1. Calculate the molar mass of the following:

(i) H_2O (ii) CO_2 (iii) CH_4

Solution:

Correct Option: $H_2O = 18\ \text{g/mol}$, $CO_2 = 44\ \text{g/mol}$, and $CH_4 = 16\ \text{g/mol}$.

- Use atomic masses: $H = 1$, $C = 12$, $O = 16$.
- $H_2O = (2 \times 1) + 16 = 18\ \text{g/mol}$.
- $CO_2 = 12 + (2 \times 16) = 44\ \text{g/mol}$.
- $CH_4 = 12 + (4 \times 1) = 16\ \text{g/mol}$.

2. Calculate the mass per cent of different elements present in sodium sulphate (Na_2SO_4).

Solution:

Correct Option: Descriptive calculation

- Molar mass of $Na_2SO_4 = (2 \times 23) + 32 + (4 \times 16) = 142\ \text{g/mol}$.
- Mass per cent of sodium $= \frac{46}{142} \times 100 = 32.39\%$.
- Mass per cent of sulphur $= \frac{32}{142} \times 100 = 22.54\%$.
- Mass per cent of oxygen $= \frac{64}{142} \times 100 = 45.07\%$.
- Therefore, the elements present are sodium 32.39% , sulphur 22.54% , and oxygen 45.07% .

3. Determine the empirical formula of an oxide of iron, which has 69.9% iron and 30.1% dioxygen by mass.

Solution:

Correct Option: Fe_2O_3

- Assume 100 g of the oxide: 69.9 g iron and 30.1 g oxygen.
- Calculate moles: $\frac{69.9}{55.85} = 1.25$ mol Fe and $\frac{30.1}{16} = 1.88$ mol O.
- Divide by the smallest value: Fe:O $= 1 : 1.5$.
- Multiply by 2 to obtain whole numbers: Fe:O $= 2 : 3$.
- Therefore, the empirical formula is Fe_2O_3 .

4. Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

Solution:

Correct Option: Fe_2O_3

- Reaction: $C + O_2 \rightarrow CO_2$.
-

(i)
1 mole of carbon in excess air produces 1 mole of $CO_2 = 44$ g.
-

(ii)
16 g of $O_2 = 0.5$ mole, producing 0.5 mole of $CO_2 = 22$ g.
-

(iii)
16 g of O_2 is limiting, producing 0.5 mole of $CO_2 = 22$ g.

5. Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1} .

Solution:

Correct Option: 15.38 g

- Convert volume: 500 mL = 0.500 L .
- Calculate moles: $n = 0.375 \times 0.500 = 0.1875$ mol .
- Calculate mass: $m = 0.1875 \times 82.0245 = 15.3796$ g ≈ 15.38 g .
- Required mass of sodium acetate: 15.38 g .

6. Calculate the concentration of nitric acid in moles per litre in a sample which has a density, 1.41 g mL^{-1} and the mass per cent of nitric acid in it being 69%.

Solution:

Correct Option: 15.44 mol L^{-1}

- Mass of 1 L solution $= 1.41 \times 1000 = 1410$ g .
- Mass of $HNO_3 = 69\%$ of $1410 = 972.9$ g .
- Moles of $HNO_3 = \frac{972.9}{63} = 15.44$ mol .
- Concentration = 15.44 mol L^{-1} .

7. How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$)?

Solution:

Correct Option: 15.44 MOL L^-1

- Molar mass of $CuSO_4 = 63.5 + 32 + 64 = 159.5$ g mol^{-1} .
- Mass fraction of copper = $\frac{63.5}{159.5}$.
- Copper obtained from 100 g of $CuSO_4 = 100 \times \frac{63.5}{159.5} \approx 39.8$ g .
- Therefore, the amount of copper obtained is approximately 39.8 g .

8. Determine the molecular formula of an oxide of iron, in which the mass per cent of iron and oxygen are 69.9 and 30.1, respectively.

Solution:

Correct Option: Fe_2O_3

- Assume 100 g of the oxide: iron = 69.9 g and oxygen = 30.1 g.
- Moles of iron = $69.9/55.85 = 1.252$ mol; moles of oxygen = $30.1/16 = 1.881$ mol.
- Divide by the smaller value: Fe:O = $1 : 1.502 \approx 2 : 3$.
- Therefore, the molecular formula is Fe_2O_3 .

