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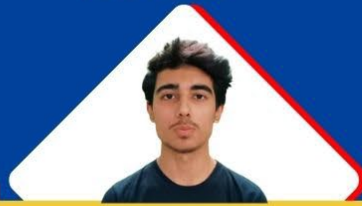

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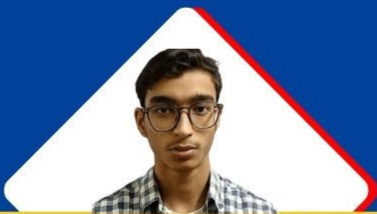

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Some Basic Concepts of Chemistry

Important Questions

- Theory based
- Numerical based

With Answers

Some Basic Concepts of Chemistry Important Questions Theory based

Q.1. What is the SI unit of molarity?

Q.2. What is meant by significant figures?

Q.3. What are the various types of mixtures?

Q.4. Which of the following mixtures are homogeneous:

(i) wood (ii) tap water (iii) smoke (iv) soil and (v) cloud?

Q.5. Define the term gram atomic mass or gram atom.

Q.6. Define the term gram molecular mass or gram mole.

Q.7. Define the term molarity.

Q.8. Define the Lin of conservation of mass.

Q.9. State Avogadro's law.

Q.10. Explain Gay Lussac Law.

Q.11. Define the term empirical formula and molecular formula.

Q.12. What is a chemical equation? What are its essential features?

Q.13. How many significant figures should be present in the answer of the following? $\frac{2.5 \times 1.25 \times 3.5}{2.01}$

Q.14. What is the symbol for SI unit of mole? How is the mole defined?

Q.15. What is the difference between molality and molarity?

Q.16. Volume of a solution changes with temperature, then will the molality of the solution be affected by temperature? Give reason for your answer.

Q.17. Explain the use of limiting and excess reagents in a chemical reaction.

Numerical based

Q.1. Calculate (i) the number of moles, (ii) the number of molecules and (iii) the volume of gas at STP in 0.28 g of nitrogen.

Q.2. How many moles of methane are required to produce 22 $gCO_2(g)$ after combustion?

Q.3. The density of 3M solution of NaCl is 1.25 g mL^{-1}. Calculate molality of the solution.

Q.4. How many moles and how many grams of sodium chloride (NaCl) are present in 250 cm^3 of a 0.500 M NaCl solution?

Q5. In a reaction vessel 0.184 g of NaOH is required to be added for completing the reaction. How many mL of 0.150MNaOH solution should be added for this requirement?

Q.6. If 20.0 g of $CaCO_3$ is treated with 20.0 g of HCl, how many grams of CO_2 can be generated according to the following equation:

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

Given: Molar mass of ($CaCO_3 = 100\ g\ mol^{-1}, HCl = 36.5\ g\ mol^{-1}, CO = 44.0\ g\ mol^{-1}$).

Q.7. Calculate the mass per cent of calcium, phosphorus and oxygen in calcium phosphate sphate $Ca_3(PO_4)_2$.

Q.8. Calculate the average atomic mass of hydrogen using the following data:

Isotope	% Natural abundance	Molar mass
^1H	99.985	1
^2H	0.015	2

Q.9. The density of 3 molal solution of NaOH is $1.110\ g\ mL^{-1}$. Calculate the molarity of the solution.

Q.10. (i) If the elemental composition of butyric acid is found to be C= 54.2%, H=9.2%, O = 36, determine the empirical formula.

(ii) The molecular mass of butyric acid was determined by experiment to be 88u. What is the ular formula?

Q.11. N_2 and H_2 react with each other to produce NH_3 according to the following chemical equation

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

(i) Calculate the mass of ammonia produced if 2.0×10^3 g of N_2 reacts with 1.0×10^3 g of H_2

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

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

Q.12. 50.0 kg of $N_2(g)$ and 10.0 kg of $H_2(g)$ are mixed to produce $NH_3(g)$. Calculate the $NH_3(g)$ formed. Identify the limiting reagent in the limiting reagent in the production of NH_3 in the situation.

