1 Some Basic Concepts in Chemistry

Question: The density of 1 M solution of a compound 'X' is 1.25 g mL^{-1}. The correct option for the molality of solution is (Molar mass of compound X = 85 g):

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A. 0.705 m

B. 1.208 m

C. 1.165 m

D. 0.858 m

Answer: D

Explanation

$$m = \frac{1000 \times M}{1000 \times d - MM_w}$$
$$m = \frac{1000 \times 1}{1000 \times 1.25 - 1 \times 85}$$
$$m = \frac{1000}{1165} = 0.858$$

Question:

The right option for the mass of CO_2 produced by heating 20 g of 20% pure limestone is

(Atomic mass of $Ca = 40$)

$$\left[CaCO_3 \xrightarrow{1200\ K} CaO + CO_2\right]$$

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A 1.76 g

B 2.64 g

C 1.32 g

D 1.12 g

Answer: A

Explanation

Weight of impure limestone $= 20$ g

Weight of pure limestone $(CaCO_3) = 20\%$ of 20 g

$= \frac{20}{100} \times 20$

$= 4$ g

$n_{CaCO_3} = \frac{4}{100} = 0.04$

Image

$n_{CO_2} = 0.04$

$W_{CO_2} = 0.04 \times 44$

$= 1.76$ g

2022

MCQ (Single Correct Answer)

Q.1. The density of the solution is 2.15 g mL^{-1}, then mass of 2.5 mL solution in correct significant figures is :

A. 53.75 g

B. 5375×10^{-3} g

C. 5.4 g

D. 5.38 g

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Ans. (C)

Explanation

Mass = Volume × Density

= 2.5 × 2.15

= 5.375 g

Since 2.5 has two significant figures, so the mass of solution in correct significant figures will be 5.4 g.

Q.2. What fraction of Fe exists as Fe(III) in $Fe_{0.96}O$?

(Consider $Fe_{0.96}O$ to be made up of Fe(II) and Fe(III) only)

A $\frac{1}{20}$

B $\frac{1}{12}$

C 0.08

D $\frac{1}{16}$

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Ans. (B)

Explanation

$Fe_{0.96}O$

Let Fe(II) present in $Fe_{0.96}O$ = x

Fe(III) present = (0.96 − x)

Total charge on Fe = 2x + (0.96 − x)3

Total charge on O = −2

2x + (0.96 − x)3 = 2

2x + 2.88 − 3x = 2

−x = −0.88

x = 0.88

Fe^{2+} = 0.88, Fe^{3+} = 0.08

Fraction of Fe^{3+} = $\frac{0.08}{0.96} = \frac{1}{12}$

Q.3. In one molal solution that contains 0.5 mole of a solute, there is

(A) 500 mL of solvent

(B) 500 g of solvent

(C) 100 mL of solvent

(D) 1000 g of solvent

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Ans. (B)

Explanation

Molality is the moles of solute dissolved per kg of solvent therefore 500 g, 1 molal solution contains 0.5 of solute, as

$$m = \frac{Moles\ of\ solute}{Mass\ of\ solvent\ (in\ kg)}$$

$$1 = \frac{0.5}{Mass\ of\ solvent\ (in\ kg)}$$

∴ Mass of solvent (in kg) = 0.5

= 500 g

Q.4. What mass of 95% pure $CaCO_3$ will be required to neutralise 50 mL of 0.5 M HCl solution according to the following reaction?

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + Co_{2(g)} + 2H_2O_{(l)}$

[Calculate upto second place of decimal point]

(A) 1.25 g

(B) 1.32 g

C 3.65 g

D 9.50 g

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Ans. (B)

Explanation

Let m gram mass of $CaCO_3$ is required

Pure $CaCO_3$ in m gram $= \frac{95}{100} \times m$

Moles of $CaCO_3 = \frac{95}{100} \times \frac{m}{100}$

Moles of HCl required = 2 $\times$ moles of $CaCO_3$

$= 2 \times \frac{95}{100} \times \frac{m}{100}$

$2 \times \frac{95}{100} \times \frac{m}{100} = \frac{50}{1000} \times 0.5$

$m = 1.315\, g \approx 1.32\, g$

TOPIC 1

Nature of Matter, Significant Figures and Laws of Chemical Combinations

01 The number of significant figures for the three numbers 161 cm, 0.161 cm, 0.0161 cm are **[CBSE AIPMT 1998]**

(a) 3,4 and 5 respectively
(b) 3,4 and 4 respectively
(c) 3,3 and 4 respectively
(d) 3,3 and 3 respectively

Ans. *(d)*

(i) All non-zero digits are significant.
(ii) Non-zero digits to the right of the decimal point are significant.
(iii) Zeroes to the left of the first non-zero digit in a number are not significant.

So, the number of significant figures for the numbers 161 cm, 0.161 cm and 0.0161 cm are same, i.e. 3.

02 0.24 g of a volatile gas, upon vaporisation, gives 45 mL vapour at NTP. What will be the vapour density of the substance? (Density of $H_2 = 0.089$) **[CBSE AIPMT 1996]**

(a) 95.93 (b) 59.93
(c) 95.39 (d) 5.993

Ans. *(b)*

Weight of gas = 0.24 g

Volume of gas $(V) = 45$ mL $= 0.045$ L

Density of $H_2(d) = 0.089$

Weight of 45 mL of $H_2 = V \times d$

$= 0.045 \times 0.089$

$= 4.005 \times 10^{-3}$ g

Therefore, vapour density

$= \frac{\text{Weight of certain volume of substance}}{\text{Weight of same volume of hydrogen}}$

$= \frac{0.24}{4.005 \times 10^{-3}} = 59.93$

03 In the final answer of the expression

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37}$$

the number of significant figures is **[CBSE AIPMT 1994]**

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

Ans. *(c)*

On calculation we find

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37} = 1.17 \times 10^6$$

As the least precise number contains 3 significant figures, therefore answer should also contains 3 significant figures.