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

% Natural Abundance	Molar Mass
^{35}Cl	34.9689
^{37}Cl	36.9659

Isotope	% Natural Abundance	Molar Mass
^{35}Cl	75.77	34.9689
^{37}Cl	24.23	36.9659

Solution:

Correct Option: 35.45 u

The average atomic mass of an element is calculated by finding the weighted average of the masses of its naturally occurring isotopes. The weighting factor for each isotope is its fractional natural abundance.

Use the formula:

$$\text{Average atomic mass} = \sum(\text{fractional abundance} \times \text{isotopic mass})$$

Step 1: Convert each percentage abundance into a decimal.

For ^{35}Cl :

$$\text{Fractional abundance} = \frac{75.77}{100} = 0.7577$$

For ^{37}Cl :

$$\text{Fractional abundance} = \frac{24.23}{100} = 0.2423$$

As a check, the fractional abundances add up to 1 :

$0.7577 + 0.2423 = 1.0000$

Step 2: Multiply the fractional abundance of each isotope by its isotopic mass.

Contribution from ^{35}Cl :

$0.7577 \times 34.9689 = 26.49377853$ u

Contribution from ^{37}Cl :

$0.2423 \times 36.9659 = 8.95902157$ u

Step 3: Add the contributions of both isotopes.

Average atomic mass $= 26.49377853$ u $+ 8.95902157$ u

Average atomic mass $= 35.4528$ u

Step 4: Round the result appropriately.

Rounding 35.4528 u to two decimal places gives:

$\boxed{35.45 \text{ u}}$

Therefore, the average atomic mass of chlorine is 35.45 u .

10. In three moles of ethane (C_2H_6), calculate the following:

(i) Number of moles of carbon atoms.

(ii) Number of moles of hydrogen atoms.

(iii) Number of molecules of ethane.

Solution:

Correct Option: Answer

- Each C_2H_6 molecule contains 2 carbon atoms and 6 hydrogen atoms.
- Moles of carbon atoms $= 3 \times 2 = 6$ mol.
- Moles of hydrogen atoms $= 3 \times 6 = 18$ mol.
- Molecules of ethane $= 3 \times 6.022 \times 10^{23} = 1.8066 \times 10^{24}$ molecules.

11. What is the concentration of sugar ($C_{12}H_{22}O_{11}$) in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume up to 2 L?

Solution:

Correct Option: $0.0292 \text{ mol L}^{-1}$

- Molar mass of $C_{12}H_{22}O_{11} = 342 \text{ g mol}^{-1}$.
- Moles of sugar = $20/342 = 0.0585 \text{ mol}$.
- Concentration = $0.0585/2 = 0.0292 \text{ mol L}^{-1}$.

12. The density of methanol is 0.793 kg L^{-1} , what is its volume needed for making 2.5 L of its 0.25 M solution?

Solution:

Correct Option: $0.0292 MOLL^{-1}$

- Moles of methanol required: $0.25 \times 2.5 = 0.625 \text{ mol}$.
- Mass of methanol required: $0.625 \times 32 = 20.0 \text{ g}$.
- Convert density: $0.793 \text{ kg L}^{-1} = 0.793 \text{ g mL}^{-1}$.
- Volume required: $\frac{20.0}{0.793} = 25.2 \text{ mL}$.
- Therefore, the required volume is 25.2 mL or 0.0252 L .

13. Pressure is determined as force per unit area of the surface. The SI unit of pressure, pascal is as shown below:

$1 \text{ Pa} = 1 \text{ N m}^{-2}$

If mass of air at sea level is 1034 g cm^{-2} , calculate the pressure in pascal.

Solution:

Correct Option: $1.01332 \times 10^5 \text{ Pa}$

- Convert mass per unit area: $1034 \text{ g cm}^{-2} = 10340 \text{ kg m}^{-2}$.
- Use pressure $P = \frac{mg}{A}$, so $P = 10340 \times 9.8$.
- Therefore, $P = 101332 \text{ Pa} \approx 1.01332 \times 10^5 \text{ Pa}$.

14. What is the SI unit of mass? How is it defined?

Solution:

Correct Option: Kilogram (kg)

- The SI unit of mass is the kilogram, symbol kg .
- It is defined by assigning the exact value $6.62607015 \times 10^{-34} \text{ J s}$ to the Planck constant.

