Chapter – 1

Basic Concepts of Chemistry & Chemical Calculations

I. Choose the Best Answer

Question 1.
40 ml of methane is completely burnt using 80 ml of oxygen at room temperature. The volume of gas left after cooling to room temperature is ……..
(a) 40 ml CO_2 gas
(b) 40 ml CO_2 gas and 80 ml H_2O gas
(c) 60 ml CO_2 gas and 60 ml H_2O gas
(d) 120 ml CO_2 gas

Answer:
(a) 40 ml CO_2 gas

Solution:
$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(l)}$

Content	CH_4	O_2	CO_2
Stoichiometric coefficient	1	2	1
Volume of reactants allowed to react	40 mL	80 mL	–
Volume of reactant reacted and product formed	40 mL	80 mL	40 mL
Volume of gas after cooling to the room temperature	–	–	–

Since the product was cooled to room temperature, water exists mostly as liquid. Hence, option (a) is correct

Question 2.
An element X has the following isotopic composition $^{200}X = 90$ %, $^{199}X = 8$ % and $^{202}X = 2$ %. The weighted average atomic mass of the element X is closest to ……
(a) 201 u

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

Answer:
(d) 200 u

$$= \frac{(200\times90)+(199\times8)+(202\times2)}{100} = 199.96 = 200 \text{ u}$$

Question 3.
Assertion:
Two moles of glucose contain 12.044×10^{23} molecules of glucose.
Reason:
The total number of entities present in one mole of any substance is equal to 6.02×10^{22}

(a) both assertion and reason are true and the reason is the correct explanation of the assertion
(b) both assertion and reason are true but the reason is not the correct explanation of the assertion
(c) the assertion is true but the reason is false
(d) both assertion and reason are false

Answer:
(c) the assertion is true but the reason is false

Correct reason:
The total number of entities present in one mole of any substance is equal to $6.022 \text{ x } 10^{23}$

Question 4.
Carbon forms two oxides, namely carbon monoxide and carbon dioxide. The equivalent mass of which element remains constant?
(a) Carbon
(b) Oxygen
(c) Both carbon and oxygen
(d) Neither carbon nor oxygen

Answer:
(b) Oxygen

Reaction 1:

$2\ C + O_2 \rightarrow 2\ CO_2$

2 × 12 g carbon combines with 32 g of oxygen.

Hence, Equivalent mass of carbon = $\frac{2\times12}{32} \times 8 = 6$

Reaction 2:

$C + O_2 \rightarrow 2\ CO_2$

12 g carbon combines with 32 g of oxygen.

Hence, Equivalent mass of carbon = $\frac{12}{32} \times 8 = 3$

Question 5.
The equivalent mass of a trivalent metal element is 9 g eq^{-1} the molar mass of its anhydrous oxide is …….
(a) 102 g
(b) 27 g
(c) 270 g
(d) 78 g

Answer:
(a) 102 g
Let the trivalent metal be M^{3+}
Equivalent mass = mass of the metal / valance factor
9g eq^{-1} = mass of the metal / 3 eq
Mass of the metal = 27 g
Oxide formed M_2O_3
Mass of the oxide = (2 × 27) + (3 × 16) = 102 g

Question 6.
The number of water molecules in a drop of water weighing 0.018 g is ……
(a) 6.022×10^{26}
(b) 6.022×10^{23}
(c) 6.022×10^{20}

(d) 99×10^{22}

Answer:
(c) 6.022×10^{20}
Weight of the water drop = 0.0 18 g
No. of moles of water in the drop = Mass of water / molar mass = 0.018/18 = 10^{-3} mole
No of water molecules present in I mole of water = 6.022×10^{23}
No. water molecules in one drop of water (10 moles) = $6.022 \times 10^{23} \times 10^{-3} = 6.022 \times 10^{20}$

Question 7.
1 g of an impure sample of magnesium carbonate (containing no thermally decomposable impurities) on complete thermal decomposition gave 0.44 g of carbon dioxide gas. The percentage of impurity in the sample is ……..
(a) 0 %
(b) 4.4 %
(c) 16 %
(d) 8.4 %

Answer:
(c) 16%
$MgCO_3 \rightarrow MgO + CO_2\uparrow$
$MgCO_3 : (1 \times 24) + (1 \times 12) + (3 \times 16) = 84$ g
$CO_2 : (1 \times 12) + (2 \times 16)$ 44g

100% pure 84 g $MgCO_3$ on heating gives 44 g CO_2
Given that I g of $MgCO_3$ on heating gives 0.44 g CO_2
Therefore, 84 g $MgCO_3$ sample on heating gives 36.96 g CO_2 = 100%

