

(d) With P = 70, Q = 35: compound 1 has equal masses → P : Q atoms = 1/70 : 1/35 = 1 : 2 → PQ_2, not P_2Q → wrong.

Hence options (b) and (c).

Ans: (b), (c)

Numerical / Integer Value

17. 100 mL of 0.5 M acetic acid is used to form a monolayer on 1 g charcoal; unadsorbed acid needs 40 mL of 1 M NaOH. Each acetic acid molecule occupies P × 10^{-23} m² (charcoal area 1.5 × 10^{2} m² g⁻¹; N_A = 6.0 × 10^{23}). P = _____. *JEE Advanced (2024)* | *Hard*

Formula used: Adsorbed molecules cover the surface. **Solution:**

Step 1: Acid taken = 100 × 0.5 = 50 mmol; unadsorbed = 40 × 1 = 40 mmol → adsorbed = 10 mmol.

Step 2: Molecules adsorbed = 0.010 × 6.0 × 10^{23} = 6.0 × 10^{21}.

Step 3: Area per molecule = 1.5 × 10^{2} m²/6.0 × 10^{21}= 2.5 × 10^{-20} m² = 2500 × 10^{-23} m².

Hence P = 2500.

Ans: 2500

18. The treatment of an aqueous solution of 3.74 g of $Cu(NO_3)_2$ with excess KI results in a brown solution along with a precipitate. Passing H_2S through this brown solution gives another precipitate X. The amount of X (in g) is _____. (H = 1, N = 14, O = 16, S = 32, K = 39, Cu = 63, I = 127) *JEE Advanced (2022)* | *Hard*

Formula used: $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$; $H_2S + I_2 \rightarrow S + 2HI$. **Solution:**

Reactions: $2Cu^{2+} + 4I^- \rightarrow 2CuI\downarrow + I_2$ (brown); then $I_2 + H_2S \rightarrow 2HI + S\downarrow$ (X = sulphur).

Step 1: $Cu(NO_3)_2$ (M = 187) = 3.74/187 = 0.02 mol → I_2 = 0.01 mol.

Step 2: S formed = 0.01 mol = 0.01 × 32 = 0.32 g. Hence 0.32.

Ans: 0.32

19. Dissolving 1.24 g of white phosphorus in boiling NaOH solution in an inert atmosphere gives a gas Q. The amount of $CuSO_4$ (in g) required to completely consume Q is _____. (H = 1, O = 16, Na = 23, P = 31, S = 32, Cu = 63) *JEE Advanced (2022)* | *Hard*

Formula used: $P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$; $3CuSO_4 + 2PH_3 \rightarrow Cu_3P_2 + 3H_2SO_4$. **Solution:**

Reaction: $P_4 + 3NaOH + 3H_2O \rightarrow PH_3$ (Q) + $3NaH_2PO_2$.

Step 1: P_4 (M = 124) = 1.24/124 = 0.01 mol → PH_3 = 0.01 mol.

Step 2: PH_3 is absorbed by $CuSO_4$: $3CuSO_4 + 2PH_3 \rightarrow Cu_3P_2 + 3H_2SO_4$ ($CuSO_4$: PH_3 = 3 : 2).

Step 3: $CuSO_4$ = 0.015 mol × 159 = 2.385 g ≈ 2.38 g. Hence 2.38.

Ans: 2.38

20. 5.6 g of an iron sample is dissolved in cold dilute HCl to make 250 mL. 25.0 mL of this needs 12.5 mL of 0.03 M $KMnO_4$. The moles of Fe^{2+} in 250 mL are x × 10^{-2}. x = _____. *JEE Advanced (2021)* | *Medium*

Formula used: MnO^-_4 : Fe^{2+} = 1 : 5. **Solution:**

Reaction: $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$.

Step 1: $KMnO_4$ used = 12.5 × 0.03 = 0.375 mmol → Fe^{2+} in 25 mL = 5 × 0.375 = 1.875 mmol.

Step 2: In 250 mL = 18.75 mmol = 1.875 × 10^{-2} mol. Hence x = 1.87 (1.875).

Ans: 1.87

21. For the sample above, the amount of iron is y % by weight. y = _____. *JEE Advanced (2021)* | *Medium*

Formula used: Fe mass/sample mass. **Solution:**

Step 1: Fe^{2+} in 250 mL = 0.01875 mol → mass = 0.01875 × 56 = 1.05 g.

Step 2: % Fe = (1.05/5.6) × 100 = 18.75%.

Hence 18.75.

Ans: 18.75

22. Aluminium reacts with sulphuric acid to form aluminium sulphate and hydrogen. The volume of hydrogen (in L) produced at 300 K and 1.0 atm when 5.4 g of Al and 50.0 mL of 5.0 M H_2SO_4 are combined is _____. (Al = 27.0; R = 0.082 atm L mol^{-1} K^{-1}) *JEE Advanced (2020)* | *Hard*

Formula used: $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$; pV = nRT. **Solution:**

Reaction: $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$.

Step 1: Al = 5.4/27 = 0.2 mol (0.2/2 = 0.1); H_2SO_4 = 0.050 × 5.0 = 0.25 mol (0.25/3 = 0.083) → acid is limiting. **Step 2:** H_2 = 0.25 mol.

Step 3: V = nRT/p = 0.25 × 0.082 × 300/1.0 = 6.15 L. Hence 6.15.

Ans: 6.15

23. 5.00 mL of 0.10 M oxalic acid is titrated with NaOH (phenolphthalein); burette readings 12.5, 10.5, 9.0, 9.0, 9.0 mL. The molarity of NaOH is _____. *JEE Advanced (2020)* | *Easy*

Formula used: Use the concordant value 9.0 mL.
Solution:

Step 1: Concordant reading = 9.0 mL (first readings are rough).

Step 2: Oxalic acid = 5.00 × 0.10 = 0.5 mmol → NaOH needed = 1.0 mmol (dibasic acid).

Step 3: Molarity of NaOH = 1.0/9.0 = 0.111 M ≈ 0.11. Hence 0.11.

Ans: 0.11

24. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm^{-3}, the molarity of the urea solution is _____. (Urea = 60, water = 18) *JEE Advanced (2019)* | *Hard*

Formula used: $x_B = n_B/(n_A + n_B)$; M = n/V.
Solution: Step 1: Water = 900/18 = 50 mol; n/(n + 50) = 0.05 → n = 2.632 mol urea = 157.9 g.

Step 2: Mass of solution = 900 + 157.9 = 1057.9 g; volume = 1057.9/1.2 = 881.6 mL.

Step 3: Molarity = 2.632/0.8816 = 2.98 M.