Q.13. Calcium carbonate reacts with aqueous HCl to give $CaCl_2$ and CO_2, according to the reaction given : $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O$ (l)

What mass of $CaCl_2$ will be formed when 250 mL of 0.76MHCl wocls with 1000 g of $CaCo_3$? Name the limiting reagent. Calculate the number of moles of $CaCl_2$ formed in the reaction.

Q14. How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$)?

Q15. Determine the molecular formula of an oxide of iron in which the mass percent of iron and oxygen are 69.9 and 30.1 respectively. Given that the molar mass of the oxide is $159.89\ mol^{-1}$.

Q16. If 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?

Q17. A sample of drinking water was found to be severely contaminated with chloroform, $CHCl_3$, supposed to be carcinogen. The level of contamination was 15 ppm (by mass).

(a) Express this in percent by mass

(b) Determine the molarity of chloroform in the water sample.

Q.18. Which one of the following will have 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)

Q19. Calculate the molarity of a solution of ethanol in water in which the mole fraction of ethanol is 0.040.

Q20. Calculate the number of atoms in each of the following:

(a) 52 moles of He (b) 52 u of He (c) 52 g of He

Q21. 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

(a) empirical formula

(b) molar mass of the gas, and

(c) molecular formula.

Theory based- Answers

1. Ans. Mol dm^{-3}.

2. Ans. The total number of digits in a number including the last digit whose value is uncertain, is called the number of significant figures.

3. Ans. Mixtures are of two types:

(i) Homogeneous - A mixture is said to be homogeneous if its composition is uniform throughout.

(ii) Heterogeneous - A mixture is said to be heterogeneous if its composition is not uniform throughout.

4. Ans. Wood and tap water are homogeneous mixtures.

5. Ans. Gram atomic mass or gram atom - Gram atomic mass or gram atom of an element is to atomic mass expressed in grams. A gram atom of an element contains 6.023×10^{23} atoms.

6. Ans. Gram molecular mass or gram mole - Gram molecular mass or gram mole of a compound is the molecular mass expressed in grams. A gram mole of a compound contains 6.023×10^{23} molecule.

7. Ans. Molarity may be defined as the number of moles of solute present in one litre of solution

$$\text{Mathematically : Molarity} = \frac{\text{Moles of solute}}{\text{Litres of solution}}.$$

8. Ans. Matter can neither be created nor destroyed in the course of a chemical reaction although it may change from one form to another.

9. Ans. Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

(B) Short Answer Type Questions (Two marks each)

10. Ans. When gases react they do in volumes which bear a simple ratio to each other and to the volume of any gaseous product all volume being measured under the same conditions at temperature and pressure, e.g.,

H_2 (1^{Vol}) +	Cl_2 (1Vol)	2HCl (2Vol)	Ratio 1: 1: 2
N_2 (1Vol) +	$3H_2$ (3Vol)	$2NH_3$ (2Vol)	Ratio 1: 3: 2.

11. Ans. The empirical formula of a compound is a chemical formula showing the relative number of atoms in the simplest ratio, and the molecular formula gives the actual number of atoms of each element in a molecule.

12. Ans. The qualitative and quantitative representation of a chemical reaction in short form in terms of symbols and formulae is called chemical equation. For example, on heating calcium carbonate, it given calcium oxide and carbon dioxide. This reaction can be represented by a chemical equation as follows:

Essential features: $CaCO_3 \longrightarrow CaO + CO_2$

(i) It should represent a true chemical reaction.

(ii) The formulae for all reactants and products must be correct.

(iii) It should be arithmetically balanced, i.e., the number of atoms of each element on both sides of the arrow should be equal.

(iv) It should be molecularly balanced.

13. Ans. 2

14. Ans. Symbol for SI unit of mole is mol. One mole is defined as the contains as many particles or entities as there are atoms in exactly 12 g(0.012 kg) of the ^{12}C isotope.

15. Ans. Molality is the number of moles of solute present in on the number of moles of solute dissolved in one litre of solution.