15. Match the following prefixes with their multiples:

	Prefixes	Multiples
(i)	micro	10^{6}
(ii)	deca	10^{9}
(iii)	mega	10^{-6}
(iv)	giga	10^{-15}
(v)	femto	10

Solution:

Correct Option: Prefix-to-multiple matching

- Micro denotes 10^{-6} .
- Deca denotes 10 .
- Mega denotes 10^{6} .
- Giga denotes 10^{9} .
- Femto denotes 10^{-15} .

16. What do you mean by significant figures?

Solution:

Correct Option:

- Significant figures are the meaningful digits in a measured quantity.
- They include all certain digits and the first uncertain digit.
- They indicate the precision of the measurement.

17. A sample of drinking water was found to be severely contaminated with chloroform, $CHCl_3$, supposed to be carcinogenic in nature. The level of contamination was 15 ppm (by mass).

(i) Express this in per cent by mass.

(ii) Determine the molality of chloroform in the water sample.

Solution:

Correct Option: 0.0015% by mass; $1.25 \times 10^{-4}\ \text{mol kg}^{-1}$

- $15\ \text{ppm} = \frac{15}{10^6} \times 100 = 0.0015\%$ by mass.
- In 1 kg of water, chloroform present $= 15\ \text{mg} = 0.015\ \text{g}$.
- Molar mass of $CHCl_3 = 119.5\ \text{g mol}^{-1}$.
- Moles of chloroform $= \frac{0.015}{119.5} = 1.255 \times 10^{-4}\ \text{mol}$.
- Molality $= \frac{1.255 \times 10^{-4}}{1} = 1.25 \times 10^{-4}\ \text{mol kg}^{-1}$.

18. Express the following in scientific notation:

(i) 0.0048

(ii) 234,000

(iii) 8008

(iv) 500.0

(v) 6.0012

Solution:

Correct Option: Descriptive answer

-

(i)

$0.0048 = 4.8 \times 10^{-3}$

-

(ii)

$234{,}000 = 2.34 \times 10^{5}$

-

(iii)

$8008 = 8.008 \times 10^{3}$

-

(iv)

$500.0 = 5.000 \times 10^{2}$

-

(v)

$6.0012 = 6.0012 \times 10^{0}$

19. How many significant figures are present in the following?

(i) 0.0025

(ii) 208

(iii) 5005

(iv) 126,000

(v) 500.0

(vi) 2.0034

Solution:

Correct Option: 2, 3, 4, 3, 4, 5

-

(i)

0.0025 has 2 significant figures.

-

(ii)

208 has 3 significant figures.

-

(iii)

5005 has 4 significant figures.

-

(iv)

126, 000 has 3 significant figures.

-

(v)

500.0 has 4 significant figures.

-

(vi)

2.0034 has 5 significant figures.

20. Round up the following upto three significant figures:

(i) 34.216

(ii) 10.4107

(iii) 0.04597

(iv) 2808

Solution:

Correct Option:

(I)

2;

(II)

3;

(III)

4;

(IV)
3;

(V)
4;

(VI)
5

- For 34.216 , retain 34.2 ; the next digit is 1 .
- For 10.4107 , retain 10.4 ; the next digit is 1 .
- For 0.04597 , retain 0.0459 ; round up to 0.0460 because the next digit is 7 .
- For 2808 , retain 2.80 thousand; round up to 2810 because the next digit is 8 .

21. The following data are obtained when dinitrogen and dioxygen react together to form different compounds:

	Mass of dinitrogen	**Mass of dioxygen**
(i)	14 g	16 g
(ii)	14 g	32 g
(iii)	28 g	32 g
(iv)	28 g	80 g

(a) Which law of chemical combination is obeyed by the above experimental data? Give its statement.

(b) Fill in the blanks in the following conversions:

(i) 1 km = _____ mm = _____ pm

(ii) 1 mg = _____ kg = _____ ng

(iii) 1 mL = _____ L = _____ dm^3

Solution:

Correct Option: Law of multiple proportions and the given conversions

- The data obey the law of multiple proportions.
- For a fixed mass of dinitrogen, the masses of dioxygen combine in simple whole-number ratios such as 1 : 2 and 2 : 5 .
- Statement: When two elements form more than one compound, the masses of one element that combine with a fixed mass of the other are in simple whole-number ratios.
- 1 km = 10^6 mm = 10^{15} pm .

- $1\ \text{mg} = 10^{-6}\ \text{kg} = 10^{6}\ \text{ng}$.
- $1\ \text{mL} = 10^{-3}\ \text{L} = 10^{-3}\ \text{dm}^3$.