Hence 2.98.

Ans: 2.98

25. $MnCl_2$ in solution is fully converted to $KMnO_4$ (with $K_2S_2O_8$). Oxalic acid (225 mg) added in portions just decolourises it. The $MnCl_2$ present was _____ mg (Mn 55, Cl 35.5). *JEE Advanced (2018)* | *Hard*

Formula used: Oxalic acid 2 e^-; MnO^-_4 5 e^-.
Solution:

Step 1: Oxalic acid (M = 90) = 225/90 = 2.5 mmol.

Step 2: $2MnO_4^- + 5C_2O_4^{2-} \rightarrow \ldots \rightarrow MnO_4^-$ = 2.5 × 2/5 = 1.0 mmol.

Step 3: $MnCl_2$ = 1.0 mmol (all Mn converted) = 1.0 × 126 = 126 mg.

Hence 126.

Ans: 126

26. The mole fraction of a solute is 0.1. At 298 K its molarity equals its molality; density 2.0 g cm^{-3}. The ratio of molecular weights of solute and solvent is _____. *JEE Advanced (2016)* | *Hard*

Formula used: Use 1 mol solute, 9 mol solvent.
Solution:

Take 0.1 mol solute (M_1) and 0.9 mol solvent (M_2).

Step 1: Molality = $0.1/(0.9M_2/1000) = 1000/(9M_2)$.

Step 2: Volume of solution = $(0.1M_1 + 0.9M_2)/2.0$ mL → molarity = $0.1 \times 2000/(0.1M_1 + 0.9M_2)$.

Step 3: Equate: $1000/(9M_2) = 2000/(M_1 + 9M_2)$ → $M_1 + 9M_2 = 18M_2$ → $M_1 = 9M_2$.

Hence the ratio $M_1/M_2 = 9$.

Ans: 9

27. If the value of Avogadro number is 6.023×10^{23} mol^{-1} and the Boltzmann constant is 1.380×10^{-23} J K^{-1}, the number of significant digits in the calculated value of the universal gas constant is _____. *JEE Advanced (2014)* | *Easy*

Formula used: R = $N_A \times k$; product has the least number of significant figures of the factors.
Solution:

$R = N_A \times k_B = 6.023 \times 10^{23} \times 1.380 \times 10^{-23} = 8.312$ J K^{-1} mol^{-1}.

Rule: in multiplication, keep the least number of significant figures; both data have 4.

So R is reported to 4 significant figures (8.312).

Hence 4.

Ans: 4

28. A compound H_2X (M = 80) is dissolved in a solvent of density 0.4 g mL^{-1} with no volume change. The molality of a 3.2 molar solution is _____. *JEE Advanced (2014)* | *Medium*

Formula used: 1 L solution ≈ 1 L solvent.
Solution: Take 1 L solution with no volume change on dissolving → solvent volume = 1 L = 400 g.

Step 1: Solute = 3.2 mol.

Step 2: Molality = 3.2/0.4 = 8 mol kg^{-1}.

Hence 8.

Ans: 8

29. 29.2% (w/w) HCl has density 1.25 g mL^{-1}. The volume (mL) needed to make 200 mL of 0.4 M HCl is _____. *IIT-JEE (2012)* | *Easy*

Formula used: M = 10 × 1.25 × 29.2/36.5 = 10 M. **Solution:**

Step 1: Molarity of stock = (10 × 29.2 × 1.25)/36.5 = 10 M.

Step 2: Moles needed = 0.2 × 0.4 = 0.08 mol.

Step 3: Volume = 0.08/10 = 0.008 L = 8 mL.

Hence 8.

Ans: 8

30. Br_2 with Na_2CO_3 in water gives NaBr, $NaBrO_3$ and CO_2. The number of NaBr molecules in the balanced equation is _____. *IIT-JEE (2011)* | *Medium*

Formula used: Disproportionation. **Solution:**

Br_2 disproportionates: Br (0) → Br^- (−1, gain 1 e^-) and Br (0) → BrO_3^- (+5, lose 5 e^-).

Step 1: Electron balance: 5 Br^- for each BrO_3^-.

Step 2: $3Br_2 + 3Na_2CO_3 \rightarrow 5NaBr + NaBrO_3 + 3CO_2$. Hence 5 NaBr.

Ans: 5

31. The volume (mL) of 0.1 M $AgNO_3$ for complete precipitation of chloride from 30 mL of 0.01 M $\left[Cr\left(H_2O\right)_5Cl\right]Cl_2$ is close to _____. *IIT-JEE (2011)* | *Easy*

Formula used: Two ionisable Cl^-. **Solution:**

Step 1: $[Cr(H_2O)_5Cl]Cl_2$ has 2 ionisable Cl^- (one Cl is coordinated).

Step 2: Cl^- = 30 × 0.01 × 2 = 0.6 mmol.

Step 3: $AgNO_3$ = 0.6/0.1 = 6 mL.

Hence 6.

Ans: 6

32. Titre values of 25.2 mL, 25.25 mL and 25.0 mL are obtained. The number of significant figures in the average titre value is _____. *IIT-JEE (2010)* | *Medium*

Formula used: Round to the least precise reading. **Solution:**

Step 1: Average = (25.2 + 25.25 + 25.0)/3 = 75.45/3 = 25.15 mL.

Step 2: The least precise reading (25.2, 25.0) has one decimal place → report 25.2.

Step 3: 25.2 has 3 significant figures.

Hence 3.

Ans: 3

33. Silver (108 g mol^{-1}) has density 10.5 g cm^{-3}. The number of Ag atoms on a surface of area 10^{-12} m² is y × 10^x. x = _____. *IIT-JEE (2010)* | *Hard*

Formula used: Atoms per cm^2 = (atoms per cm^3) to the power 2/3. **Solution:**

Step 1: Atoms per cm^3 = (10.5/108) × 6.022 × 10^{23} = 5.86 × 10^{22} cm^{-3}.

Step 2: Atoms per cm^2 of surface ≈ (5.86 × 10^{22}) raised to 2/3 = 1.51 × 10^{15} cm^{-2}.

Step 3: Area = 10^{-12} m^2 = 10^{-8} cm^2 → atoms = 1.51 × 10^{15} × 10^{-8} = 1.5 × 10^7.

Hence x = 7.

Ans: 7

Fill in the Blanks

34. In $YBa_2Cu_3O_7$ (Y is +3), copper is in oxidation state _____. *IIT-JEE (1994)* | *Medium*

Formula used: Sum of oxidation states = 0. **Solution: Step 1:** Y +3, Ba +2 (two Ba = +4), O −2 (seven O = −14), Cu = x each.