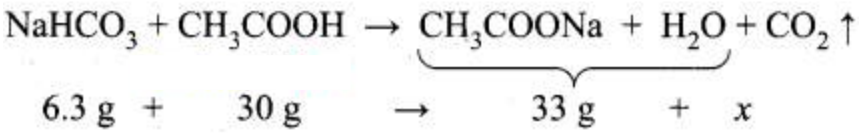
Percentage of purity of the sample = $\frac{100\%}{44gCO_2} \times 36.96\ g\ CO_2 = 84\%$

Percentage of impurity = 16%

Question 8.
When 6.3 g of sodium bicarbonate is added to 30 g of the acetic acid solution,

the residual solution is found to weigh 33 g. The number of moles of carbon dioxide released in the reaction is-
(a) 3
(b) 0.75
(c) 0.075
(a) 0.3

Answer:
(c) 0.075



The amount of CO_2 released, x = 3.3 g
No. of moles of CO_2 released = 3.3 / 44 = 0.075 mol

Question 9.
When 22.4 liters of H_2 (g) is mixed with 11.2 liters of Cl_2 (g), each at 273 K at 1 atm the moles of HCl (g), formed is equal to …….
(a) 2 moles of HCl (g)
(b) 0.5 moles of HCl (g)
(c) 1.5 moles of HCl (g)
(d) 1 moles of HCl (g)

Answer:
(d) 1 moles of HCl (g)

Solution:
$H_2(g) + Cl_2(g) \rightarrow 2\ HCl\ (g)$

Content	$H_2(g)$	$cl_2(g)$	HCl (g)
Stoichiometric coefficient	1	1	2
No. of moles of reactants allowed to react at 273 K and 1 atm pressure	22.4 L (1 mol)	11.2 L (0.5 mol)	—
No. of moles of a reactant reacted and product formed	0.5	0.5	1
Amount of HCl formed 1 mol			

Question 10.
Hot concentrated sulfuric acid is a moderately strong oxidizing agent. Which of the following reactions does not show oxidizing behavior?
(a) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$
(b) $C + 2H_2SO_4 \rightarrow 4\ CO_2 + 2SO_2 + 2H_2O$
(c) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$
(d) none of the above

Answer:
(c) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$

$$\overset{+2\ -1}{BaCl_2} + \overset{+1\ +6\ -2}{H_2SO_4} \rightarrow \overset{+2\ +6\ -2}{BaSO_4} + \overset{+1\ -1}{2HCl}$$

Question 11.
Choose the disproportional reaction among the following redox reactions.
(a) $3Mg\ (s) + N_2(g) \rightarrow Mg_2N_2\ (s)$
(b) $P_4\ (s) + 3NaOH + 3H_2O \rightarrow PH_3(g) + 3NaH_2PO_2\ (aq)$
(c) $Cl_2\ (g) + 2Kl\ (aq) \rightarrow 2KC1\ (aq) + I_2$
(d) $Cr_2O_3\ (s) + 2Al\ (s) \rightarrow A_2O_3\ (s) + 2Cr\ (s)$

Answer:
(b) $P_4\ (s) + 3NaOH + 3H_2O \rightarrow PH_3(g) + 3NaH_2PO_2\ (aq)$

$$\overset{0}{P_4}\ (s) + 3NaOH + 3H_2 \rightarrow \overset{-3}{PH_3}(g) + 3NaH_2\overset{+1}{PO_2}\ (aq)$$

Question 12.
The equivalent mass of potassium permanganate in alkaline medium is
$MnO_4 + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$
(a) 31.6
(b) 52.7
(c) 79
(d) None of these

Answer:
(b) 52.7
The reduction reaction of the oxidizing agent(MnO_4) involves gain of 3 electrons.
Hence the equivalent mass = (Molar mass of $KMnO_4$) / 3 = 158.1 / 3 = 52.7

Question 13.
Which one of the following represents 180 g of water?