04 The molecular weight of O_2 and SO_2 are 32 and 64 respectively. At 15°C and 150 mmHg pressure, 1 L of O_2 contains '*N*' molecules. The number of molecules in 2L of SO_2 under the same conditions of temperature and pressure will be **[CBSE AIPMT 1990]**

(a) *N*/2 (b) *N*
(c) 2 *N* (d) 4 *N*

Ans. *(c)*

According to Avogadro's law "equal volumes of all gases contain equal number of molecules under similar conditions of temperature and pressure." Thus, if 1 L of one gas contains *N* molecules, 2 L of any gas under similar conditions will contain 2 *N* molecules.

TOPIC 2

Atomic Mass, Molecular Mass and Formulae of Compounds

05 An organic compound contains 78% (by wt.) carbon and remaining percentage of hydrogen. The right option for the empirical formula of this compound is [At. wt. of C is 12, H is 1] **[NEET 2021]**

(a) CH (b) CH_2
(c) CH_3 (d) CH_4

Ans. *(c)*

Element	%	Atomic mass	Relative number of moles	Simple ratio of moles	Simplest whole number ratio
C	78	12	$\frac{78}{12} = 6.5$	$\frac{6.5}{6.5} = 1$	1
H	22	1	$\frac{22}{1} = 22$	$\frac{22}{6.5} =$ 3.3	3

The empirical formula of the organic compound is CH_3.

06 The number of protons, neutrons and electrons in $^{175}_{71}Lu$, respectively, are **[NEET (Sep.) 2020]**

(a) 104, 71 and 71 (b) 71, 71 and 104
(c) 175, 104 and 71 (d) 71, 104 and 71

Ans. *(d)*

In $^{175}_{71}Lu$,

Mass number $(A) = 175 = n + p$
Atomic number $(Z) = 71 = p = e^-$
$\therefore$ Number of protons = 71
Number of neutrons
$= A - Z = 175 - 71 = 104$
Number of electrons = 71

07 Suppose the elements X and Y combine to form two compounds XY_2 and X_3Y_2. When 0.1 mole of XY_2 weighs 10 g and 0.05 mole of X_3Y_2 weighs 9 g, the atomic weights of X and Y are **[NEET Phase II 2016]**

(a) 40, 30 (b) 60, 40 (c) 20, 30 (d) 30, 20

Ans. *(a)*

Let atomic masses of X and Y be A_X and A_Y, respectively

For XY_2, $n_{XY_2} = 0.1 = \frac{10}{A_X + 2A_Y}$

or $A_X + 2A_Y = 100$ ...(i)

For X_3Y_2, $n_{X_3Y_2} = 0.05 = \frac{9}{3A_X + 2A_Y}$

or $3A_X + 2A_Y = 180$ ...(ii)

On solving Eqs. (i) and (ii), we get,

$A_X = 40 \text{ g mol}^{-1} \Rightarrow A_Y = 30 \text{ g mol}^{-1}$

08 An organic compound contains carbon, hydrogen and oxygen. Its elemental analysis gave C, 38.71% and H, 9.67%. The empirical formula of the compound would be **[CBSE AIPMT 2008]**

(a) CH_3O (b) CH_2O (c) CHO (d) CH_4O

Ans. *(a)*

Element	% abundance	At. wt.	Molar ratio	Simple ratio
C	38.71	12	$\frac{38.71}{12} = 3.23$	$\frac{3.23}{3.23} = 1$
H	9.67	1	$\frac{9.67}{1} = 9.67$	$\frac{9.67}{3.23} = 3$
O	[100 − (38.71 + 9.67)] = 51.62	16	$\frac{51.62}{16} = 3.23$	$\frac{3.23}{3.23} = 1$

Thus, the empirical formula of the compound is CH_3O.

09 An element, X has the following isotopic composition:

$^{200}X : 90\%$, $^{199}X : 8.0\%$, $^{202}X : 2.0\%$

The weighted average atomic mass of the naturally occurring element X is closest to **[CBSE AIPMT 2007]**

(a) 201 u (b) 202 u
(c) 199 u (d) 200 u

Ans. *(d)*

Weight of $^{200}X = 0.90 \times 200 = 180.00$ u
Weight of $^{199}X = 0.08 \times 199 = 15.92$ u
Weight of $^{202}X = 0.02 \times 202 = 4.04$ u
Total weight $= 199.96 \approx 200$ u

10 Which of the following is isoelectronic? **[CBSE AIPMT 2002]**

(a) CO_2, NO_2
(b) NO_2^-, CO_2
(c) CN^-, CO
(d) SO_2, CO_2

Ans. *(c)*

CN^- and CO are isoelectronic because they have equal number of electrons.
In CN^- the number of electrons
$= 6 + 7 + 1 = 14$
In CO the number of electrons
$= 6 + 8 = 14$

11 An organic compound containing C, H and N gave the following results on analysis C = 40%, H = 13.33%, N = 46.67%. Its empirical formula would be **[CBSE AIPMT 2002, 1999, 98]**

(a) $C_2H_7N_2$ (b) CH_5N
(c) CH_4N (d) C_2H_7N

Ans. *(c)*

Table for empirical formula

Element	%	At. wt.	Molar ratio	Simple ratio
C	40.00	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	13.33	1	$\frac{13.33}{1} = 13.33$	$\frac{13.33}{3.33} = 4$
N	46.67	14	$\frac{46.67}{14} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence, empirical formula is CH_4N.