Step 2: 3 + 4 + 3x − 14 = 0 → 3x = 7 → x = +7/3 (average).

Hence +7/3.

Ans: +7/3

35. The weight of 1 × 10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is _____. *IIT-JEE (1991)* | *Easy*

Formula used: M = 249.5. **Solution:**

Step 1: Moles = 1 × 10^{22}/6.022 × 10^{23} = 0.0166 mol. **Step 2:** Mass = 0.0166 × 249.5 = 4.14 g.

Hence 4.14 g.

Ans: 4.14 g

36. The total number of electrons in 18 mL of water is _____. *IIT-JEE (1980)* | *Easy*

Formula used: 10 e^- per molecule. **Solution:**

Step 1: 18 mL water = 18 g = 1 mol.

Step 2: Each H_2O has 2 + 8 = 10 electrons → 10 mol electrons = 10 × 6.02 × 10^{23} = 6.02 × 10^{24}.

Hence 6.02 × 10^{24}.

Ans: 6.02 × 10^{24}

37. The modern atomic mass unit is based on the mass of _____. *IIT-JEE (1980)* | *Easy*

Formula used: Definition. **Solution:**

1 amu (u) = 1/12 of the mass of one carbon-12 atom = 1.66×10^{-27} kg.

Hence carbon-12.

Ans: carbon-12

38. Of the halide ions, _____ is the most powerful reducing agent. *IIT-JEE (1978)* | *Easy*

Formula used: Largest, least electronegative. **Solution:**

Reducing power increases down the group as ionic size increases and electrons are lost more easily (E° of I_2/I^- is lowest).

Hence I^-.

Ans: I^-

Statement Type

39. Statement 1: In the titration of Na_2CO_3 with HCl using methyl orange, the volume at the equivalence point is twice that with phenolphthalein. Statement 2: Two moles of HCl are needed for complete neutralisation of one mole of Na_2CO_3. *IIT-JEE (1991)* | *Medium*

(a) Both true; 2 explains 1
(b) Both true; 2 does not explain 1
(c) 1 true, 2 false
(d) 1 false, 2 true

Formula used: Phenolphthalein marks HCO^-_3 only. **Solution:**

Phenolphthalein end point: $Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$ (1 mol HCl).

Methyl orange end point: complete neutralisation, $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$ (2 mol HCl), so the volume is twice → Statement 1 true.

Statement 2 is also true.

Official answer (b).

Ans: (b)

Subjective Problems

40. Calculate the molarity of water if its density is 1000 kg m^{-3}. *IIT-JEE (2003)* | *Easy*

Formula used: M = 1000/18. **Solution:**

Step 1: 1 L water = 1000 g.

Step 2: Moles = 1000/18 = 55.55 mol → molarity = 55.55 M.

Hence 55.55 M.

Ans: 55.55 M

41. 20 mL of H_2O_2 reacts with 20 mL of acidified $KMnO_4$. The same volume of $KMnO_4$ is decolourised by 10 mL of $MnSO_4$ in neutral medium, forming MnO_2, which dissolves in 10 mL of 0.2 M sodium oxalate. Find the molarity of H_2O_2. *IIT-JEE (2001)* | *Hard*

Formula used: $2MnO^-_4 + 3Mn^{2+} \rightarrow 5MnO_2$; MnO_2 : oxalate = 1 : 1. **Solution:**

Step 1: $MnO_2 + C_2O_4^{2-} + 4H^+ \rightarrow Mn^{2+} + 2CO_2 + 2H_2O \rightarrow MnO_2 = 10 \times 0.2 = 2$ mmol.

Step 2: Neutral medium: $2MnO_4^- + 3Mn^{2+} \rightarrow 5MnO_2 \rightarrow MnO_4^- = 2 \times 2/5 = 0.8$ mmol in 20 mL.

Step 3: Acid medium: $2MnO_4^- + 5H_2O_2 \rightarrow \ldots \rightarrow H_2O_2 = 0.8 \times 5/2 = 2$ mmol in 20 mL.

Step 4: Molarity of $H_2O_2 = 2/20 = 0.1$ M.

Hence 0.1 M.

Ans: 0.1 M

42. How many millilitres of 0.5 M H_2SO_4 dissolve 0.5 g of copper(II) carbonate? *IIT-JEE (1999)* | *Easy*

Formula used: 1 : 1. **Solution:**

Reaction: $CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$. **Step 1:** $CuCO_3$ (M = 123.5) = 0.5/123.5 = 4.05 mmol. **Step 2:** H_2SO_4 = 4.05 mmol → V = 4.05/0.5 = 8.1 mL. Hence 8.1 mL.

Ans: 8.1 mL

43. 0.10 g KIO_3 (214) with excess KI and HCl liberates iodine needing 45.0 mL of thiosulphate. Find the molarity of thiosulphate. *IIT-JEE (1998)* | *Medium*

Formula used: $IO^-_3 \rightarrow 3\ I_2 \rightarrow 6\ S_2O^2_3{}^-$. **Solution:**

Reactions: $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$; $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$.

Step 1: $KIO_3 = 0.10/214 = 0.467$ mmol → $I_2 = 1.40$ mmol.

Step 2: $S_2O_3^{2-} = 2 \times 1.40 = 2.80$ mmol.

Step 3: Molarity = 2.80/45.0 = 0.0623 M.

Hence 0.0623 M.

Ans: 0.0623 M

44. A 3.00 g sample of Fe_3O_4, Fe_2O_3 and inert matter with excess KI (all iron → Fe^{2+}) is diluted to 100 mL. 20 mL needs 11.0 mL of 0.5 M $Na_2S_2O_3$; 50 mL (iodine removed) needs 12.80 mL of 0.25 M $KMnO_4$. Find % Fe_2O_3 and % Fe_3O_4. *IIT-JEE (1996)* | *Hard*

Formula used: I_2 count gives Fe^{3+}; $KMnO_4$ gives total Fe^{2+}. **Solution:**

Let Fe_3O_4 = a mmol and Fe_2O_3 = b mmol in 3.00 g. Fe_3O_4 contains 2 Fe^{3+} + 1 Fe^{2+}; Fe_2O_3 contains 2 Fe^{3+}. **Step 1:** I_2 liberated by Fe^{3+}: $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$. Thiosulphate for 20 mL = 11.0 × 0.5 = 5.5 mmol = Fe^{3+}in 20 mL → 27.5 mmol in 100 mL: 2a + 2b = 27.5 → a + b = 13.75.