22. If the speed of light is $3.0 \times 10^{8}\ \text{m}\,\text{s}^{-1}$, calculate the distance covered by light in $2.00\ \text{ns}$.

Solution:

Correct Option: LAW OF MULTIPLE PROPORTIONS;

(I)
10^{6} , 10^{15} ;

(II)
10^{-6} , 10^{6} ;

(III)
10^{-3} , 10^{-3}

- Convert time: $2.00\ \text{ns} = 2.00 \times 10^{-9}\ \text{s}$.
- Use $d = vt$.
- $d = (3.0 \times 10^{8})(2.00 \times 10^{-9}) = 0.600\ \text{m}$.
- Distance covered is $0.600\ \text{m}$.

23. In a reaction

$A + B_2 \rightarrow AB_2$

Identify the limiting reagent, if any, in the following reaction mixtures.

(i) 300 atoms of A + 200 molecules of B_2

(ii) 2 mol A + 3 mol B_2

(iii) 100 atoms of A + 100 molecules of B_2

(iv) 5 mol A + 2.5 mol B_2

(v) 2.5 mol A + 5 mol B_2

Solution:

Correct Option: Not applicable

- The reaction requires 1 unit of A for every 1 unit of B_2 .
-

(i)
B_2 is limiting.
-

(ii)
A is limiting.
-
(iii)
Neither reagent is limiting.
-
(iv)
B_2 is limiting.
-
(v)
A is limiting.

24. Dinitrogen and dihydrogen react with each other to produce ammonia according to the following chemical equation:

$$N_2\ (g) + H_2\ (g) \rightarrow 2NH_3\ (g)$$

(i) Calculate the mass of ammonia produced if 2.00×10^3 g dinitrogen reacts with 1.00×10^3 g of dihydrogen.

(ii) Will any of the two reactants remain unreacted?

(iii) If yes, which one and what would be its mass?

Solution:

Correct Option: 2.43×10^3 g NH_3 ; H_2 remains with mass 5.71×10^2 g .

• Balance the equation: $N_2 + 3H_2 \rightarrow 2NH_3$.
• Moles of $N_2 = \frac{2000}{28} = 71.43$ mol .
• Moles of $H_2 = \frac{1000}{2} = 500$ mol .
• 71.43 mol N_2 requires 214.29 mol H_2 ; hence, N_2 is the limiting reactant.
• Moles of $NH_3 = 2 \times 71.43 = 142.86$ mol .
• Mass of $NH_3 = 142.86 \times 17 = 2.43 \times 10^3$ g .
• Excess $H_2 = 500 - 214.29 = 285.71$ mol .
• Mass of unreacted $H_2 = 285.71 \times 2 = 5.71 \times 10^2$ g .

25. How are 0.50 mol Na_2CO_3 and 0.50 mol Na_2CO_3 different?

Solution:

Correct Option: 2.43×10^3 g ammonia is produced; dihydrogen remains unreacted, with mass 5.71×10^2 g .

- The stated result gives 2.43×10^3 g ammonia produced.
- Dihydrogen remains unreacted, with mass 5.71×10^2 g .

26. If 10 volumes of dihydrogen gas reacts with five volumes of dioxygen gas, how many volumes of water vapour would be produced?

Solution:

Correct Option: 10 volumes of water vapour

- Balanced equation: $2H_2 + O_2 \rightarrow 2H_2O$.
- Volume ratio of $H_2 : O_2 : H_2O$ is $2 : 1 : 2$.
- 10 volumes of H_2 react with 5 volumes of O_2 .
- Therefore, 10 volumes of water vapour are produced.

27. Convert the following into basic units:

(i) 28.7 pm

(ii) 15.15 pm

(iii) 25365 mg

Solution:

Correct Option: The converted values are:

- $28.7 \text{ pm} = 2.87 \times 10^{-11} \text{ m}$.
- $15.15 \text{ pm} = 1.515 \times 10^{-11} \text{ m}$.
- $25365 \text{ mg} = 2.5365 \times 10^{-2} \text{ kg}$.

28. Which one of the following will have the largest number of atoms?

(A) 1 g Au (s) **(B)** 1 g Na (s)

(C) 1 g Li (s) **(D)** 1 g of Cl_2 (g)

Solution:

Correct Option: C

- For a fixed mass, the number of atoms depends on the moles of atoms.
- 1 g Li contains approximately $\frac{1}{6.94} = 0.144$ mol of atoms.
- 1 g Cl_2 contains approximately $2 \times \frac{1}{70.9} = 0.028$ mol of atoms.
- Li provides the greatest number of atoms.