Molality is independent of temperature whereas molarity depends on temperature

16. Ans. No, molality of the solution does not change with temperature since mass remains unaffected with temperature.

17. Ans. In a chemical reaction, sometimes, an excess of one or more substance is available. Naturally, some of these excess substances will be left over when the reaction is complete. The reaction stops immediately as soon as one of the reactant is totally consumed. Consider a chemical reaction given below initiated by passing a spark through a reaction vessel containing 16 moles of H_2 and 10 moles of O_2.

The balanced equation would be

	$2H_2(g)$	$+ O_2(g) \longrightarrow$	$2H_2O(g)$
Number of moles before reaction	16	10	0
Number of moles after reaction	0	2	16

(Since 2 moles of $H_2 \equiv$ one mole of O_2)

From the above example, it is clear that the reaction stops after the consumption of 8 moles of O_2 since no, further amount of H_2 is left to react with unreacted O_2. The substance H_2, that is completely consumed is called limiting reagent as it limits the amount of the product formed. The other substance present in excess is called excess reagent. Here, O_2 is excess reagent.

Numerical based - Answers

1. Ans. (i) Number of moles of $N_2 = 0.28/28 = 0.01$

(ii) Number of molecules of $N_2 = 0.01 \times 6.023 \times 10^{23} = 6.023 \times 10^{21}$

(iii) Volume of nitrogen at STP $= 0.01 \times 22.4 = 0.224$ L.

2. Ans. Combustion equation for methane :

$CH_4(g)$	$+2O_2(g)$	$CO_2(g)$	$+2H_2O(g)$
1 mole	2 mole	1 mole	2 mole
16 g	64 g	44 g	36 g

From the above equation :

44 $gCO_2(g)$ is obtained from 16 $gCH_4(g)$ and 1 mole of $CO_2(g)$ is obtained from 1 mole of $CH_4(g)$

$$\text{Mole of } CO_2(g) = 22\ gCO_2(g) \times \frac{1\ molCO_2(g)}{44\ gCO_2(g)}$$
$$= 0.5\ molCO(g).$$

Hence, 0.5 $molCO2(g)$ would be obtained from 0.5 $molCH_4(g)$ or 0.5 mol of $CH_4(g)$ would be required to produce 22 $gCO_2(g)$.

3. Ans. Given : $M = 3$ mol L^{-1}

Mass of NaCl in 1 L solution $= 3 \times 58.5 = 175.5$ g

Mass of 1 L solution $= 1000 \times 1.25 = 1250$ g

Since density $= 1.25$ g mL^{-1}

Mass of water in solution $= 1250 - 175.5 = 1074.5$ g

$$\text{Molality} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}$$
$$= \frac{3\ \text{mol}}{1.0745\ \text{kg}}$$
$$= 2.79\ \text{m}.$$

4. Ans. A 0.500M NaCl contains 0.500 mol of NaCl in 1 L or 1000 cm^3 of solution

Number of moles of NaCl in 250 $cm^3 = \frac{0.500}{4}$

$$= 0.125 \text{ mol of NaCl}$$
$$\text{Molar mass of NaCl} = 58.44\ g$$
$$\text{Mass of } 0.125\ \text{molNaCl} = 58.44 \times 0.125\ g \text{ of NaCl}$$
$$= 7.305\ g \text{ of NaCl}$$

5. Ans.

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{per litre of the solution}}$$

$$0.150 = \frac{\frac{0.184}{40}}{\text{Volume in litres}}$$

$$\text{Volume in litres} = \frac{0.184}{40 \times 0.150}$$

$$= \frac{0.184}{6.0}$$

$$= 0.0307 \text{ litres}$$

$$= 30.7 \text{ mL of NaOH.}$$

6. Ans. Let us calculate the amount of $CaCO_3$ which will react with 20.0 g of HCl

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

100 g 73 g 44g

From the equation, we find that 100 $gCaCO_3(s)$ reacts with 73 gHCl to produce 44 gCO_2.

73 gHCl requires = 100 $gCaCO_3$

20 gHCl requires $= \frac{100}{73} \times 20 = 27.39$ $gCaCO_3$

Thus, $CaCO_3$ is the limiting reagent.