Step 2: After reduction all Fe is Fe^{2+}; $KMnO_4$ for 50 mL = 12.80 × 0.25 = 3.2 mmol × 5 = 16 mmol Fe^{2+} → 32 mmol in 100 mL: 3a + 2b = 32.

Step 3: Solve: a = 32 − 27.5 = 4.5 mmol; b = 9.25 mmol.

Step 4: Fe_3O_4 = 4.5 × 232 = 1.044 g → 34.8%; Fe_2O_3 = 9.25 × 160 = 1.48 g → 49.3%.

Hence 49.3% Fe_2O_3 and 34.8% Fe_3O_4.

Ans: 49.3% and 34.8%

45. 8.0575 × 10^{-2} kg of Glauber's salt is dissolved to 1 dm³ (density 1077.2 kg m^{-3}). Find molarity, molality and mole fraction of Na_2SO_4. *IIT-JEE (1994)* | *Medium*

Formula used: $Na_2SO_4 \cdot 10H_2O$ = 322. **Solution:**

Step 1: $Na_2SO_4 \cdot 10H_2O$ (M = 322) = 80.575/322 = 0.25 mol → molarity = 0.25 M.

Step 2: Mass of solution = 1077.2 g; Na_2SO_4 (142) = 0.25 × 142 = 35.5 g → water = 1077.2 − 35.5 = 1041.7 g.

Step 3: Molality = 0.25/1.0417 = 0.24 m.

Step 4: Water = 1041.7/18 = 57.87 mol → $x(Na_2SO_4)$ = 0.25/(0.25 + 57.87) = 0.0043.

Hence 0.25 M, 0.24 m, 0.0043.

Ans: 0.25 M, 0.24 m, 0.0043

46. 45.0 mL of 0.25 M lead nitrate is mixed with 25.0 mL of 0.10 M chromic sulphate. Find the moles of $PbSO_4$ formed and the molarities of ions left. *IIT-JEE (1993)* | *Medium*

Formula used: Sulphate limiting. **Solution:**

Step 1: Pb^{2+} = 45 × 0.25 = 11.25 mmol; NO_3^- = 22.5 mmol.

Step 2: $Cr_2(SO_4)_3$ = 2.5 mmol → Cr^{3+} = 5 mmol, SO_4^{2-}= 7.5 mmol.

Step 3: $PbSO_4$ = 7.5 mmol (sulphate limiting); Pb^{2+} left = 3.75 mmol.

Step 4: Total volume 70 mL: $[Pb^{2+}]$ = 3.75/70 = 0.0536 M; $[NO_3^-]$ = 22.5/70 = 0.321 M; $[Cr^{3+}]$ = 5/70 = 0.0714 M.

Hence 7.5 mmol $PbSO_4$ and the concentrations above. **Ans: 7.5 mmol; $[Pb^{2+}]$ 0.0536, $[NO^-_3]$ 0.321, $[Cr^{3+}]$ 0.0714 M**

47. A 2.0 g mixture of Na_2CO_3, $NaHCO_3$ and Na_2SO_4 gives 123.9 mL CO_2 at 750 mmHg, 298 K on gentle heating; 1.5 g needs 150 mL of M/10 HCl. Find the composition. *IIT-JEE (1992)* | *Hard*

Formula used: $n(CO_2) = pV/RT$ = 0.005 mol. **Solution:**

Step 1: $CO_2 = pV/RT = (750/760) \times 0.1239/(0.0821 \times 298)$ = 0.005 mol.

Step 2: $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$ → $NaHCO_3$ = 0.01 mol = 0.84 g (42%).

Step 3: HCl for 1.5 g = 15 mmol → for 2.0 g = 20 mmol; $NaHCO_3$ uses 10 mmol, so Na_2CO_3 uses 10 mmol → 5 mmol Na_2CO_3 = 0.53 g (26.5%).

Step 4: Na_2SO_4 = 2.0 − 0.84 − 0.53 = 0.63 g (31.5%). Hence $NaHCO_3$ 42%, Na_2CO_3 26.5%, Na_2SO_4 31.5%. **Ans:** $NaHCO_3$**42%,** Na_2CO_3**26.5%,** Na_2SO_4**31.5%**

48. One gram of commercial $AgNO_3$ with 50 mL of KI solution gives AgI. Excess KI in the filtrate needs 50 mL of M/10 KIO_3 (to ICl); 20 mL of the KI stock needs 30 mL of M/10 KIO_3. Find % $AgNO_3$. *IIT-JEE (1992)* | *Hard*

Formula used: $KIO_3 + 2KI + 6HCl \rightarrow 3ICl$. **Solution:** Reaction with KIO_3 (to ICl): $KIO_3 + 2KI + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$ (KI : KIO_3 = 2 : 1).

Step 1: Stock KI: 20 mL needs 3 mmol KIO_3 → 6 mmol KI → 0.3 M; 50 mL contains 15 mmol.

Step 2: Excess KI in filtrate: 5 mmol KIO_3 → 10 mmol KI.

Step 3: KI used by $AgNO_3$ = 15 − 10 = 5 mmol → $AgNO_3$ = 5 mmol × 170 = 0.85 g.

Step 4: Purity = 0.85/1 × 100 = 85%.

Hence 85%.

Ans: 85%

49. 0.2 g of a compound with Cu^{2+} and $C_2O_4^{2-}$ needs 22.6 mL of 0.02 M $KMnO_4$; the resulting solution, treated with KI, liberates iodine needing 11.3 mL of 0.05 M thiosulphate. Find the molar ratio Cu^{2+} : $C_2O_4^{2-}$. *IIT-JEE (1991)* | *Hard*

Formula used: Oxalate 2 e^-; Cu^{2+} 1 e^- in iodometry. **Solution:**

Step 1: $KMnO_4$ = 22.6 × 0.02 = 0.452 mmol; $2MnO_4^-$: $5C_2O_4^{2-}$ → oxalate = 0.452 × 5/2 = 1.13 mmol.

Step 2: $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$; $I_2 + 2S_2O_3^{2-} \rightarrow \dots \rightarrow Cu^{2+} = S_2O_3^{2-}$ = 11.3 × 0.05 = 0.565 mmol.

Step 3: $Cu^{2+} : C_2O_4^{2-}$ = 0.565 : 1.13 = 1 : 2.

Hence 1 : 2.

Ans: 1 : 2

50. 1.0 g of 55.2% pure Fe_2O_3 is dissolved, reduced by Zn and made to 100 mL. 25.0 mL needs 17.0 mL of 0.0167 M oxidant. Find the electrons taken up per oxidant ion. *IIT-JEE (1991)* | *Hard*

Formula used: Equivalents of Fe^{2+} = equivalents of oxidant. **Solution:**

Step 1: Fe_2O_3 = 0.552/160 = 3.45 mmol → Fe^{2+} = 6.9 mmol in 100 mL → 1.725 mmol in 25 mL.