(a) 5 Moles of water

(b) 90 moles of water

(c) $\frac{6.022\times10^{23}}{180}$ Molecules of water

(d) 6.022×10^{24} Molecules of water

Answer:
(d) 6.022 x 10^{24} Molecules of water
No. of moles of water present in 180 g
= Mass of water / Molar mass of water
= 180 g /18 g mol^{-1} = 10 moles
One mole of water contains
= 6.022×10^{23} water molecules
10 mole of water contains = $6.022 \times 10^{23} \times 10$
= 6.022×10^{24} water molecules

Question 14.
7.5 g of a gas occupies a volume of 5.6 liters at 0°C and 1 atm pressure. The gas is ……
(a) NO
(b) N_2O
(c) CO
(d) CO_2

Answer:
(a) NO
7.5 g of gas occupies a volume of 5.6 liters at 273 K and 1 atm pressure
Therefore, the mass of gas that occupies a volume of 22.4 liters –

$\frac{7.5g}{5.6L} \times 22.4\ L = 30g$

Molar mass of NO (14 + 16) = 30g

Question 15.
The total number of electrons present in 1.7 g of ammonia is ……..

(a) 6.022×10^{23}

(b) $\frac{6.022 \times 10^{22}}{1.7}$

(c) $\frac{6.022 \times 10^{24}}{1.7}$

(d) $\frac{6.022 \times 10^{23}}{1.7}$

Answer:

(a) 6.022×10^{23}

No. of electrons present in one ammonia (NH_3) molecule $(7 + 3) = 10$

No. of moles of ammonia = $\frac{Mass}{Molarmass}$

$= \frac{1.7g}{17gmol^{-1}} = 0.1$ mol

No. of molecules present in 0ne ammonia

$= 0.1 \times 6.022 \times 10^{23} = 6.O22 \times 10^{22}$

No. of electrons present in 0.1 mol of ammonia

$10 \times 6.022 \times 10^{22} = 6.022 \times 10^{23}$

Question 16.

The correct increasing order of the oxidation state of sulphur in the anions SO_4^{2-}, SO_3^{2-}, $S_2O_4^{2-}$,$S_2O_6^{2-}$ is …….

(a) $SO_3^{2-} < SO_3^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$

(b) $SO_4^{2-} < S_2O_4^{2-} < S_2O_6^{2-} < SO_3^{2-}$

(c) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-} < SO_4^{2-}$

(d) $S_2O_6^{2-} < S_2O_4^{2-} < SO_4^{2-} < SO_3^{2-}$

Answer:

(c) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-} < SO_4^{2-}$

Solution: $\overset{+3}{S_2}O_4^{2-} < \overset{+4}{S}O_3^{2-} < \overset{+5}{S_2}O_6^{2-} < \overset{+6}{S}O_4^{2-}$

Question 17.

The equivalent mass of ferrous oxalate is …….

(a) $\frac{\text{molar mass of ferrous oxalate}}{1}$

(b) $\frac{\text{molar mass of ferrous oxalate}}{2}$

(c) $\frac{\text{molar mass of ferrous oxalate}}{3}$

(d) none of these

Answer:

(c) $\frac{\text{molar mass of ferrous oxalate}}{3}$

$$\overset{2+}{Fe}\overset{3+}{C_2}O_4 \xrightarrow{\text{Oxidising agent}} \overset{3+}{Fe} + \overset{4+}{CO_2}$$

Question 18.

If Avogadro number were changed from 6.022×10^{23} to 6.022×10^{20}, this would change …….

(a) the ratio of chemical species to each other in a balanced equation

(b) the ratio of elements to each other in a compound

(c) the definition of mass in units of grams

(d) the mass of one mole of carbon

Answer:

(d) the mass of one mole of carbon

Question 19.

Two 22.4 liter containers A and B contains 8 g of O_2 and 8 g of SO_2 respectively, at 273 K and 1 atm pressure, then …….

(a) number of molecules in A and B are the same

(b) number of molecules in B is more than that in A

(c) the ratio between the number of molecules in A to the number of molecules in B is 2 : 1

(d) number of molecules in B is three times greater than the number of molecules in A

Answer:

(c) The ratio between the number of molecules in A to number of molecules in B is 2 : 1

Question 20.
What is the mass of precipitate formed when 50 ml of 8.5% solution of Ag NO_3 is mixed with 100 ml of 1.865% potassium chloride solution?
(a) 3.59 g
(b) 7 g
(c) 14 g
(d) 28 g

Answer:
(a) 3.59 g
$AgNO_3 + KCl \rightarrow KNO_3 + AgCl$

Solution:
50 mL of 8.5% solution contains 4.25 g of $AgNO_3$
No. of moles of $AgNO_3$ present in 50 mL of 8.5% $AgNO_3$ solution
= Mass / Molar mass = 4.25 / 170 = 0.025 moles
Similarly, No of moles of KCl present in loo mL of 1.865% KCl solution
= 1.865 / 74.5 = 0.025 moles

So total amount of AgCl formed is 0.025 moles (based on the stoichiometry calculator)