12 An organic compound contains C = 40%, O = 53.34% and H = 6.60%. The empirical formula of the compound is **[CBSE AIPMT 1994]**

(a) CH_2O (b) CHO
(c) CH_4O_2 (d) C_2H_2O

Ans. *(a)*

Element	%	At. wt.	Molar ratio	Simple ratio
C	40	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	6.60	1	$\frac{6.60}{1} = 6.60$	$\frac{6.60}{3.33} = 2$
O	53.34	16	$\frac{53.34}{16} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence, empirical formula is
C : H : O = 1 : 2 : 1 = CH_2O

13 Boron has two stable isotopes, ^{10}B (19%) and ^{11}B (81%). Calculate average atomic weight of boron in the periodic table. **[CBSE AIPMT 1990]**

(a) 10.8 (b) 10.2
(c) 11.2 (d) 10.0

Ans. *(a)*

Average of atomic weight

$$= \frac{\% \text{ of } {}^{10}B \times \text{atomic mass of } {}^{10}B + \% \text{ of } {}^{11}B \times \text{atomic mass of } {}^{11}B}{\% \text{ of } {}^{10}B + \% \text{ of } {}^{11}B}$$

$$= \frac{19 \times 10 + 81 \times 11}{19 + 81}$$

$$= \frac{190 + 891}{100} = 10.81$$

14 While extracting an element from its ore, the ore is grind and leached with dil. KCN solution to form the soluble product potassium argento- cyanide. The element is **[CBSE AIPMT 1989]**

(a) lead
(b) chromium
(c) manganese
(d) silver

Ans. *(d)*

Silver metal is extracted from the argentite ore Ag_2S by cyanide process. In this method, the concentrated ore is treated with dilute solution of potassium cyanide, then a soluble complex potassium dicyanoargentate (I) is formed which when reacted with zinc, silver is extracted as a ppt.

$$Ag_2S + 4KCN \longrightarrow 2K[Ag(CN)_2] + Na_2S$$
$$2K[Ag(CN)_2] + Zn \longrightarrow K_2[Zn(CN)_4] + 2Ag\downarrow$$

15 A metal oxide has the formula Z_2O_3. It can be reduced by hydrogen to give free metal and water. 0.1596 g of the metal oxide requires 6 mg of hydrogen for complete reduction. The atomic weight of the metal is **[CBSE AIPMT 1989]**

(a) 27.9 (b) 159.6
(c) 79.8 (d) 55.8

Ans. *(d)*

$$Z_2O_3 + 3H_2 \longrightarrow 2Z + 3H_2O$$

$\because 6\times10^{-3}$ g H_2 reduces = 0.1596 g of Z_2O_3

$\therefore$ 1 g H_2 reduces $= \dfrac{0.1596}{6\times10^{-3}}$ g Z_2O_3

$= 26.6$ g of Z_2O_3

$\therefore$ Equivalent weight of $Z_2O_3 = 26.6$

Equivalent weight of Z + Equivalent weight of O = 26.6

Equivalent weight of $Z + 8 = 26.6$

Equivalent weight of $Z = (26.6 - 8) = 18.6$

Valency of metal in $Z_2O_3 = 3$

Equivalent weigh $= \dfrac{\text{Atomic weight}}{\text{Valency}}$

Atomic weight $= 18.6 \times 3 = 55.8$

TOPIC 3
Mole Concept and Concentration Terms

16 One mole of carbon atom weighs 12 g, the number of atoms in it is equal to, (Mass of carbon -12 is 1.9926×10^{-23} g) **[NEET (Oct.) 2020]**

(a) 1.2×10^{23} (b) 6.022×10^{22}
(c) 12×10^{22} (d) 6.022×10^{23}

Ans. *(d)*

1 mole of carbon atoms weight 12 g, its contains Avogadro number of carbon atoms, i.e. 6.022×10^{23} number of carbon atoms.

17 Which one of the followings has maximum number of atoms? **[NEET (Sep.) 2020]**

(a) 1 g of Mg(*s*) [Atomic mass of Mg = 24]
(b) 1 g of $O_2(g)$ [Atomic mass of O = 16]
(c) 1 g of Li(*s*) [Atomic mass of Li = 7]
(d) 1 g of Ag(*s*) [Atomic mass of Ag = 108]

Ans. *(c)*

Number of atoms (n)

$$= \frac{\text{Mass in g (1 g)} \times \text{Atomicity of the molecule}}{\text{Gram molar mass } (M)} \times N_A$$

[$\because N_A$ = Avogadro's number]

$\Rightarrow n \propto \dfrac{\text{Atomicity}}{M}$

(a) $n_{Mg} = \dfrac{1}{24}$

(b) $n_O = \dfrac{2}{32} = \dfrac{1}{16}$

(c) $n_{Li} = \dfrac{1}{7}$

(d) $n_{Ag} = \dfrac{1}{108}$

So, $n_{Li} > n_O > n_{Mg} > n_{Ag}$

18 In which case is the number of molecules of water maximum? **[NEET 2018]**

(a) 0.00224 L of water vapours at 1 atm and 273 K
(b) 0.18 g of water
(c) 18 mL of water
(d) 10^{-3} mol of water

Ans. *(c)*

Number of molecules = Mole × Avogadro's number (N_A)

The number of molecules of water in each of the given options is calculated as

(i) 18 mL of water

Number of moles (n_{H_2O})

$$= \frac{\text{Mass of substance in } g\ (w_{H_2O})}{\text{Molar mass in g mol}^{-1}\ (M_{H_2O})}$$

$w_{H_2O} = 18$g

[$\because$ Density of water (d_{H_2O}) = 1 g L^{-1}]

$\therefore \quad n_{H_2O} = \dfrac{18}{18} = 1$

Number of molecules of water $= 1 \times N_A$

(ii) 0.18 g of water

$$n_{H_2O} = \frac{w_{H_2O}}{M_{H_2O}} = \frac{0.18}{18} = 0.01$$

Number of molecules of water $= 0.01 \times N_A$

(iii) 0.00224 L of water vapours at 1 atm and 273 K. At STP [1 atm and 273 K], Number of moles [with reference to volume]

$$= \frac{\text{Volume of gas in litres}}{22.4}$$

$$= \frac{0.00224}{22.4} = 0.0001$$

Number of molecules of water $= 0.0001 \times N_A$

(iv) 10^{-3} mol of water

Number of molecules of water $= 10^{-3} \times N_A$

$\therefore$ Among the given options, option (i) contains the maximum number of water molecules.

19 If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1} this would change **[CBSE AIPMT 2015]**

(a) the definition of mass in units of grams
(b) the mass of one mole of carbon
(c) the ratio of chemical species to each other in a balanced equation
(d) the ratio of elements to each other in a compound

Ans. *(b)*

If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change the mass of one mole of carbon.