Step 2: Oxidant = 17.0 × 0.0167 = 0.284 mmol.

Step 3: Electrons per oxidant ion = 1.725/0.284 = 6.07 ≈ 6.

Hence 6.

Ans: 6

51. Calculate the molality of 1 L of 93% (w/v) H_2SO_4 of density 1.84 g mL^{-1}. *IIT-JEE (1990)* | *Medium*

Formula used: Solvent mass = 1840 − 930 g. **Solution:**

Step 1: 93% (w/v) → 930 g H_2SO_4 in 1 L = 930/98 = 9.49 mol.

Step 2: Mass of solution = 1840 g → water = 1840 − 930 = 910 g.

Step 3: Molality = 9.49/0.910 = 10.43 m.

Hence 10.43 m.

Ans: 10.43 m

52. 5.0 g of lead nitrate and sodium nitrate heated below 600 °C loses 28.0% of its weight. Find the amounts of each. *IIT-JEE (1990)* | *Hard*

Formula used: $Pb(NO_3)_2 \rightarrow PbO + 2NO_2 + ½O_2$; $NaNO_3 \rightarrow NaNO_2 + ½O_2$. **Solution:**

Reactions: $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$ (loss 216 g per 662 g = 0.326 g/g); $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ (loss 32 g per 170 g = 0.188 g/g).

Step 1: Total loss = 0.28 × 5.0 = 1.40 g.

Step 2: 0.326x + 0.188(5 − x) = 1.40 → 0.138x = 0.46 → x = 3.32 g $Pb(NO_3)_2$.

Step 3: $NaNO_3$ = 5 − 3.32 = 1.68 g.

Hence 3.32 g and 1.68 g.

Ans: 3.32 g $Pb(NO_3)_2$**, 1.68 g** $NaNO_3$

53. A sugar syrup of 214.2 g contains 34.2 g sugar ($C_{12}H_{22}O_{11}$). Find the molal concentration and the mole fraction of sugar. *IIT-JEE (1988)* | *Easy*

Formula used: Water = 180 g. **Solution:**

Step 1: Sugar = 34.2/342 = 0.1 mol; water = 214.2 − 34.2 = 180 g = 10 mol.

Step 2: Molality = 0.1/0.180 = 0.556 m.

Step 3: Mole fraction = 0.1/(0.1 + 10) = 0.0099.

Hence 0.556 m and 0.0099.

Ans: 0.556 m, 0.0099

54. 2.68 × 10^{-3} mol of an ion A^{n+} need 1.61 × 10^{-3} mol MnO_4^- for oxidation to AO_3^- in acid. Find n. *IIT-JEE (1984)* | *Medium*

Formula used: Electrons per A ion. **Solution:**

Step 1: Electrons accepted by MnO_4^- = 5 × 1.61 × 10^{-3} = 8.05 × 10^{-3} mol.

Step 2: Electrons lost per A^{n+} = 8.05/2.68 = 3.

Step 3: Oxidation state of A in AO_3^- = +5 → n + 3 = 5 → n = 2.

Hence n = 2.

Ans: 2

55. 4.08 g of BaO and an unknown carbonate MCO_3 was heated strongly; the residue weighed 3.64 g, dissolved in 100 mL of 1 N HCl; excess acid needed 16 mL of 2.5 N NaOH. Identify M (Ba 138). *IIT-JEE (1983)* | *Hard*

Formula used: Mass loss = CO_2. **Solution:**

Step 1: Loss on heating = 4.08 − 3.64 = 0.44 g CO_2 = 0.01 mol → MCO_3 = 0.01 mol (BaO does not decompose).

Step 2: HCl used = 100 × 1 − 16 × 2.5 = 60 meq → oxides = 30 mmol (each MO needs 2 eq).

Step 3: BaO = 30 − 10 = 20 mmol = 0.02 × 153 = 3.06 g.

Step 4: MO = 3.64 − 3.06 = 0.58 g for 0.01 mol → M(MO) ≈ 58 → M ≈ 42 ≈ 40 (Ca).

Hence M is calcium.

Ans: Ca

56. A 3 M sodium thiosulphate solution has density 1.25 g mL^{-1}. Find % by weight, mole fraction and molalities of Na^+ and $S_2O_3^{2-}$. *IIT-JEE (1983) | Medium*

Formula used: Use 1 L. **Solution:**

Take 1 L: mass = 1250 g; $Na_2S_2O_3$ = 3 × 158 = 474 g; water = 776 g = 43.1 mol.

Step 1: % by weight = 474/1250 × 100 = 37.9%.

Step 2: Mole fraction = 3/(3 + 43.1) = 0.065.

Step 3: Molality of $S_2O_3^{2-}$ = 3/0.776 = 3.86 m; of Na^+ = 2 × 3.86 = 7.73 m.

Hence 37.9%, 0.065, 7.73 m and 3.86 m.

Ans: 37.9%, 0.065, 7.73 m and 3.86 m

57. Find the equivalent weight of H_3PO_4 in $Ca(OH)_2 + H_3PO_4 \rightarrow CaHPO_4 + 2H_2O$. *IIT-JEE (1980) | Easy*

Formula used: Two H replaced. **Solution:**

Step 1: $CaHPO_4$ is formed, so 2 H^+ of H_3PO_4 are replaced → n-factor = 2.

Step 2: Equivalent weight = 98/2 = 49.

Hence 49.

Ans: 49

F. Practice Questions

Single Correct Option

1. Which of the following is a compound? *[Easy]*

(a) Brass (b) Graphite
(c) Ozone (d) Washing soda

2. The number of significant figures in 6.0230×10^{23} is *[Easy]*

(a) 4 (b) 5 (c) 6 (d) 23

3. The value of 0.0256 + 1.2, reported correctly, is *[Easy]*

(a) 1.2 (b) 1.23 (c) 1.226 (d) 1.2256

4. Three readings of a mass with true value 2.000 g are 2.005 g, 2.006 g and 2.005 g. The readings are *[Easy]*

(a) accurate and precise
(b) precise but not accurate
(c) accurate but not precise
(d) neither accurate nor precise

5. Hydrogen combines with oxygen to form H_2O and H_2O_2. For a fixed mass of hydrogen, the masses of oxygen are in the ratio 1 : 2. This illustrates the law of *[Easy]*

(a) definite proportions
(b) reciprocal proportions
(c) multiple proportions
(d) conservation of mass