Amount of AgCl present in 0.025 moles of AgCl
= no. of moles × molar mass
= 0.025 × 143.5 = 3.59 g

Question 21.
The mass of a gas that occupies a volume of 612.5 ml at room temperature and pressure (25°C and 1 atm pressure) is 1.1g. The molar mass of the gas is ……..
(a) 66.25 g mol^{-1}
(b) 44 g mol^{-1}
(c) 24.5 g mol^{-1}
(d) 662.5 g mol^{-1}

Answer:
(b) 44 g mol^{-1}

Solution:
No. of moles of a gas that occupies a volume of 6 12.5 ml at room temperature and pressure
(25° C and 1 atm pressure)
$= 612.5 \times 10^{-3}$ L/24.5 L mol^{-1}
= 0.02 5 moles

We know that,
Molar mass = Mass / no. of moles
= 1.1 g/0.025 mol = 44 g mol^{-1}

Question 22.
Which of the following contain same number of carbon atoms as in 6 g of carbon -12?
(a) 7.5 g ethane
(b) 8 g methane
(c) both (a) and (b)
(d) none of these

Answer:
(c) both (a) and (b)

Solution:
No. of moles of carbon present in 6 g of C – 12 = Mass / Molar mass
$= 6/12 = 0.5$ moles $= 0.5 \times 6.022 \times 10^{23}$ carbon atoms.

No. of moles in 8 g of methane = 8 116 = 0.5 moles
$= 0.5 \times 6.022 \times 10^{23}$ carbon atoms.

No. of moles in 7.5 g of ethane = 7.5 / 16 = 0.25 moles
$= 2 \times 0.25 \times 6.022 \times 10^{23}$ carbon atoms.

Question 23.
Which of the following compound(s) has/have a percentage of carbon same as that in ethylene (C_2H_4)?
(a) propene
(b) ethyne
(c) benzene
(d) ethane

Answer:

(a) propene
Solution:
Molar mass of carbon

Percentage of carbon in ethylene(C_2H_6) = $\frac{\text{Molar mass of carbon}}{\text{Molar mass}} \times 100$
$= 24/28 \times 100 = 85.71\%$
Percentage of carbon in propene (C_3H_6) $= 24/28 \times 100 = 85.71\%$

Question 24.
Which of the following is/are true with respect to carbon – 12?
(a) relative atomic mass is 12 u
(b) oxidation number of carbon is +4 in all its compounds.
(c) I mole of carbon -12 contain 6.022×10^{22} carbon atoms.
(d) all of these

Answer:
(a) relative atomic mass is 12 u

Question 25.
Which one of the following is used as a standard for atomic mass?
(a) ${}_6C^{12}$
(b) ${}_7C^{12}$
(c) ${}_6C^{13}$
(d) ${}_6C^{14}$

Answer:
(a) ${}_6C^{12}$

II. Write brief answer to the following questions

Question 26.
Define relative atomic mass.

Answer:
On the basis of carbon, the relative atomic mass of an element is defined as the ratio of the mass of one atom of the element to the mass of l/12th mass of one atom of Carbon – 12.

$$\text{Relative atomic mass} = \frac{\text{Mass of one atom of the element}}{\text{Mass of } 1/12^{\text{th}} \text{ mass of one atom of Carbon-12}}$$

Question 27.
What do you understand by the term mole?

Answer:
The term 'mole' is used to represent 6.022×10^{23} entities (atoms or molecules or ions). One mole is the amount of substance of a system, which contains as many elementary particles as there are atoms in 12 g of carbon -12 isotope. The elementary particles can be molecules, atoms, ions, electrons, or any other specified particles.

Question 28.
Define equivalent mass.

Answer:
The equivalent mass of an element is the number of parts of the mass of an element which combines with or displaces 1.008 parts of hydrogen or 8 parts of oxygen or 35.5 parts of chlorine.

Question 29.
What do you understand by the term oxidation number?

Answer:
Oxidation number refers to the number of charges an atom would have in a molecule or an ionic compound, if electrons were transferred completely. The oxidation numbers reflect the number of electrons "transferred".

Question 30.
Distinguish between oxidation and reduction.

Answer:
The oxidation number is defined as the imaginary charge left on the atom when all other atoms of the compound have been removed in their usual oxidation states that are assigned according to set of rules. A term that is often used interchangeably with oxidation number is oxidation state.

Question 31.
Calculate the molar mass of the following compounds.