$\because$ 1 mole of carbon has mass = 12 g

or 6.022×10^{23} atoms of carbon have mass = 12 g

$\therefore 6.022\times10^{20}$ atoms of carbon have mass

$$= \frac{12}{6.022\times10^{23}} \times 6.022\times10^{20} = 0.012 \text{ g}$$

20 How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70% HNO_3. **[NEET 2013]**

(a) 45.0 g conc. HNO_3
(b) 90.0 g conc. HNO_3
(c) 70.0 g conc. HNO_3
(d) 54.0 g conc. HNO_3

Ans. *(a)*

Given, molarity of solution = 2

Volume of solution = 250 mL

$$= \frac{250}{1000} = \frac{1}{4} \text{ L}$$

Molar mass of

$HNO_3 = 1 + 14 + 3 \times 16 = 63 \text{ g mol}^{-1}$

∵ Molarity

$$= \frac{\text{Weight of } HNO_3}{\text{Molecular mass of } HNO_3 \times \text{volume of solution (L)}}$$

∴ Weight of

HNO_3 = molarity × molecular mass × volume (L)

$$= 2 \times 63 \times \frac{1}{4} \text{ g}$$

$$= 31.5 \text{ g}$$

It is the weight of 100% HNO_3

But the given acid is 70% HNO_3

∴ Its weight $= 31.5 \times \frac{100}{70}$ g

$= 45$ g

21 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of solution is **[NEET 2013]**

(a) 0.02 M (b) 0.01 M
(c) 0.001 M (d) 0.1 M

Ans. ***(b)***

Given, number of molecules of urea $= 6.02 \times 10^{20}$

$$\therefore \text{ Number of moles} = \frac{6.02 \times 10^{20}}{N_A}$$

$$= \frac{6.02 \times 10^{20}}{6.023 \times 10^{23}}$$

$$= 0.999 \times 10^{-3}$$

$$\simeq 1 \times 10^{-3} \text{ mol}$$

Volume of the solution

$$= 100 \text{ mL} = \frac{100}{1000} \text{ L} = 0.1 \text{L}$$

Concentration of urea solution (in mol L^{-1})

$$= \frac{1 \times 10^{-3}}{0.1} \text{ mol L}^{-1}$$

$$= 1 \times 10^{-2} \text{ mol L}^{-1}$$

$$= 0.01 \text{ mol L}^{-1}$$

22 The number of atoms in 0.1 mole of a triatomic gas is ($N_A = 6.023 \times 10^{23}$ mol^{-1}) **[CBSE AIPMT 2010]**

(a) 6.026×10^{22} (b) 1.806×10^{23}
(c) 3.600×10^{23} (d) 1.800×10^{22}

Ans. ***(b)***

Number of atoms = number of moles $\times N_A \times$ atomicity

$$= 0.1 \times 6.023 \times 10^{23} \times 3$$

$$= 1.806 \times 10^{23} \text{ atoms}$$

23 Volume occupied by one molecule of water (density = 1 g cm^{-3}) is **[CBSE AIPMT 2008]**

(a) 9.0×10^{-23} cm^3
(b) 6.023×10^{-23} cm^3
(c) 3.0×10^{-23} cm^3
(d) 5.5×10^{-23} cm^3

Ans. ***(c)***

1 mole $= 6.023 \times 10^{23}$ molecule

18 g $= 6.02 \times 10^{23}$ molecule

18 g = mass of 6.02×10^{23} water molecules

Mass of one water molecule

$$= \frac{18}{6.023 \times 10^{23}} \text{ g}$$

Density = 1 g cm^{-3}

$$\text{Volume} = \frac{\text{Mass of one water molecule}}{\text{Density}}$$

$$= \frac{18}{6.023 \times 10^{23} \times 1} \text{ cm}^3$$

$$\approx 3.0 \times 10^{-23} \text{ cm}^3$$

24 The maximum number of molecules are present in **[CBSE AIPMT 2004]**

(a) 15 L of H_2 gas at STP
(b) 5 L of N_2 gas at STP
(c) 0.5 g of H_2 gas
(d) 10 g of O_2 gas

Ans. ***(a)***

In 15 L of H_2 gas at STP, the number of molecules

$$= \frac{6.023 \times 10^{23}}{22.4} \times 15$$

$$= 4.033 \times 10^{23}$$

In 5 L of N_2 gas at STP, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 5}{22.4}$$

$$= 1.344 \times 10^{23}$$

In 0.5 g of H_2 gas, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 0.5}{2}$$

$$= 1.505 \times 10^{23}$$

In 10 g of O_2 gas, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 10}{32}$$

$$= 1.882 \times 10^{23}$$

Hence, maximum number of molecules are present in 15 L of H_2 at STP.

25 Percentage of Se in peroxidase anhydrase enzyme is 0.5% by weight (at. weight = 78.4), then minimum molecular weight of peroxidase anhydrase enzyme is **[CBSE AIPMT 2001]**

(a) 1.568×10^3 (b) 15.68
(c) 2.168×10^4 (d) 1.568×10^4

Ans. ***(d)***

Suppose the molecular weight of enzyme = x

0.5% by weight means in 100 g of enzyme weight of Se = 0.5 g

∴ In x g of enzyme weight of Se $= \frac{0.5}{100} \times x$

Hence, $78.4 = \frac{0.5 \times x}{100}$

∴ $x = 15680$

$= 1.568 \times 10^4$

26 The number of atoms in 4.25 g of NH_3 is approximately **[CBSE AIPMT 1999]**

(a) 4×10^{23} (b) 2×10^{23}
(c) 1×10^{23} (d) 6×10^{23}

Ans. ***(d)***

Weight of $NH_3 = 4.25$ g

Number of moles of

$$NH_3 = \frac{\text{Weight}}{\text{Molecular weight}}$$

$$= \frac{4.25}{17} = 0.25 \text{ mol}$$

Number of molecules in 0.25 mole of NH_3

$$= 0.25 \times 6.023 \times 10^{23}$$

So, number of atoms

$$= 4 \times 0.25 \times 6.023 \times 10^{23}$$

$$= 6.0 \times 10^{23}$$

27 Haemoglobin contains 0.33% of iron by weight. The molecular weight of haemoglobin is approximately 67200 g. The number of iron atoms (at. weight of Fe is 56) present in one molecule of haemoglobin are **[CBSE AIPMT 1998]**

