

CHAPTER 4

STOICHIOMETRY

Complete Exercise & Numerical Solutions

Class 9 • Chemistry

MCQs | Short Answers | Constructed Response
Descriptive & Investigative Questions — fully solved, step by step

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1. Tick (✓) the Correct Answer

(1) How many atoms are present in one gram of H_2O ?

✓ (a) 1.002×10^{23} atoms

(b) 2.004×10^{23} atoms

(c) 3.011×10^{23} atoms

(d) 6.022×10^{23} atoms

Explanation:

Molar mass of $\text{H}_2\text{O} = (2 \times 1) + 16 = 18 \text{ g/mol}$.

Moles in 1 g of $\text{H}_2\text{O} = 1 / 18 \approx 0.0556 \text{ mol}$.

Molecules = $0.0556 \times 6.022 \times 10^{23} \approx 3.34 \times 10^{22}$.

Each H_2O molecule has 3 atoms (2 H + 1 O), so total atoms = $3 \times 3.34 \times 10^{22} \approx 1.002 \times 10^{23}$ atoms.

(2) Which is the correct formula of calcium phosphide?

- (a) CaP
- (b) Ca_2P_3
- (c) CaP_2

✓ (d) Ca_3P_2

Explanation:

Calcium (Group 2) forms the ion Ca^{2+} .

Phosphide (Group 15) forms the ion P^{3-} .

Balancing charges by the criss-cross method: $3 \times (+2) = +6$ and $2 \times (-3) = -6$.

This gives the formula Ca_3P_2 .

(3) How many atomic mass units (amu) are there in one gram?

(a) 1.66×10^{-24} amu

(b) 1.0 amu

✓ (c) 6.022×10^{23} amu

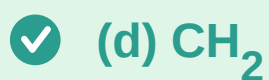
(d) 12 amu

Explanation:

1 amu is defined as 1/12th the mass of a carbon-12 atom, $\approx 1.66 \times 10^{-24}$ g.

So 1 gram = $1 \div (1.66 \times 10^{-24})$ amu = 6.022×10^{23} amu — this is Avogadro's number.

(4) The structural formula of 2-hexene is $\text{CH}_3\text{--CH=CH--}(\text{CH}_2)_2\text{--CH}_3$. What is its empirical formula?



Explanation:

The molecular formula of 2-hexene is C_6H_{12} .

The empirical formula is the simplest whole-number ratio of atoms.

$\text{C} : \text{H} = 6 : 12 \rightarrow$ dividing by 6 gives $1 : 2$.

So the empirical formula is CH_2 .

(5) How many moles are there in 25 g of H_2SO_4 ?

(a) 0.155 mol

(b) 0.198 mol

✓ (c) 0.255 mol

(d) 0.355 mol

Explanation:

Molar mass of $\text{H}_2\text{SO}_4 = (2 \times 1) + 32 + (4 \times 16) = 98$ g/mol.

Moles = mass $\div$ molar mass = $25 \div 98 = 0.255$ mol.

(6) A necklace has 6 g of diamonds in it. How many carbon atoms are in it?

(a) 1.505×10^{23}

(b) 2.008×10^{23}

(c) 2.500×10^{23}

✓ (d) 3.011×10^{23}

Explanation:

Diamond is pure carbon; molar mass of C = 12 g/mol.

Moles in 6 g = $6 \div 12 = 0.5$ mol.

Atoms = $0.5 \times 6.022 \times 10^{23} = 3.011 \times 10^{23}$ atoms.

(7) What is the mass of Al in 204 g of aluminium oxide, Al_2O_3 ?

- (a) 27 g
- (b) 54 g
- (c) 81 g

✓ (d) 108 g

Explanation:

Molar mass of $\text{Al}_2\text{O}_3 = (2 \times 27) + (3 \times 16) = 102 \text{ g/mol}$.

Moles of $\text{Al}_2\text{O}_3 = 204 \div 102 = 2 \text{ mol}$.

Each mole of Al_2O_3 contains 2 mol of Al, so $2 \text{ mol} \rightarrow 4 \text{ mol Al}$.

Mass of Al = $4 \times 27 = 108 \text{ g}$.

(8) Which compound has the highest percentage by mass of nitrogen?

(a) $\text{CO}(\text{NH}_2)_2$

✓ (b) N_2H_4

(c) NH_3

(d) NH_4OH

Explanation:

$\text{CO}(\text{NH}_2)_2$: $(28 \div 60) \times 100 = 46.67 \%$

N_2H_4 : $(28 \div 32) \times 100 = \mathbf{87.5 \%}$

NH_3 : $(14 \div 17) \times 100 = 82.35 \%$

NH_4OH : $(14 \div 35) \times 100 = 40 \%$

N_2H_4 has the highest nitrogen percentage.