1. urea $[CO(NH_2)_2]$
2. acetone $[CH_3COCH_3]$
3. boric acid $[H_3BO_3]$
4. sulphuric acid $[H_2SO_4]$

Answer:
1. urea $[CO(NH_2)_2]$
Atomic mass of C $=12$
Atomic mass of O $=16$
Atomic mass of $2(N) = 28$
Atomic mass of $4(H) = 4$
$\therefore$ Molar mass of Urea $= 60$

2. Acetone $[CH_3COCH_3]$
Atomic mass of $3(C) = 36$
Atomic mass of $1(0) = 16$
Atomic mass of $6(H) = 6$
$\therefore$ Molar mass of Acetone $= 58$

3. Boric acid $[H_3BO_3]$
Atomic mass of $B = 10$
Atomic mass of $3(H) = 3$
Atomic mass of $3(O) = 48$
$\therefore$ Molar mass of Boric acid $= 61$

4. Sulphuric acid $_2[H_2SO_4]$
Atomic mass of $2(H) = 2$

Atomic mass of $1(S) = 32$
Atomic mass of $4(O) = 64$
$\therefore$ Molar mass of Sulphuric acid $= 98$

Question 32.
The density of carbon dioxide is equal to 1.977 kg m^{-3} at 273 K and 1 atm pressure. Calculate the molar mass of CO_2

Answer:
Molecular mass = Density x Molar volume
Molar volume of $CO_2 = 2.24 \times 10^{-2}$ m^3
Density of $CO_2 = 1.977$ kg m^{-3}
Molecular mass of $CO_2 = 1.977 \times 10^3$ $gm^{-3} \times 2.24 \times 10^{-2}$ m^3
$= 1.977 \times 10^{-1} \times 2.24 = 44$ g

Question 33.
Which contains the greatest number of moles of oxygen atoms?

1. 1 mol of ethanol
2. 1 mol of formic acid
3. 1 mol of H_2O

Answer:
1. 1 mol of ethanol
C_2H_5OH (ethanol) – Molar mass $= 24 + 6 + 16 = 46$
46 g of ethanol contains $1 \times 6.023 \times 10^{23}$ number of oxygen atoms.

2. 1 mol of formic acid.
HCOOH (formic acid) – Molar mass $= 2+12 + 32 = 46$
46 g of HCOOH contains $2 \times 6.023 \times 10^{23}$ number of oxygen atoms.

3. 1 mol of H_2O
H_2O (water) – Molar mass $= 2 + 16 = 18$
18 g of water contains $1 \times 6.023 \times 10^{23}$ number of oxygen atoms.
$\therefore$ 1 mole of formic acid contains the greatest number of oxygen atoms.

Question 34.
Calculate the average atomic mass of naturally occurring magnesium using the following data

Isotope	Isotopic atomic mass	Abundance (%)
Mg^{24}	23.99	78.99
Mg^{26}	24.99	10
Mg^{25}	25.98	11.01

Answer:
Isotopes of Mg.

Atomic mass = Mg^{24} = 23.99 x $\frac{783.99}{100}$ = 18.95

Atomic mass = Mg^{26} = 24.99 x $\frac{10}{100}$ = 2.499

Atomic mass = Mg^{25} = 25.98 x $\frac{11.01}{100}$ = 2.860

Average Atomic mass = 24.309

Average atomic mass of Mg = 24.309

Question 35.
In a reaction $x + y + z_2 \rightarrow xyz_2$, identify the limiting reagent if any, in the following reaction mixtures.
(a) 200 atoms of x + 200 atoms of y + 50 molecules of z_2
(b) 1 mol of x + 1 mol of y + 3 mol of z_2
(c) 50 atoms of x + 25 atoms of y + 50 molecules of z_2
(d) 2.5 mol of x + 5 mol of y + 5 mol of z_2

Answer:
$x + y + z_2$

(a) 200 atoms of x + 200 atoms of y + 50 molecules of z_2 According to the reaction, 1 atom of x reacts with one atom of y and one molecule of z to give product. In the case (a) 200 atoms of x, 200 atoms of y react with 50 molecules of z_2 (4 part) i.e. 50 molecules of z_2 react with 50 atoms of x and 50 atoms of y. Hence z is the limiting reagent.

(b) 1 mol of x + 1 mol of y + 3 mol of z_2
According to the equation 1 mole of z_2 only react with one mole of x and one mole of y. If 3 moles of z_2 are there, z is limiting reagent.

(c) 50 atoms of x + 25 atoms of y + 50 molecules of z_2
25 atoms of y react with 25 atoms of x and 25 molecules of z_2. So y is the limiting reagent.

(d) 2.5 mol of x + 5 mol of y + 5 mol of z_2
2.5 mol of x react with 2.5 mole of y and 2.5 mole of z_2. So x is the limiting reagent.