We can now say that

100 $gCaCO_3$ with enough HCl produces = 44 gCO_2

20 $gCaCO_3$ with enough HCl produces $= \frac{44}{100} \times 20$

$= 8.8$ gCO_2.

7. Ans. Mass per cent of calcium $= \frac{3\times(\text{ atomic mass of calcium })}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

$$= \frac{120u}{310u} \times 100 = 38.71\%$$

Mass per cent of phosphorus $= \frac{2\times(\text{ atomic mass of phosphorus })}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

$$= \frac{2 \times 31u}{310u} \times 100 = 20\%$$

Mass per cent of oxygen $= \frac{8\times(\text{ atomic mass of oxygen })}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

$$= \frac{8 \times 16u}{310u} \times 100 = 41.29\%$$

8. Ans. Average Atomic Mass $= \frac{\{(\text{Natural abundance of } ^1\text{H} \times \text{molar mass}) + (\text{Natural abundance of } ^2\text{H} \times \text{molar mass of } ^2\text{H})\}}{100}$

$$= \frac{99.985 \times 1 + 0.015 \times 2}{100}$$
$$= \frac{99.985 + 0.030}{100} = \frac{100.015}{100} = 1.00015\ \text{u}$$

9. Ans. 3 molal solution of NaOH means that 3 mols of NaOH are dissolved in 1000g of solvent

Mass of solution = Mass of solvent + mass o solute

$$= 1000\ \text{g} + (3 \times 40\ \text{g}) = 1120\ \text{g}$$

Volume of solution $= \frac{1120}{1.110}$ mL = 1009.00 mL

(Since density of solution = 1.110 g mL^{-1})

Since 1009 mL solution contains 3 mols of NaOH

$$\therefore \text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}}$$
$$= \frac{3\ \text{mol}}{1009.00} \times 1000 = 2.97\text{M}.$$

10. Ans. (i)

Element	% Composition	At. mass	Atomic ratio	Simple ratio
C	54.2	12	54.2/12 = 4.5	4.5/2.24 = 2
H	9.2	1	9.2/1 = 9.2	9.2/2.4 = 4
O	36.6	16	36.6/16 = 2.24	2.24/2.24 = 1

∴ Emprical formula is C_2H_4O

Given molecular mass of butyric acid = 88u

Now empirical formula mass of $C_2H_4O = 2 \times 12 + 4 \times 1 + 1 \times 16 = 44$

(ii)

$$n = \frac{\text{Molecular Mass}}{\text{Empirical formula mass}} = \frac{88}{44} = 2$$

Hence, molecular formula of butyric acid is $(C_2H_4O)_2$ or $(C_4H_8O_2)$.

11. Ans.
$$\underset{28\ \text{g}}{N_2(g)} + \underset{6\ \text{g}}{3H_2(g)} \longrightarrow \underset{34\ \text{g}}{2NH_3(g)}$$

28 g of nitrogen reacts with = 6 g of hydrogen

2×10^3 g of nitrogen react with $= \frac{6}{28} \times 2 \times 10^3$ g of hydrogen

$= 0.4286 \times 10^3$ g of hydrogen

(i) 28 g of nitrogen produce = 34 g of NH_3

(i) 28g of nitrogen produce $= 34$ g of NH_3

2×10^3 g of nitrogen produce $= \frac{34}{28} \times 2 \times 10^3\ gNH_3$

$= 2.4286 \times 10^3\ gNH_3$

(ii) Hydrogen will remain unreacted.

(iii) $(1 \times 10^3 - 0.4286 \times 10^3)$g or 0.5714×10^3 g of hydrogen.

12. Ans. Balanced chemical equation for the above reaction :

$$\begin{array}{ccc} N_2(g) & +3H_2(g) & \rightleftharpoons 2NH_3(g) \\ 1\text{ mol} & 3\text{ mol} & 2\text{ mol} \\ (28\text{ g}) & (6\text{ g}) & (34\text{ g}) \end{array}$$

6 g H_2 reacts with nitrogen to produce $= 34\ gNH_3$

or 6 kg H_2 reacts with nitrogen to produce $= 34\ gNH_3$

$\therefore$ 10 kgH_2 reacts with nitrogen to produce $= \frac{34}{6} \times 10 = 56.67$ kg NH_3

Hydrogen is the limiting reagent in this case. This can be proved as under:

Nitrogen required by 6 kg of $H_2 = 28$ kg

Nitrogen required by 10 kg of $H_2 = \frac{28}{6} \times 10 = 46.67$ kg.