(9) One mole of each compound below is reacted with oxygen. Which produces the maximum CO_2 ?

(a) Carbon

(b) Diamond

✓ (c) Ethane (C_2H_6)

(d) Methane (CH_4)

Explanation:

The amount of CO_2 produced depends directly on the number of carbon atoms in the reactant.

Carbon and Diamond each supply 1 C atom; Methane supplies 1 C atom.

Ethane (C_2H_6) supplies 2 C atoms, so 1 mole of ethane gives 2 moles of CO_2 — the maximum.

(10) What mass of 95% pure CaCO_3 is required to neutralize 50 cm^3 of 0.5 M HCl?

(a) 1.15 g

(b) 1.25 g

✓ (c) 1.32 g

(d) 1.45 g

Explanation:

Reaction: $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

Moles of HCl = $M \times V(\text{L}) = 0.5 \times 0.05 = 0.025 \text{ mol}$.

Moles of pure CaCO_3 needed = $0.025 \div 2 = 0.0125 \text{ mol}$.

Mass of pure $\text{CaCO}_3 = 0.0125 \times 100 = 1.25 \text{ g}$.

Since the sample is only 95% pure: $1.25 \div 0.95 \approx \mathbf{1.32 \text{ g}}$.

2. Questions for Short Answers

(i) Write down the chemical formula of barium nitride.

Barium ion is Ba^{2+} and nitride ion is N^{3-} .

Balancing charges gives the formula $\mathbf{Ba_3N_2}$.

(ii) Find the molecular formula of a compound whose empirical formula is CH_2O and whose molar mass is 180.

Empirical formula mass = $12 + (2 \times 1) + 16 = 30 \text{ g/mol}$.

$n = \text{molar mass} \div \text{empirical formula mass} = 180 \div 30 = 6$.

Molecular formula = $(\text{CH}_2\text{O})_6 = \text{C}_6\text{H}_{12}\text{O}_6$.

(iii) How many molecules are present in 1.5 g of H_2O ?

Moles = $1.5 \div 18 = 0.0833 \text{ mol}$.

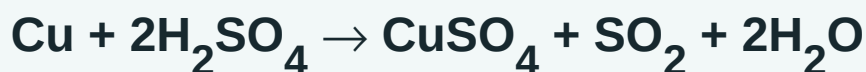
Molecules = $0.0833 \times 6.022 \times 10^{23} = 5.018 \times 10^{22}$ molecules.

(iv) What is the difference between a mole and Avogadro's number?

A **mole** is the SI unit for the amount of substance — it represents a fixed quantity of particles.

Avogadro's number (6.022×10^{23}) is the actual count of particles (atoms, molecules or ions) present in exactly one mole of any substance.

(v) Write the chemical equation: Copper + Sulphuric acid → Copper sulphate + Sulphur dioxide + Water.



3. Constructed Response Questions

(i) Different compounds will never have the same molecular formula, but they can have the same empirical formula. Explain.

Compounds that share a molecular formula but differ in structure are called isomers (e.g. Ethanol and Dimethyl ether both have $\text{C}_2\text{H}_6\text{O}$).

However, different compounds CAN share the same empirical formula if the simplest whole-number ratio of their atoms matches, even though their molecular formulas differ.

For example, Acetylene (C_2H_2) and Benzene (C_6H_6) both reduce to the empirical formula **CH**.

Similarly, Formaldehyde (CH_2O) and Acetic acid ($\text{C}_2\text{H}_4\text{O}_2$) both share the empirical formula **CH_2O** .

(ii) Write the chemical formulas of: Calcium phosphate, Aluminium nitride, Sodium acetate, Ammonium carbonate, Bismuth sulphate.

Calcium phosphate: $\text{Ca}_3(\text{PO}_4)_2$

Aluminium nitride: AlN

Sodium acetate: CH_3COONa

Ammonium carbonate: $(\text{NH}_4)_2\text{CO}_3$

Bismuth sulphate: $\text{Bi}_2(\text{SO}_4)_3$

(iii) Why does Avogadro's number have immense importance in chemistry?

It bridges the microscopic world (atoms and molecules) with the macroscopic world (grams and litres), letting chemists count particles by weighing them.

It defines the mole — the foundation of every stoichiometric calculation in chemistry.

(iv) 8.657 g of a compound, when broken into its elements, gave 5.217 g carbon, 0.962 g hydrogen and 2.478 g oxygen. Calculate the percentage of each element.

$$\% \text{ Carbon} = (5.217 \div 8.657) \times 100 = \mathbf{60.26 \%}$$

$$\% \text{ Hydrogen} = (0.962 \div 8.657) \times 100 = \mathbf{11.11 \%}$$

$$\% \text{ Oxygen} = (2.478 \div 8.657) \times 100 = \mathbf{28.62 \%}$$

$$\text{Check: } 60.26 + 11.11 + 28.62 \approx 100 \% \checkmark$$

4. Descriptive Questions

(i) Which conditions must be fulfilled before writing a chemical equation for a reaction?