6. At the same temperature and pressure, the volume of ammonia formed from 30 mL of H_2 and excess N_2 is *[Easy]*

(a) 10 mL (b) 15 mL (c) 20 mL (d) 30 mL

7. The mass of 1 atomic mass unit is *[Easy]*

(a) 1.66×10^{-24} g (b) 1.66×10^{-27} g
(c) 6.022×10^{-23} g (d) 1.0 g

8. The number of electrons in 1.6 g of methane is *[Medium]*

(a) 6.022×10^{22} (b) 3.0×10^{23}
(c) 1.2×10^{24} (d) 6.022×10^{23}

9. Which of the following has the largest mass? *[Medium]*

(a) 0.1 mol of CO_2
(b) 1×10^{23} molecules of water
(c) 3.01×10^{23} atoms of Na
(d) 5.6 L of O_2 at 22.4 L mol^{-1}

10. The number of moles of chlorine atoms in 1.5 mol of $CaCl_2$ is *[Easy]*

(a) 1.5 (b) 3 (c) 0.75 (d) 4.5

11. Boron has two isotopes: B-10 (19.9%) and B-11 (80.1%). Its average atomic mass is *[Easy]*

(a) 10.20 u (b) 10.50 u (c) 10.80 u (d) 11.00 u

12. The number of oxygen atoms in 2.2 g of CO_2 is *[Easy]*

(a) 6.022×10^{22} (b) 3.011×10^{22}

(c) 1.2×10^{23} (d) 6.022×10^{23}

13. A compound contains 32.4% Na, 22.6% S and 45.0% O. Its empirical formula is *[Medium]*

(a) $NaSO_4$ (b) Na_2SO_3 (c) $Na_2S_2O_3$ (d) Na_2SO_4

14. A compound has empirical formula CH_2O and molar mass 90 g mol^{-1}. Its molecular formula is *[Easy]*

(a) $C_2H_4O_2$ (b) $C_3H_6O_3$ (c) $C_4H_8O_4$ (d) $C_6H_{12}O_6$

15. The percentage of oxygen in $CaCO_3$ is *[Easy]*

(a) 40% (b) 12% (c) 48% (d) 60%

16. A metal M forms the oxide M_2O_3 containing 52.94% metal. The atomic mass of M is *[Medium]*

(a) 27 (b) 24 (c) 56 (d) 45

17. 8 g of CH_4 is burnt in 16 g of O_2. The mass of CO_2 formed is *[Medium]*

(a) 22 g (b) 44 g (c) 5.5 g (d) 11 g

18. The volume of H_2 at STP (22.7 L mol^{-1}) liberated when 6.54 g Zn reacts with excess dilute HCl is *[Easy]*

(a) 1.12 L (b) 2.27 L (c) 4.54 L (d) 22.7 L

19. 10 g of H_2 and 64 g of O_2 are ignited to form water. Which statement is correct? *[Medium]*

(a) H_2 is the limiting reagent

(b) 90 g of water is formed

(c) 2 g of H_2 is left unreacted

(d) 8 g of H_2 is left unreacted

20. The mass of CaO obtained from 50 g of $CaCO_3$ if the yield is 80% is *[Easy]*

(a) 22.4 g (b) 28 g (c) 14 g (d) 35 g

21. The molarity of pure water is *[Easy]*

(a) 18 M (b) 1 M (c) 100 M (d) 55.5 M

22. The mole fraction of solute in a 1 m aqueous solution is *[Medium]*

(a) 0.0177 (b) 0.1 (c) 0.5 (d) 1.0

23. 100 mL of 0.2 M HCl is mixed with 300 mL of 0.6 M HCl. The molarity of the mixture is *[Easy]*

(a) 0.4 M (b) 0.8 M (c) 0.3 M (d) 0.5 M

24. The molarity of 98% (w/w) H_2SO_4 of density 1.84 g mL^{-1} is *[Medium]*

(a) 9.2 M (b) 18.4 M (c) 36.8 M (d) 1.84 M

25. The equivalent mass of $KMnO_4$ (M = 158) in acidic medium is *[Medium]*

(a) 158 (b) 52.7 (c) 31.6 (d) 79

26. Assertion (A): Molality is preferred over molarity in studying colligative properties. Reason (R): Molality involves only masses and is independent of temperature. *[Medium]*

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

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

(c) A is true but R is false

(d) A is false but R is true

27. Match the compound (List-I) with its percentage of hydrogen (List-II): A. H_2O; B. CH_4; C. NH_3; D. C_2H_6. I. 25%; II. 11.1%; III. 20%; IV. 17.6% *[Medium]*

(a) A-I, B-II, C-III, D-IV

(b) A-II, B-I, C-IV, D-III

(c) A-II, B-IV, C-I, D-III

(d) A-III, B-I, C-IV, D-II

28. The normality of 0.2 M $Ca(OH)_2$ is *[Easy]*

(a) 0.1 N **N**(b) 0.2 N **umerical Valu** (c) 0.8 N **e Questions** (d) 0.4 N

Numerical Value Questions

29. The number of significant figures in 0.007020 is _____. *[Easy]*

30. The mass (in g) of oxygen that combines with 3 g of carbon to form CO_2 is _____. *[Easy]*

31. The total number of moles of atoms in 9.8 g of H_2SO_4 is x × 10^{-1}. The value of x is _____. *[Easy]*

32. The volume occupied by 22 g of CO_2 at STP is x × 10^{-2} L (molar volume 22.7 L mol^{-1}). The value of x is _____. *[Easy]*

33. The percentage of carbon in glucose ($C_6H_{12}O_6$) is _____. *[Easy]*

34. 0.5 g of a gas occupies 113.5 mL at STP (22.7 L mol^{-1}). Its molar mass (in g mol^{-1}) is _____. *[Medium]*

35. The mass (in g) of NaOH required to neutralise 49 g of H_2SO_4 completely is _____. *[Easy]*

36. The percentage of iron in Fe_2O_3 is _____. *[Easy]*

37. The molarity of a solution containing 5.85 g NaCl in 500 mL is x × 10^{-2} M. The value of x is _____. *[Easy]*

38. 2.5 g of ethanoic acid (CH_3COOH) is dissolved in 75 g of benzene. The molality is x × 10^{-3} m. The value of x is _____ (nearest integer). *[Medium]*