13. Ans.

Number of moles of HCl $= 250\text{ mL} \times \frac{0.76M}{1000} = 0.19$ mol

Mass of $CaCO_3 = 1000$ g

Number of moles of $CaCO_3 = \frac{1000\text{ g}}{100\text{ g}} = 10$ moles

According to given equation 1 mole of $CaCO_3(s)$ requires 2 moles of $HCl(aq)$.

Hence, for the reaction of 10 moles of $CaCO_3(s)$ number of moles of HCl required would be :

10 moles of $CaCO_3 \times \frac{2\text{ moles }HCl(aq)}{1\text{ mole }CaCO_3(s)} = 20$ moles of $HCl(aq)$

But we have only 0.19 mole of $HCl(aq)$, hence, $HCl(aq)$ is limiting reagent.

So amount of $CaCl_2$ formed will depend on the amount of HCl available. Since, 2 moles of HCl (aq) forms 1 mol of $CaCl_2$, therefore, 0.19 mol of $HCl(aq)$ would give :

0.19 moles of $HCl(aq) \times \frac{1\text{ mole }CaCl_2(aq)}{2\text{ moles }HCl(aq)} = 0.095$ moles

or $0.095 \times$ molar mass of $CaCl_2 = 0.095 \times 111 = 10.54$ g.

14. Sol. Molar mass of $CuSO_4$

$= 63.54 + 32.06 + (4 \times 16)$

$159.6g\ CuSO_4$ contains $= 63.54g$ Cu

$1g\ CuSO_4$ contains $= \frac{63.54}{159.6} g$ Cu

$\therefore 100g\ CuSO_4$ contains $= \frac{63.54 \times 100}{159.6}$

$= 39.81g$ Cu

15. Sol. Calculation of empirical formula.

Empirical formula mass of

$Fe_2O_3 = (2 \times 55.85) + (3 \times 16.00) = 159.7 g\,mol^{-1}$

$$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}} = \frac{159.8}{159.7} = 1$$

Hence, molecular formula is same as empirical formula; Fe_2O_3.

16. Sol. Given, $d = 0.793\,kg\,L^{-1} = 0.793 * 10^3 g\,L^{-1}$

Final volume, $V_2 = 2.5L$

Final molarity, $M_2 = 0.25M$

Molarity of initial solution $M_1 = ?$

Initial volume $V_1 = ?$

Molar mass of methanol,

$CH_3OH = (1 \times 12.01) + (4 \times 1.0079) + 16.00$

$= 32.0416 \approx 32$

$$\text{Molarity} = \frac{0.793 \times 10^3 g\,L^{-1}}{32 g\,mol^{-1}} = 24.781\,mol\,L^{-1}$$

$\Rightarrow M_1V_1 = M_2V_2 \Rightarrow 24.781 \times V_1 = 0.25 \times 2.5$

$$\Rightarrow V_1 = \frac{0.25 \times 2.5}{24.781} = 0.02522L = 25.22mL$$

17. Sol. (a) 15 ppm means 15 parts in million (10^6) parts.

Therefore, % by mass $= \frac{15 \times 100}{10^6} = 1.5 \times 10^{-3}\%$

(b) Molar mass of chloroform $CHCl_3$

$= 12.01 + 1.0079 + (3 \times 35.45)$

$M_{CHCl_3} = 119.367 \approx 119\,g\,mol^{-1}$

$1.5 \times 10^{-3}\%$ means $1.5 \times 10^{-3}\,g$ chloroform is present in 100g sample.