It must represent a genuine chemical change.

It must be balanced, satisfying the Law of Conservation of Mass.

Correct chemical formulas must be used for every reactant and product.

Physical states (s, l, g, aq) should be indicated where relevant.

Necessary conditions — temperature, pressure, catalyst — are written above/below the arrow.

(ii) Explain the concepts of Avogadro's number and the mole.

Mole: the SI unit for amount of substance; one mole contains exactly 6.022×10^{23} particles, and its mass in grams equals the substance's atomic/molecular mass.

Avogadro's number: the experimentally determined number of particles (atoms, ions or molecules) present in one mole of any substance ($6.022 \times 10^{23} \text{ mol}^{-1}$).

(iii) How many grams of CO_2 form when 10 g of CH_4 reacts with excess O_2 ? ($\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$)

Moles of $\text{CH}_4 = 10 \div 16 = 0.625 \text{ mol}$.

1 mole CH_4 gives 1 mole CO_2 , so 0.625 mol CH_4 gives 0.625 mol CO_2 .

Mass of $\text{CO}_2 = 0.625 \times 44 = 27.5 \text{ g}$.

(iv) How many moles of coal are needed to produce 10 moles of CO ? ($3\text{C} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2 + 3\text{CO}$)

From the equation, 3 mol carbon (coal) produce 3 mol CO — a 1 : 1 ratio.

To produce 10 mol CO , **10 moles of coal** are needed.

(v) How much SO_2 (in grams) is needed to produce 10 moles of sulphur? ($2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 2\text{H}_2\text{O} + 3\text{S}$)

1 mole SO_2 produces 3 moles S, so moles of SO_2 needed = $10 \div 3 = 3.33$ mol.

Molar mass of $\text{SO}_2 = 32 + 32 = 64$ g/mol.

Mass of $\text{SO}_2 = 3.33 \times 64 \approx \mathbf{213.33 \text{ g}}$.

(vi) How much ammonia (in grams) is needed to produce 1 kg of urea fertilizer? ($2\text{NH}_3 + \text{CO}_2 \rightarrow \text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O}$)

Molar mass of urea $\text{CO}(\text{NH}_2)_2 = 60$ g/mol; 1 kg = 1000 g.

Moles of urea = $1000 \div 60 = 16.67$ mol.

2 mol NH_3 produce 1 mol urea, so NH_3 needed = $2 \times 16.67 = 33.33$ mol.

Mass of $\text{NH}_3 = 33.33 \times 17 \approx \mathbf{566.67 \text{ g}}$.

(vii) Calculate the number of atoms in: (a) 3 g of H_2 , (b) 3.4 moles of N_2 , (c) 10 g of $\text{C}_6\text{H}_{12}\text{O}_6$.

(a) Moles = $3 \div 2 = 1.5 \text{ mol} \rightarrow$ molecules = $1.5 \times 6.022 \times 10^{23} = 9.033 \times 10^{23}$; atoms = $2 \times$ that = **1.807×10^{24}** .

(b) Molecules = $3.4 \times 6.022 \times 10^{23} = 2.047 \times 10^{24}$; atoms = $2 \times$ that = **4.095×10^{24}** .

(c) Molar mass = 180 g/mol $\rightarrow$ moles = $10 \div 180 = 0.0555 \text{ mol}$; molecules = 3.34×10^{22} ; atoms per molecule = 24; total atoms = **8.016×10^{23}** .

5. Investigative Questions

(i) Drinking eight glasses of water a day is recommended for hydration. If a glass holds 400 cm^3 on average, how many moles of water does that provide for one adult?

Total volume = $8 \times 400 = 3200 \text{ cm}^3$.

Density of water = 1 g/cm^3 , so mass = 3200 g.

Moles = mass $\div$ molar mass = $3200 \div 18 \approx$ **177.78 moles**.

(ii) Sand has the chemical formula SiO_2 , yet it does not exist as discrete molecules like H_2O . How is its formula determined given its structure?

Sand (silica) forms a giant covalent network, not individual molecules.

Each silicon atom bonds tetrahedrally to four oxygen atoms, and each oxygen bridges two silicon atoms, building a continuous three-dimensional lattice.

Because there are no separate SiO_2 units, its formula is an **empirical formula** — the simplest whole-number ratio of Si to O atoms (1 : 2) found throughout the crystal lattice.

Well Done!

You have completed every MCQ, short-answer, constructed-response, descriptive and investigative question of Chapter 4 — Stoichiometry.

Keep practising. Keep exploring.

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