39. A 500 g sample of water contains 2.5 mg of fluoride ion. Its concentration in ppm is _____. *[Easy]*

40. The volume (in mL) of 0.5 M H_2SO_4 required to neutralise 50 mL of 1 M NaOH is _____. *[Medium]*

Answer Key with Hints

1. (d) Fixed composition of different elements

2. (b) Count digits of the coefficient only

3. (a) Least number of decimal places

4. (b) Closeness to each other vs to the true value

5. (c) Two compounds of the same pair of elements

6. (c) Volume ratio 3 : 2

7. (a) 1/N_A gram

8. (d) 10 electrons per CH_4

9. (c) Convert each to grams

10. (b) Two Cl per formula unit

11. (c) Weighted average

12. (a) 0.05 mol × 2

13. (d) Ratio 2 : 1 : 4

14. (b) n = 90/30

15. (c) 48/100

16. (a) Ratio of masses in M_2O_3

17. (d) Find the limiting reagent first

18. (b) 0.1 mol Zn

19. (c) O_2 limits

20. (a) Theoretical × 0.8

21. (d) 1000 g per litre

22. (a) 1 mol solute in 55.5 mol water

23. (d) Total moles / total volume

24. (b) M = 10 × % × d / M

25. (c) Mn: +7 → +2

26. (a) Mass does not change with temperature

27. (b) Mass of H / molar mass

28. (d) n_f = 2

29. 4 Ignore leading zeros

30. 8 C : O = 12 : 32

31. 7 7 atoms per molecule

32. 1135 0.5 mol

33. 40 72/180

34. 100 n = V/22.7

35. 40 $H_2SO_4 + 2NaOH$

36. 70 112/160

37. 20 0.1 mol in 0.5 L

38. 556 n / kg of solvent

39. 5 Mass ratio × 10^6

40. 50 Equivalents of acid = base

Worked Solutions

1. Formula used: A compound has two or more elements combined in a fixed ratio. **Solution:** Brass is an alloy (mixture); graphite and ozone are elements. Washing soda $Na_2CO_3 \cdot 10H_2O$ is a compound. **Ans: (d)**

2. Formula used: In scientific notation only the coefficient counts; trailing zeros after the decimal are significant. **Solution:** 6.0230 has five significant figures. **Ans: (b)**

3. Formula used: Addition: keep decimal places of the least precise term. **Solution:** 0.0256 + 1.2 = 1.2256; 1.2 has one decimal place, so 1.2. **Ans: (a)**

4. Formula used: Precision: agreement among readings; accuracy: agreement with true value. **Solution:** The readings agree closely (precise) but all differ from 2.000 g by about 0.005 g (not accurate). **Ans: (b)**

5. Formula used: Law of multiple proportions. **Solution:** 2 g H combines with 16 g O in H_2O and 32 g O in H_2O_2: 16 : 32 = 1 : 2. **Ans: (c)**

6. Formula used: Gay-Lussac's law: $N_2 + 3H_2 \rightarrow 2NH_3$. **Solution:** NH_3 = 30 × 2/3 = 20 mL. **Ans: (c)**

7. Formula used: 1 u = 1 g/N_A. **Solution:** 1/(6.022×10^{23}) = 1.66×10^{-24} g. **Ans: (a)**

8. Formula used: Electrons = moles × electrons per molecule × N_A. **Solution:** n = 1.6/16 = 0.1 mol; electrons = 0.1 × 10 × N_A = 6.022×10^{23}. **Ans: (d)**

9. Formula used: m = n × M. **Solution:** (a) 4.4 g; (b) 0.166 × 18 = 3.0 g; (c) 0.5 × 23 = 11.5 g; (d) 0.25 × 32 = 8 g. Largest: (c). **Ans: (c)**

10. Formula used: Moles of atoms = moles × atoms per formula. **Solution:** 1.5 × 2 = 3 mol. **Ans: (b)**

11. Formula used: $\acute{A} = \sum x_i m_i / 100$. **Solution:** (19.9 × 10 + 80.1 × 11)/100 = (199 + 881.1)/100 = 10.80 u. **Ans: (c)**

12. Formula used: Atoms = n × atomicity × N_A. **Solution:** n = 2.2/44 = 0.05; O atoms = 0.1 × N_A = 6.022×10^{22}. **Ans: (a)**

13. Formula used: Divide % by atomic mass, then by the smallest. **Solution:** Na 1.409, S 0.706, O 2.81 → 2 : 1 : 4, so Na_2SO_4. **Ans: (d)**

14. Formula used: n = molar mass / EF mass. **Solution:** EF mass = 30; n = 3, so $C_3H_6O_3$. **Ans: (b)**

15. Formula used: Mass % = mass of element in 1 mol / M × 100. **Solution:** O = 3 × 16 = 48 in 100 g; 48%. **Ans: (c)**

16. Formula used: Mass % equation. **Solution:** 2A/(2A + 48) = 0.5294 → 2A = 0.5294(2A + 48) → 0.9412A = 25.41 → A = 27 (aluminium). **Ans: (a)**

17. Formula used: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. **Solution:** CH_4 = 0.5 mol (0.5/1); O_2 = 0.5 mol (0.5/2 = 0.25). O_2 is limiting → CO_2 = 0.25 mol = 11 g. **Ans: (d)**

18. Formula used: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$. **Solution:** Zn = 6.54/65.4 = 0.1 mol → H_2 = 0.1 × 22.7 = 2.27 L. **Ans: (b)**

19. Formula used: $2H_2 + O_2 \rightarrow 2H_2O$. **Solution:** H_2 = 5 mol (5/2 = 2.5); O_2 = 2 mol (2/1 = 2). O_2 limiting; water = 4 mol = 72 g; H_2 used 4 mol, left 1 mol = 2 g. **Ans: (c)**

20. Formula used: Actual = theoretical × % yield/100. **Solution:** Theoretical CaO = 0.5 × 56 = 28 g; actual = 28 × 0.8 = 22.4 g. **Ans: (a)**

21. Formula used: M = n/V. **Solution:** n = 1000/18 = 55.5 mol in 1 L. **Ans: (d)**

22. Formula used: $x_B = n_B / (n_A + n_B)$. **Solution:** 1/(1 + 55.5) = 0.0177. **Ans: (a)**

23. Formula used: $M_{mix} = (M_1V_1 + M_2V_2)/(V_1 + V_2)$. **Solution:** (20 + 180)/400 = 0.5 M. **Ans: (d)**

24. Formula used: M = 10 × (% w/w) × d / M_B. **Solution:** 10 × 98 × 1.84/98 = 18.4 M. **Ans: (b)**

25. Formula used: E = M/n_f. **Solution:** n_f = 5; E = 158/5 = 31.6. **Ans: (c)**

26. Formula used: Temperature dependence of concentration terms. **Solution:** Both statements are true, and the temperature-independence of molality (R) is exactly why it is preferred (A). **Ans: (a)**