(a) 1 (b) 6 (c) 4 (d) 2

Ans. ***(c)***

∵ 0.33 % of iron by weight means 100 g of haemoglobin has 0.33 g of iron

100 g of haemoglobin contains iron = 0.33 g

∴ 67200 g of haemoglobin contains iron

$$= \frac{0.33 \times 67200}{100} \text{ g}$$

$$= 221.76 \text{ g of Fe}$$

Number of Fe-atoms $= \frac{221.76}{56}$

$= 3.96 \approx 4$

28 The number of moles of oxygen in 1 L of air containing 21% oxygen by volume, under standard conditions, is **[CBSE AIPMT 1995]**

(a) 0.0093 mole (b) 2.10 moles
(c) 0.186 mole (d) 0.21 mole

Ans. *(a)*

Volume of oxygen in 1 L of air

$= \frac{21}{100} \times 1000 = 210 \text{ mL}$

$\because$ 22400 mL volume at STP is occupied by oxygen = 1 mole

Therefore, number of moles occupied by 210 mL

$= \frac{210}{22400} = 0.0093 \text{ mol}$

29 The percentage weight of Zn in white vitriol $[ZnSO_4 \cdot 7H_2O]$ is approximately equal to (at. mass of Zn = 65, S = 32, O = 16 and H = 1) **[CBSE AIPMT 1995]**

(a) 33.65% (b) 32.56%
(c) 23.65% (d) 22.65%

Ans. *(d)*

Molecular weight of

$ZnSO_4 \cdot 7H_2O = 65 + 32 + (4 \times 16) + 7(18)$

$= 287$

$\therefore$ Percentage weight of Zn $= \frac{65}{287} \times 100$

$= 22.65\%$

30 The total number of valence electrons in 4.2 g of N_3^- ion is (N_A is the Avogadro's number) **[CBSE AIPMT 1994]**

(a) 2.1 N_A (b) 4.2 N_A (c) 1.6 N_A (d) 3.2 N_A

Ans. *(c)*

Moles of N_3^- ion $= \frac{4.2}{42} = 0.1$

Each nitrogen atom has 5 valence electrons. Therefore, total number of electrons in N_3^- ion = 16

Total number of electrons in 0.1 mole or 4.2 g of N_3^- ion $= 0.1 \times 16 \times N_A = 1.6 N_A$

31 The number of gram molecules of oxygen in 6.02×10^{24} CO molecules is **[CBSE AIPMT 1990]**

(a) 10 g molecules (b) 5 g molecules
(c) 1 g molecule (d) 0.5 g molecule

Ans. *(b)*

6.023×10^{23} molecules of CO

= 1 mole of CO

6.02×10^{24} molecules of CO

= 10 moles of CO

= 10 g atoms of O = 5 g molecules of O_2

32 The number of oxygen atoms in 4.4 g of CO_2 is **[CBSE AIPMT 1990]**

(a) 1.2×10^{23} (b) 6×10^{22}
(c) 6×10^{23} (d) 12×10^{23}

Ans. *(a)*

1 mole of CO_2 = 44 g of CO_2

$= 6.023 \times 10^{23}$ molecules

$\therefore$ 4.4 g of CO_2 = 0.1 mole of CO_2

$= 6.023 \times 0.1 \times 10^{23}$ molecules

$= 6.023 \times 10^{22}$ molecules

$= 6.023 \times 10^{22}$ molecules of O_2

$= 2 \times 6.023 \times 10^{22}$ atoms of O

$\approx 1.2 \times 10^{23}$ atoms of O

33 Ratio of C_p and C_V of a gas 'X' is 1:4. The number of atoms of the gas 'X' present in 11.2 L of it at NTP will be **[CBSE AIPMT 1989]**

(a) 6.02×10^{23} (b) 1.2×10^{23}
(c) 3.01×10^{23} (d) 2.01×10^{23}

Ans. *(a)*

For the gas X ratio of $C_p / C_V = 1:4$

So, the gas X is diatomic.

At NTP, volume of 1 mole of a gas

= 22.4 L

1 mole of a gas $= 6.023 \times 10^{23}$ molecules

Thus, at NTP 22.4 L contains

$= 6.023 \times 10^{23}$ molecules

So, at NTP 11.2 L contains

$= \frac{6.023 \times 10^{23} \times 11.2}{22.4}$ molecules

$= 3.01 \times 10^{23}$ molecules

Hence, number of atoms of gas 'X' (diatomic)