Molarity, $M = \frac{w \times 1000}{m \times \text{volume of sample}}$

$M = \frac{1.5 \times 10^{-3} \times 1000}{119 \times 100} = 0.000126 = 1.26 \times 10^{-4}\,M$

18. Sol.

(a) $1g\ Au = \frac{1}{197}$ mol atoms of $Au = \frac{1}{197} \times 6.022 \times 10^{23}$ atoms of Au.

(b) $1g\,Na = \frac{1}{23}$ mole atoms of $Na = \frac{1}{23} \times 6.022 \times 10^{23}$ atoms of Na.

(c) $1g\,Li = \frac{1}{7}$ mole atoms of $Li = \frac{1}{7} \times 6.022 \times 10^{23}$ molecules of Li.

(d) $1g\ Cl_2 = \frac{1}{71}$ mole molecules of $Cl_2 = \frac{1}{71} \times 6.022 \times 10^{23}$ molecules of Cl_2.

$= \frac{2}{71} \times 6.022 \times 10^{23}$ atoms of Cl

19. Sol. Molarity is defined as the moles of solute (ethanol) I 1L of the solution.

1L of ethanol solution (as it is diluted)

= 1L of water

Number of moles of H_2O it 1L water

$= \frac{1000g}{18} = 55.55$ moles

For a binary solution (binary solution contains two components)

Hence, $x_1 + x_2 = 1 \Rightarrow x_{H_2O} = 1 - x_{C_2H_5OH}$

$$\Rightarrow x_{H_2O} = 1 - 0.040 = 0.96$$

$$\Rightarrow x_{H_2O} = \frac{n_{H_2O}}{n_{H_2O} + n_{C_2H_5OH}}$$

$$\Rightarrow 0.96 = \frac{55.55}{55.55 + n_{C_2H_5OH}}$$

$$\Rightarrow 53.328 + 0.96 n_{C_2H_5OH} = 55.55$$

$$\Rightarrow 0.96 n_{C_2H_5OH} = 55.55 - 53.328 = 2.222$$

$$\Rightarrow n_{C_2H_5OH} = \frac{2.222}{0.96} = 2.3145\,\text{mol}$$

20. Sol.(a) $1\,\text{mol of Ar} = 6.022 \times 10^{23}$ atoms.

$52\,\text{moles of Ar} = 52 \times 6.022 \times 10^{23}$ atoms

$= 313.144 \times 10^{23}$ atoms $= 3.131 \times 10^{25}$ atoms

(b) $4u$ of He $= 1$ He atom

$\therefore$ $52u$ of He $= \frac{52}{4}$ He atoms $= 13$ He atoms.

(c) $1\,\text{mol}$ atom of He $= 4g = 6.022 \times 10^{23}$ atoms.

$\Rightarrow 52g$ of He $= \frac{52 \times 6.022 \times 10^{23}}{4}$ atoms

$= 78.286 \times 10^{23}$ atoms $= 7.8282 \times 10^{24}$ atoms

21. Sol. (a) $44\,g\,CO_2 = 12g$ carbon

$3.38\,g\,CO_2 = \frac{12}{44} \times 3.38\,g = 0.9218g$ carbon

$18\,g\,H_2O = 2g$ hydrogen

$0.690\,g\,H_2O = \frac{2}{18} \times 0.690g = 0.0767\,g$ hydrogen

Total mass of compound

(Because compound contains only carbon and hydrogen)

$= 0.9218 + 0.0767 = 0.9985\,g$

% of C in the compound $= \dfrac{0.9218}{0.9985} \times 100 = 92.32$

% of H in the compound $= \dfrac{0.0767}{0.9985} \times 100 = 7.68$

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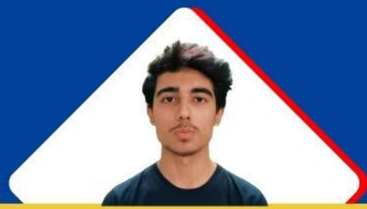

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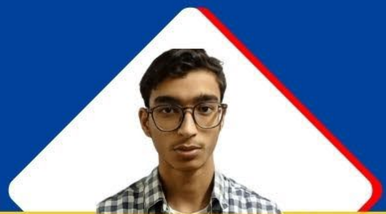

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