Question 36.
Mass of one atom of an element is 6.645×10^{-23} g. How many moles of element are there in 0.320 kg?

Answer:
Mass of one atom of an element = 6.645×10^{-23} g = Atomic mass.
Mass of given element = 0.320 kg
Number of moles = Atomic mass

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Atomic mass}}$$
$$= \frac{0.320 \times 1000\ \text{g}}{6.645 \times 10^{-23}\ \text{g}}$$
$$= \frac{320 \times 10^{23}}{6.645}$$
$$= 48.156 \times 10^{25}$$
$$= 4.8156 \times 10^{24}\ \text{moles}$$

$= 48.156 \times 10^{-23}$
$= 4.8156 \times 10^{-24}$ moles.

Question 37.
What is the difference between molecular mass and molar mass? Calculate the molecular mass and molar mass for carbon monoxide.

Answer:
Molecular mass is defined as the ratio of the mass of a molecule to the unified atomic mass unit.

The relative molecular mass of any compound can be calculated by adding the relative atomic masses of its constituent atoms.

Molar mass is defined as the mass of one mole of a substance.

The molar mass of a compound is equal to the sum of the relative atomic masses of its constituents expressed in g mol^{-1}.
Molecular mass of Carbon monoxide
= (1 × Atomic mass of carbon) + (1 × Atomic mass of oxygen)
= (1 × 12) +(1 × 16) = 28 u.
Molar mass of Carbon monoxide
= (1 × Atomic mass of carbon) + (1 × Atomic mass of oxygen)
= (1 × 12) + (1 × 16) = 28 g mol^{-1}.

Question 38.
What is the empirical formula of the following?

1. Fructose ($C_6H_{12}O_6$) found in honey
2. Caffeine ($C_8H_{10}N_4O_2$) a substance found in tea and coffee.

Answer:

1. Fructose ($C_6H_{12}O_6$)
Empirical formula is the simplest formula. So it is divided by 6 and so empirical formula is CH_2O.

2. Caffeine ($C_8H_{10}N_4O_2$)

Simplified formula = $\frac{molecular\,formula}{2}$

Empirical formula = $C_4H_5N_2O$.

Question 39.
The reaction between aluminium and ferric oxide can generate temperatures up to 3273 K and is used in welding metals. (Atomic mass of AC = 21 u Atomic mass of 0 = 16 u) $2Al + Fe_2O_2 \rightarrow Al_2O_3 + 2Fe$; If, in this process, 324 g of aluminium is allowed to react with 1.12 kg of ferric oxide.

1. Calculate the mass of Al_2O_3 formed.
2. How much of the excess reagent is left at the end of the reaction?

Answer:
(*i*) $\underset{54g}{2Al} + \underset{160g}{Fe_2O_3} \rightarrow \underset{102g}{Al_2O_3} + \underset{112g}{2Fe}$

1. As per the balanced equation 54 g A1 is required for 112 g of iron and 102 g of Al_2O_3.

54 g of Al gives 102 g of Al_2O_3.

∴ 324 g of Al will give $\frac{102}{54}$ x 324 = 612 g of Al_2O_3.

2. 54 g of Al requires 160 g of Fe_2O_3 for welding reaction.

∴ 324 g of Al will require $\frac{160}{54}$ x 324 = 960 g of Fe_2O_3.

∴ Excess Fe_2O_3 – Unreacted Fe_2O_3 = 1120 – 960 = 160 g

160 g of excess reagent is left at the end of the reaction.

Question 40.
How many moles of ethane is required to produce 44 g of CO_2 (g) after combustion.

Answer:

$$C_2H_6 + 3\ ½\ O_2 \rightarrow 2CO_2 + 3H_2O$$

Ethane Carbon dioxide

1 mole of ethane $\xrightarrow{\text{Combustion}}$ 2 moles of CO_2

∴ 44g of CO_2 = I mole of CO_2
2 moles of CO_2 is produced by 1 mole of ethane.
∴ 1 mole of CO_2 will be produced by = ?
∴ To produce 1 mole of CO_2, the required mole of ethane is = 1/2 x 1 = 0.5 mole of ethane.

Question 41.
Hydrogen peroxide is an oxidizing agent. It dioxides ferrous ion to ferric ion and reduced itself to water. Write a balanced equation.

Answer:
H_2O_2 – Oxidizing agent
$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + H_2O$ (Acetic medium)
Ferrous ion is oxidized by H_2O_2 to Ferric ion.