29. Calculate the molarity of a solution of ethanol in water, in which the mole fraction of ethanol is 0.040 (assume the density of water to be one).

Solution:

Correct Option: C

- Assume 1 mol of solution: ethanol $= 0.04$ mol and water $= 0.96$ mol.
- Mass of water $= 0.96 \times 18 = 17.28$ g.
- Volume of water $= 17.28$ mL $= 0.01728$ L.
- Molarity $= \frac{0.04}{0.01728} \approx 2.31$ M.

30. What will be the mass of one ^{12}C atom in g?

Solution:

Correct Option: C

- Mass of one ^{12}C atom = 12 atomic mass units.
- 1 atomic mass unit = 1.6605×10^{-24} g.
- Mass = $12 \times 1.6605 \times 10^{-24} = 1.9926 \times 10^{-23}$ g.

31. How many significant figures should be present in the answer of the following calculations?

(i) $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$

(ii) 5×5.364

(iii) $0.0125 + 0.7864 + 0.0215$

Solution:

Correct Option: C

-

(i)

The result is limited by 0.112 , so it should have 3 significant figures.

-

(ii)

The result is limited by 5 , so it should have 1 significant figure.

-

(iii)

The sum is 0.8204 , which has 4 significant figures.

32. Use the data given in the following table to calculate the molar mass of naturally occuring argon isotopes:

Isotope	Isotopic molar mass	Abundance
^{36}Ar	35.96755 g mol^{-1}	0.337%
^{38}Ar	37.96272 g mol^{-1}	0.063%
^{40}Ar	39.9624 g mol^{-1}	99.600%

Solution:

- Convert the abundances to decimal fractions: 0.00337 , 0.00063 , and 0.99600 .
- Calculate the weighted average: $(35.96755)(0.00337) + (37.96272)(0.00063) + (39.9624)(0.99600) =$

$39.9477\ \text{g mol}^{-1}$.
- Report the molar mass to four significant figures: $39.95\ \text{g mol}^{-1}$.

33. Calculate the number of atoms in each of the following (i) 52 moles of Ar (ii) 52 u of He (iii) 52 g of He.

Solution:
- Use Avogadro's number, $N_A = 6.022 \times 10^{23}$ atoms/mol.
- For 52 mol of Ar: $52 \times N_A = 3.13 \times 10^{25}$ atoms.
- For 52 u of He: $52 \div 4 = 13$ atoms.
- For 52 g of He: $(52 \div 4) \times N_A = 7.83 \times 10^{24}$ atoms.

34. A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.38 g carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. Calculate (i) empirical formula, (ii) molar mass of the gas, and (iii) molecular formula.

Solution:
- Moles of carbon: $\frac{3.38}{44.0} = 0.0768$ mol ; moles of hydrogen atoms: $2 \times \frac{0.690}{18.0} = 0.0767$ mol .
- The simplest mole ratio is $C : H = 1 : 1$, so the empirical formula is CH .
- Moles of gas at STP: $\frac{10.0}{22.4} = 0.446$ mol .
- Molar mass of the gas: $\frac{11.6}{0.446} = 26.0\ \text{g mol}^{-1}$.
- Empirical formula mass is $13.0\ \text{g mol}^{-1}$; $\frac{26.0}{13.0} = 2$.
- Molecular formula: $(CH)_2 = C_2H_2$.

35. Calcium carbonate reacts with aqueous HCl to give $CaCl_2$, and CO_2 , according to the reaction,

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

What mass of $CaCO_3$ is required to react completely with 25 mL of 0.75 M HCl?

Solution:
- Moles of $HCl = 0.75 \times 0.025 = 0.01875$ mol .
- From the equation, moles of $CaCO_3 = \frac{0.01875}{2} = 0.009375$ mol .
- Mass of $CaCO_3 = 0.009375 \times 100.1 \approx 0.94$ g .

36. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction

$$4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$$

How many grams of HCl react with 5.0 g of manganese dioxide?

Solution:
Correct Option: 8.4 g

- Molar mass of $MnO_2 = 86.9\ \text{g mol}^{-1}$.
- Moles of $MnO_2 = \frac{5.0}{86.9} = 0.0575$ mol .

- Moles of $HCl = 4(0.0575) = 0.230$ mol .
- Mass of $HCl = 0.230 \times 36.5 = 8.4$ g .