$= 3.01 \times 10^{23} \times 2$ atoms

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

34 1 cc N_2O at NTP contains **[CBSE AIPMT 1988]**

(a) $\frac{1.8}{224} \times 10^{22}$ atoms

(b) $\frac{6.02}{22400} \times 10^{23}$ molecules

(c) $\frac{1.32}{224} \times 10^{23}$ electrons

(d) All of the above

Ans. *(d)*

At NTP 22400 cc of N_2O contains

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

$\therefore$ 1 cc N_2O will contain

$= \frac{6.02 \times 10^{23}}{22400}$ molecules

In N_2O molecule, number of atoms

$= 2 + 1 = 3$

Thus, number of atoms

$= \frac{3 \times 6.02 \times 10^{23}}{22400}$ atoms

$= \frac{1.8 \times 10^{22}}{224}$ atoms

In N_2O molecule, number of electrons

$= 7 + 7 + 8 = 22$

Hence, number of electrons

$= \frac{6.02 \times 10^{23}}{22400} \times 22$ electrons

$= \frac{1.32 \times 10^{23}}{224}$ electrons

35 At STP, the density of CCl_4 vapour in g/L will be nearest to **[CBSE AIPMT 1988]**

(a) 6.87 (b) 3.42 (c) 10.26 (d) 4.57

Ans. *(a)*

1 mole CCl_4 vapours

$= 12 + 4 \times 35.5 = 154$ g

At STP, volume of 1 mole of a gas

= 22.4 L

Thus, 154 g = 22.4 L

$\therefore$ Density of CCl_4 vapours $= \frac{154}{22.4}$ g L^{-1}

$= 6.87$ g L^{-1}

TOPIC 4

Stoichiometric and Volumetric Calculations

36 The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is **[NEET (National) 2019]**

(a) 20 (b) 30 (c) 40 (d) 10

Ans. *(b)*

According to Haber's process,

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

Now, according to above equations

2 moles of ammonia (NH_3) require = 3 moles of H_2

$\therefore$ 1 mole of NH_3 require = 3/2 moles of H_2

or, 20 moles of NH_3 require $= \frac{3}{2} \times 20$ moles of $H_2 = 30$ moles of H_2.

Note Involvement of any limiting reagent is not mentioned in question.

37 20.0 g of a magnesium carbonate sample decomposes on heating to give carbon dioxide and 8.0 g magnesium oxide. What will be the percentage purity of magnesium carbonate in the sample? (Atomic weight of Mg = 24) **[CBSE AIPMT 2015]**

(a) 75 (b) 96 (c) 60 (d) 84

Ans. *(d)*

Key Concept *In the given problem we have provided practical yield of MgO. For calculation of percentage yield of MgO, we need theoretical yield of MgO. For this we shall use mole concept.*

$$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g) \quad ...(i)$$

$$\text{Moles of } MgCO_3 = \frac{\text{Weight in gram}}{\text{Molecular weight}} = \frac{20}{84} = 0.238 \text{ mol}$$

From Eq. (i)

1 mole of $MgCO_3$ gives = 1 mol MgO

$\therefore$ 0.238 mole $MgCO_3$ will give

$= 0.238$ mol MgO

$= 0.238 \times 40$ g

$= 9.52$ g MgO

Now, practical yield of MgO = 8 g

$$\therefore \quad \% \text{ purity} = \frac{8}{9.52} \times 100 = 84\%$$

Alternate Method

$$\underset{84\text{ g}}{MgCO_3} \longrightarrow \underset{40\text{ g}}{MgO} + CO_2$$

$\therefore$ 8 g MgO will be form from $\frac{84}{5}$ g

$$\therefore \quad \% \text{ purity} = \frac{84}{5} \times \frac{100}{20} = 84\%$$

38 What is the mass of precipitate formed when 50 mL of 16.9% solution of $AgNO_3$ is mixed with 50 mL of 5.8% NaCl solution? (Ag = 107.8, N = 14, O = 16, Na = 23, Cl = 35.5) **[CBSE AIPMT 2015]**

(a) 28 g (b) 3.5 g
(c) 7 g (d) 14 g

Ans. *(c)*

Plan For the calculation of mass of AgCl precipitated, we find mass of $AgNO_3$ and NaCl in equal volume with the help of mole concept.

16.9% solution of $AgNO_3$ means 16.9 g $AgNO_3$ is present in 100 mL solution.

$\therefore$ 8.45 g $AgNO_3$ will be present in 50 mL solution.

Similarly,

5.8 g NaCl is present in 100 mL solution

$\therefore$ 2.9 g NaCl is present in 50 mL solution

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

Initial mole $\frac{8.45}{169.8}$ $\quad \frac{2.9}{58.5}$ $\quad 0 \quad 0$

$= 0.049 = 0.049$

After reaction

$0 \quad 0 \quad 0.049 \quad 0.049$

$\therefore$ Mass of AgCl precipitated

$= 0.049 \times 143.5 = 7$ g

39 When 22.4 L of $H_2(g)$ is mixed with 11.2 L of $Cl_2(g)$, each at STP, the moles of HCl(g) formed is equal to **[CBSE AIPMT 2014]**

(a) 1 mole of HCl (g)
(b) 2 moles of HCl (g)
(c) 0.5 mole of HCl (g)
(d) 1.5 moles of HCl (g)

Ans. *(a)*

The given problem is related to the concept of stoichiometry of chemical equations. Thus, we have to convert the given volumes into their moles and then, identify the limiting reagent [possessing minimum number of moles and gets completely used up in the reaction]. The limiting reagent gives the moles of product formed in the reaction.

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$

Initial vol. 22.4 L $\quad$ 11.2 L $\quad$ 2 mol

$\because$ 22.4 L volume at STP is occupied by $Cl_2 = 1$ mole

$\therefore$ 11.2 L volume will be occupied by

$$Cl_2 = \frac{1 \times 11.2}{22.4} \text{ mol} = 0.5 \text{ mol}$$

22.4 L volume at STP is occupied by H_2 = 1 mol

Thus, $\underset{1\text{ mol}}{H_2(g)} + \underset{0.5\text{ mol}}{Cl_2(g)} \longrightarrow 2HCl(g)$

Since, Cl_2 possesses minimum number of moles, thus it is the limiting reagent.

As per equation,

1 mole of Cl_2 = 2 moles of HCl

$\therefore$ 0.5 mole of $Cl_2 = 2 \times 0.5$ mole of HCl

$= 1.0$ mole of HCl

Hence, 1.0 mole of HCl(g) is produced by 0.5 mole of Cl_2 [or 11.2 L].

40 1.0 g of magnesium is burnt with 0.56 g of oxygen in a closed vessel. Which reactant is left in excess and how much? **[CBSE AIPMT 2014]**
(At. weight of Mg = 24, O = 16)

(a) Mg, 0.16 g
(b) O_2, 0.16 g
(c) Mg, 0.44 g
(d) O_2, 0.28 g

Ans. *(a)*

The balanced chemical equation is

$$\underset{24\text{ g}}{Mg} + \underset{16\text{ g}}{\frac{1}{2}O_2} \longrightarrow \underset{40\text{ g}}{MgO}$$

From the above equation, it is clear that, 24 g of Mg reacts with 16 g of O_2.