27. Formula used: Mass % = mass of H in 1 mol / M × 100. **Solution:** H_2O 2/18 = 11.1%; CH_4 4/16 = 25%; NH_3 3/17 = 17.6%; C_2H_6 6/30 = 20%. **Ans: (b)**

28. Formula used: N = M × n_f. **Solution:** 0.2 × 2 = 0.4 N. **Ans: (d)**

29. Formula used: Leading zeros are not significant; trailing zeros after a decimal are. **Solution:** Significant digits: 7, 0, 2, 0 → 4. **Ans: 4**

30. Formula used: Law of definite proportions. **Solution:** O = 3 × 32/12 = 8 g. **Ans: 8**

31. Formula used: Moles of atoms = n × atomicity. **Solution:** n = 9.8/98 = 0.1; atoms = 0.7 mol = 7 × 10^{-1}. **Ans: 7**

32. Formula used: V = n × 22.7. **Solution:** 0.5 × 22.7 = 11.35 L = 1135 × 10^{-2} L. **Ans: 1135**

33. Formula used: Mass % = mass of C / M × 100. **Solution:** 72/180 × 100 = 40%. **Ans: 40**

34. Formula used: M = m/n. **Solution:** n = 0.1135/22.7 = 0.005 mol; M = 0.5/0.005 = 100 g mol^{-1}. **Ans: 100**

35. Formula used: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$. **Solution:** H_2SO_4 = 0.5 mol → NaOH = 1 mol = 40 g. **Ans: 40**

36. Formula used: Mass % = mass of Fe / M × 100. **Solution:** 112/160 × 100 = 70%. **Ans: 70**

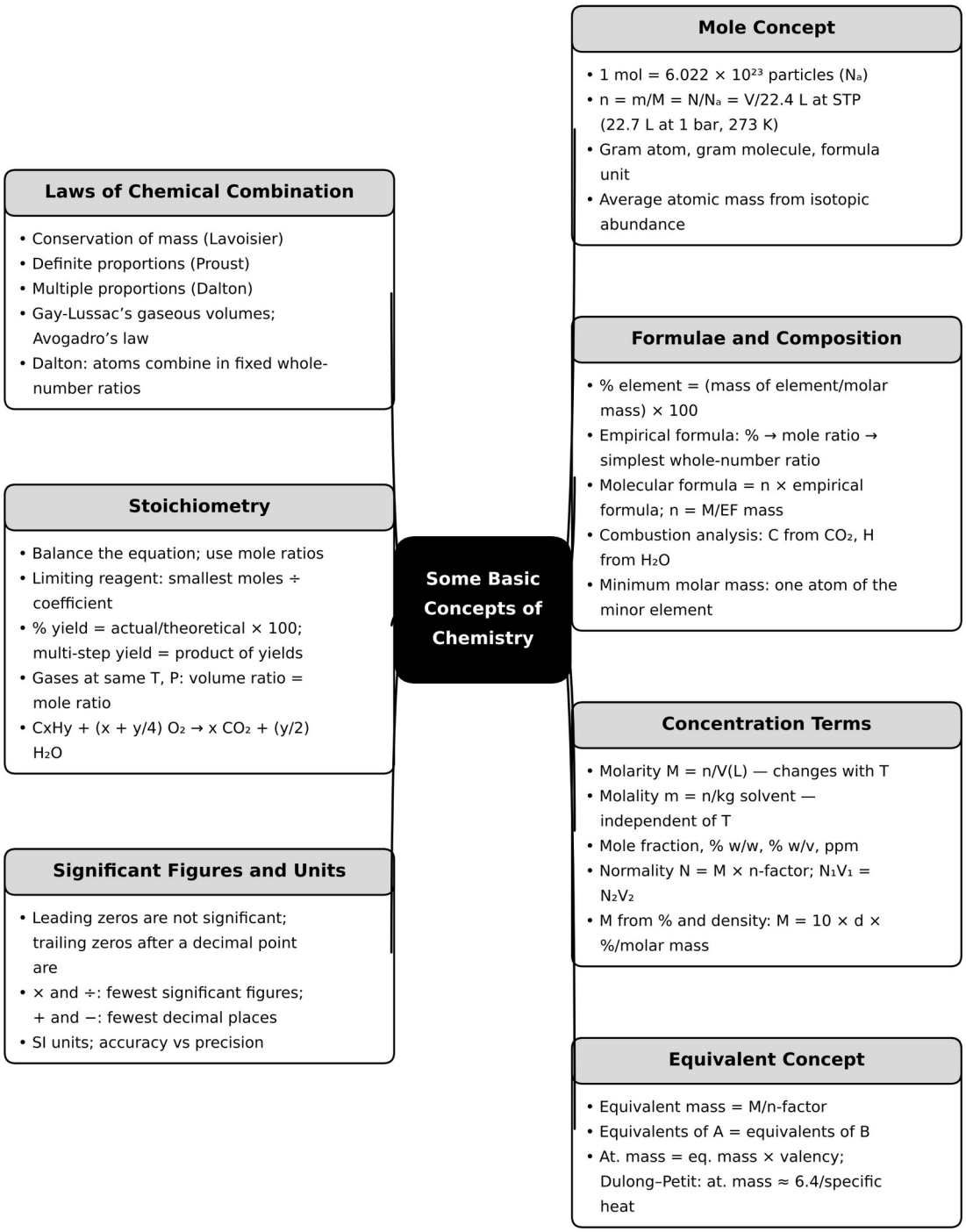
37. Formula used: M = n/V. **Solution:** 0.1/0.5 = 0.2 M = 20 × 10^{-2} M. **Ans: 20**

38. Formula used: m = n(solute)/mass of solvent (kg). **Solution:** n = 2.5/60 = 0.04167; m = 0.04167/0.075 = 0.5556 m ≈ 556 × 10^{-3} m. **Ans: 556**

39. Formula used: ppm = $(w_B/w_{soln}) \times 10^6$. **Solution:** (0.0025/500) × 10^6 = 5 ppm. **Ans: 5**

40. Formula used: $N_1V_1 = N_2V_2$ with N = M × n_f. **Solution:** Acid: 1.0 N; base: 1.0 N. V = 1 × 50/1 = 50 mL. **Ans: 50**

G. Revision Mind Map



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IIT Foundation Chemistry for Class 11 is built JEE-first. It covers the complete JEE Main and JEE Advanced syllabus and the full NCERT/CBSE and Tamil Nadu State Board syllabus. Each chapter moves from clear concepts and formula summaries to JEE-level solved questions, real previous year questions and graded practice, so students prepare for board exams and IIT entrance at the same time.

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