The balanced equation is $Fe^{2+} \rightarrow Fe^{3+} + e^{-} \times 2$

$H_2O_2 + 2H^+ + \cancel{2e^-} \rightarrow 2H_2O$

$2Fe^{2+} \rightarrow 2Fe^{3+} + \cancel{2e^-}$

$H_2O_2 + 2H^+ \rightarrow 2H_2O$

$2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$

Question 42.

Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 % hydrogen and rest oxygen its vapour density is 47.

Answer:

Elements	Percentage	Atomic mass	Relative No. of atoms	Simple ratio of atoms	Simplest whole number ratio
Carbon (C)	76.6%	12	$\frac{76.6}{12} = 6.38$	$\frac{6.38}{1.063} = 6$	6
Hydrogen (H)	6.38%	1	$\frac{6.38}{1} = 6.38$	$\frac{6.38}{1.063} = 6$	6
Oxygen (O)	17.02%	16	$\frac{17.02}{16} = 1.063$	$\frac{1.063}{1.063} = 1$	1

Empirical formula = C_6H_6O

Va-pour density 47

∴ Molecular mass = 2 x vapor density = 2 x 47 = 94

Molecular formula Empirical formula x n

Molecular mass x n

$n = \frac{Molecular mass}{Empirical formula mass} = \frac{94}{94} = 1$

∴ Molecular formula = C_6H_6O

Question 43.

A Compound on analysis gave Na = 14.31% S = 9.97% H = 6.22% and O = 69.5% calculate the molecular formula of the compound if all the hydrogen in the compound is present in combination with oxygen as water of crystallization, (molecular mass of the compound is 322).

Answer:

Element	Percentage	Atomic mass	Relative No. of atoms	Simple ratio of atoms	Simplest whole number ratio
Na	14.31%	23	$\frac{14.31}{23} = 0.622$	$\frac{0.622}{0.311} = 2$	2
S	9.97%	32	$\frac{9.97}{32} = 0.311$	$\frac{0.311}{0.311} = 1$	1
H	6.22%	1	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.311} = 20$	20
O	69.5%	16	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.311} = 13.96 = 14$	14

All H combines with 10 oxygen atoms to form as $10H_2O$.
So the empirical formula is $Na_2SO_4 .10H_2 O$
Empirical formula mass = (23 x 2) + (32 x 1) + (16 x 4) + (10 x 18)
= 46 + 32 + 64 + 180 = 322

$$n = \frac{Molecular mass}{Empirical formula mass} = \frac{322}{322} = 1$$

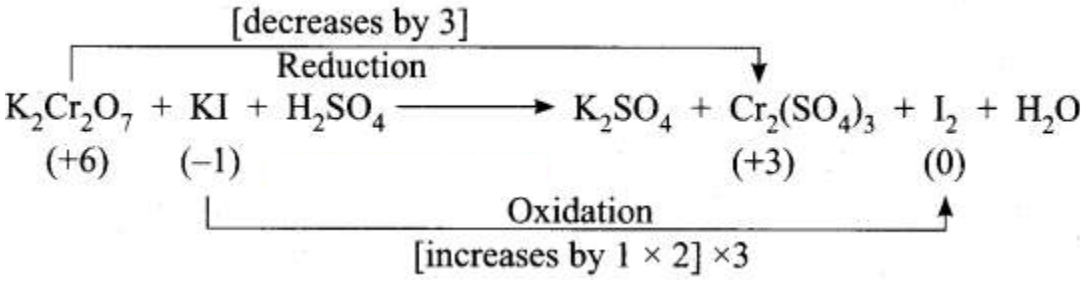
Molecular formula = $Na_2SO_4. 10H_2O$

Question 44.
Balance the following equations by oxidation number method

1. $K_2Cr_2 O_7 + KI + H_2SO_2 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$
2. $KMnO_4 + Na_2SO_3 \rightarrow Mn0_2 + Na_2SO_4 + KOH$
3. $Cu + HNO_3 \rightarrow Cu(N0_3)_2 + NO_2 + H_2O$
4. $H_2C_2O_4 + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

Answer:
1. $K_2Cr_2 O_7 + KI + H_2SO_2 \rightarrow K_2SO_2 + Cr_2(SO_4)_3 + I_2 + H_2O$

Step – 1.