Thus, 1.0 g of Mg reacts with

$\frac{16}{24}$ g of $O_2 = 0.67$ g of O_2.

But only 0.56 g of O_2 is available which is less than 0.67 g. Thus, O_2 is the limiting reagent.

Further, 16 g of O_2 reacts with 24 g of Mg.

$\therefore$ 0.56 g of O_2 will react with Mg

$= \frac{24}{16} \times 0.56$

$= 0.84$ g

$\therefore$ Amount of Mg left unreacted

$= (1.0 - 0.84)$ g Mg

$= 0.16$ g Mg

41 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be **[CBSE AIPMT 2009]**

(a) 2 moles (b) 3 moles
(c) 4 moles (d) 1 mole

Ans. *(c)*

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$

H_2	$\frac{1}{2}O_2$	H_2O
1 mol	$\frac{1}{2}$ mol	1 mol
$\frac{10}{2}$ mol	$\frac{64}{32}$ mol	?
5 mol	2 mol	

$\because$ $\frac{1}{2}$ mole of O_2 gives = 1 mole of H_2O

$\therefore$ 2 moles of O_2 will give $= 1 \times 2 \times 2$

= 4 moles of water

42 How many moles of lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl? **[CBSE AIPMT 2008]**

(a) 0.044 (b) 0.333 (c) 0.011 (d) 0.029

Ans. *(d)*

$$\underset{\substack{207+16\\=223\\(1\text{ mol})}}{PbO} + \underset{\substack{2\times 36.5\\=73\\(2\text{ mol})}}{2HCl} \longrightarrow \underset{(1\text{ mol})}{PbCl_2} + H_2O$$

$$\text{Mole of PbO} = \frac{6.5}{223} = 0.029$$

$$\text{Mole of HCl} = \frac{3.2}{36.5} = 0.087$$

Since, 1 mole of PbO reacts with 2 moles of HCl, thus in this reaction PbO is the limiting reagent.

Hence, 1 mole of PbO forms

$= 1$ mole of $PbCl_2$

0.029 mole of PbO will form $= 0.029$ mole of $PbCl_2$

43 What volume of oxygen gas (O_2) measured at 0°C and 1 atm, is needed to burn completely 1L of propane gas (C_3H_8) measured under the same conditions? **[CBSE AIPMT 2008]**

(a) 7 L (b) 6 L
(c) 5 L (d) 10 L

Ans. *(c)*

$$\underset{22.4\text{ L}}{C_3H_8} + \underset{5\times 22.4\text{ L}}{5O_2} \longrightarrow 3CO_2 + 4H_2O$$

For the combustion of 22.4 L propane, oxygen required $= 5 \times 22.4$ L

For the combustion of 1 L of propane oxygen required

$$= \frac{5 \times 22.4}{22.4}\text{ L} = 5\text{ L}$$

44 Number of moles of MnO_4^- required to oxidise one mole of ferrous oxalate completely in acidic medium will be **[CBSE AIPMT 2008]**

(a) 0.6 mole (b) 0.4 mole
(c) 7.5 moles (d) 0.2 mole

Ans. *(b)*

In acidic medium MnO_4^- oxidises ferrous oxalate as follows:

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

∵ 5 moles of oxalate ions are oxidised by 2 moles of MnO_4^-.

∴ 1 mole of oxalate ion is oxidised by

$$= \frac{2}{5}\text{ mole of } MnO_4^- = 0.4 \text{ mole of } MnO_4^-$$

45 The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite ion in acidic solution is **[CBSE AIPMT 2007]**

(a) 4/5 (b) 2/5
(c) 1 (d) 3/5

Ans. *(b)*

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$[MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O] \times 2$$
$$[SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-] \times 5$$
$$\overline{2MnO_4^- + 6H^+ + 5SO_3^{2-} \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O}$$

5 moles of sulphite ions react with

$= 2$ moles of MnO_4^-

So, 1 mole of sulphite ions react with

$$= \frac{2}{5}\text{ moles of } MnO_4^-.$$

46 The number of moles of $KMnO_4$ reduced by one mole of KI in alkaline medium is **[CBSE AIPMT 2005]**

(a) one fifth (b) five
(c) one (d) two

Ans. *(c)*

In alkaline medium, $KMnO_4$ is reduced to K_2MnO_4

$$KI + H_2O \longrightarrow KOH + HI$$

$$2K\overset{+7}{Mn}O_4 + 2KOH \longrightarrow 2K_2\overset{+6}{Mn}O_4 + H_2O + [O]$$

Hence, one mole of $KMnO_4$ is reduced by one mole of KI.

47 The mass of carbon anode consumed (giving only carbon dioxide) in the production of 270 kg of aluminium metal from bauxite by the Hall process is
(at. mass of Al = 27) **[CBSE AIPMT 2005]**

(a) 180 kg (b) 270 kg (c) 540 kg (d) 90 kg

Ans. *(d)*

In Hall and Heroult process,

$$2Al_2O_3 + 4C \longrightarrow 4Al + 2CO_2 + 2CO$$

but for the removal of only CO_2, following equation is possible.

$$2Al_2O_3 + \underset{\substack{3\times 12\\=36}}{3C} \longrightarrow \underset{\substack{4\times 27\\=108}}{4Al} + 3CO_2$$

∵ For 108 g of Al, 36 g of C is required in above reaction.

∴ For 270×10^3 g of Al required amount of C

$$= \frac{36}{108} \times 270 \times 10^3$$

$$= 90 \times 10^3 \text{ g} = 90 \text{ kg}$$

48 In Haber process 30L of dihydrogen and 30L of dinitrogen were taken for reaction which yielded only 50% of the expected product. What will be the composition of gaseous mixture under the aforesaid condition in the end? **[CBSE AIPMT 2003]**

(a) 20 L ammonia, 10 L nitrogen, 30 L hydrogen
(b) 20 L ammonia, 25 L nitrogen, 15 L hydrogen
(c) 20 L ammonia, 20 L nitrogen, 20 L hydrogen
(d) 10 L ammonia, 25 L nitrogen, 15 L hydrogen

Ans. *(d)*

$$\underset{\substack{1V\\10\text{ L}}}{N_2} + \underset{\substack{3V\\30\text{ L}}}{3H_2} \longrightarrow \underset{\substack{2V\\20\text{ L}}}{2NH_3}$$

As only 50% of the expected product is formed, hence only 10 L of NH_3 is formed.

Thus, for the production of 10 L of NH_3, 5 L of N_2 and 15 L of H_2 are used and composition of gaseous mixture under the aforesaid condition in the end is

$$H_2 = 30 - 15 = 15\text{ L}$$
$$N_2 = 30 - 5 = 25\text{ L}$$
$$NH_3 = 10\text{ L}$$

49 Which has maximum number of molecules? **[CBSE AIPMT 2002]**

(a) 7 g N_2 (b) 2 g H_2
(c) 16 g NO_2 (d) 16 g O_2

Ans. *(b)*

In 7 g nitrogen, number of molecules

$$= \frac{7.0}{28}\text{ mol}$$

$$= 0.25 \times N_A \text{ molecules}$$

where, N_A = Avogadro numbe

$$= 6.023 \times 10^{23}$$

In 2 g of $H_2 = \frac{2.0}{2}$ mol

$$= 1 \times N_A \text{ molecules}$$

In 16 g of $NO_2 = \frac{16.0}{46}$ mol

$= 0.348 \times N_A$ molecules

In 16 g of

$O_2 = \frac{16}{32}$ mol $= 0.5 \times N_A$ molecules

Hence, maximum number of molecules are present in 2 g of H_2.

50 Assuming fully decomposed, the volume of CO_2 released at STP on heating 9.85 g of $BaCO_3$ (at. mass of Ba = 137) will be **[CBSE AIPMT 2000]**

(a) 1.12 L (b) 0.84 L
(c) 2.24 L (d) 4.96 L

Ans. *(a)*

On decomposition, $BaCO_3$ liberates CO_2 as

$$\underset{197\text{ g}}{BaCO_3} \longrightarrow BaO + \underset{22.4\text{ L at STP}}{CO_2 \uparrow}$$

$\because$ 197 g of $BaCO_3$ gives

$= 22.4$ L of CO_2 at STP

$\therefore$ 9.85 g of $BaCO_3$ will give

$= \frac{22.4 \times 9.85}{197} = 1.12$ L

51 In the reaction,

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$$

When 1 mole of ammonia and 1 mole of O_2 are made to react to completion, then **[CBSE AIPMT 1998]**

(a) 1.0 mole of H_2O is produced
(b) 1.0 mole of NO will be produced
(c) all the oxygen will be consumed
(d) all the ammonia will be consumed

Ans. *(c)*

$$\underset{4\text{ mol}}{4NH_3(g)} + \underset{5\text{ mol}}{5O_2(g)} \longrightarrow \underset{4\text{ mol}}{4NO(g)} + \underset{6\text{ mol}}{6H_2O(l)}$$

According to equation,

5 moles of O_2 required = 4 moles of NH_3

1 mole of O_2 requires

$= \frac{4}{5} = 0.8$ mole of NH_3

While 1 mole of NH_3 requires $= \frac{5}{4}$

$= 1.25$ moles of O_2

As there is 1 mole of NH_3 and 1 mole of O_2, so all the oxygen will be consumed.

52 Liquid benzene (C_6H_6) burns in oxygen according to the equation,

$$2C_6H_6(l) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(g)$$

How many litres of O_2 at STP are needed to complete the combustion of 39 g of liquid benzene? (Mol. weight of $O_2 = 32$, $C_6H_6 = 78$) **[CBSE AIPMT 1996]**

(a) 74 L (b) 11.2 L (c) 22.4 L (d) 84 L

Ans. *(d)*

$$\underset{\substack{2\times 78\\=156}}{2C_6H_6} + \underset{\substack{15\times 32\\=330}}{15O_2(g)} \longrightarrow 12CO_2(g) + 6H_2O(g)$$

$\because$ 156 g of benzene required oxygen

$= 15 \times 22.4$ L

$\therefore$ 1 g of benzene required oxygen

$= \frac{15 \times 22.4}{156}$ L

$\therefore$ 39 g of benzene required oxygen

$= \frac{15 \times 22.4 \times 39}{156}$

$= 84.0$ L

53 What is the weight of oxygen required for the complete combustion of 2.8 kg of ethylene? **[CBSE AIPMT 1989]**

(a) 2.8 kg (b) 6.4 kg
(c) 9.6 kg (d) 96 kg

Ans. *(c)*

$$\underset{\substack{12\times 2+4\times 1\\=28\text{ g}}}{C_2H_4} + \underset{\substack{16\times 6\\=96\text{ g}}}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

$\because$ For the combustion of 28×10^{-3} kg of ethylene oxygen required $= 96 \times 10^{-3}$ kg

$\therefore$ For the combustion of 2.8 kg of ethylene oxygen required

$= \frac{96 \times 10^{-3} \times 2.8}{28 \times 10^{-3}}$

$= 9.6$ kg

54 One litre hard water contains 12.00 mg Mg^{2+}. Milliequivalents of washing soda required to remove its hardness is **[CBSE AIPMT 1988]**

(a) 1
(b) 12.16
(c) 1×10^{-3}
(d) 12.16×10^{-3}

Ans. *(a)*

$$\underset{1\text{ g-eq}}{Mg^{2+}} + \underset{1\text{ g-eq}}{Na_2CO_3} \longrightarrow MgCO_3 + 2Na^+$$

1 g-equivalent of $Mg^{2+} = 12$ g of Mg^{2+}

$= 12000$ mg of Mg^{2+}

Now, 12000 mg of $Mg^{2+} \equiv 1000$ milliequivalent of Na_2CO_3

12 mg of $Mg^{2+} \equiv 1$ milliequivalent of Na_2CO_3