Step – 2

$K_2Cr_2O_7 + 6KI + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + H_2O$

Step – 3

To balance other atoms

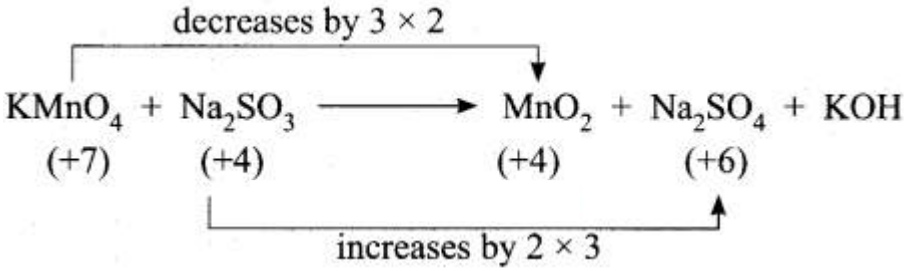
$K_2Cr_2O_7 + 6KI + H_2SO_4 \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + H_2O$

Step – 4

$K_2Cr_2O_7 + 6KI + 7H_2SO_4 \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + 7H_2O$

2. $KMnO_4 + Na_2SO_3 \rightarrow MnO_2 + Na_2SO_4 + KOH$ (Alkaline medium)

Step – 1



Step – 2

$2KMnO_4 + 3Na_2SO_3 \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$

Step – 3

balancing potassium, KOH is multiplied by 2

$2KMnO_4 + 3Na_2SO_3 \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$

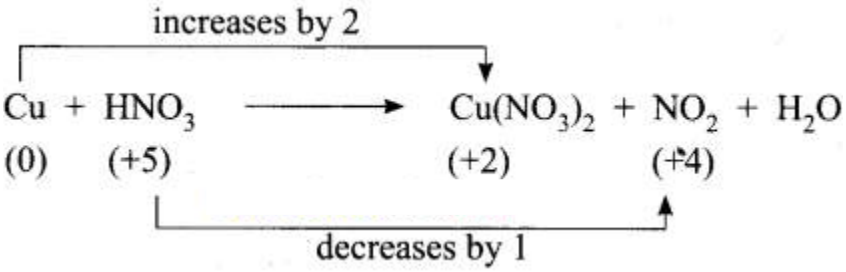
Step – 4

To balance H atom, H_20 is added on reactant side.

$2KMnO_4 + 3Na_2SO_3 + H_2O \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$

3. $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

Step – 1



Step – 2

$Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

Step – 3

To balance Nitrogen, $2HNO_3$ is multiplied by 2 and NO_2 is multiplied by 2

$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + H_2O$

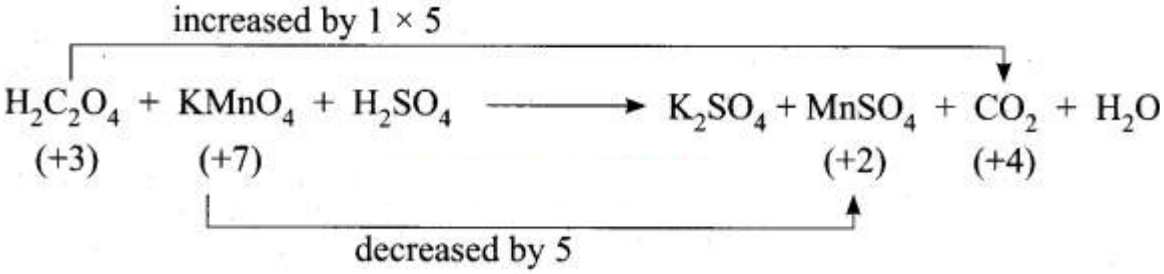
Step 4.

To balance oxygen, H_2O is multiplied by 2

$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

4. $H_2C_2O_4 + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

Step – 1



Step – 2

$5\ H_2C_2O_4 + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + 10\ CO_2 + H_2O$

Step – 3

To balance K, $KMnO_4$ and $MnSO_4$ are multiplied by 2

$5\ H_2C_2O_4 + 2KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10\ CO_2 + H_2O$

Step – 4

To balance O and H, H_2O and H_2SO_4 are multiplied by 3 and 6.

$5\ H_2C_2O_4 + 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10\ CO_2 + 8H_2O$

Question 45.

Balance the following equations by ion-electron method.

1. $KMnO_4 + SnCl_2 + HCl \rightarrow MnCl_2 + SnCl_4 + H_2O + KCl$
2. $C_2O_4^{2-} + Cr_2O_7^{2-} \rightarrow Cr^{3+} + CO_2$ (in acid medium)
3. $Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + NaI$ (in acid medium)
4. $Zn + NO_3^- \rightarrow Zn^{2+} + NO$

Answer:

1. $KMnO_4 + SnCl_2 + HCl \rightarrow MnCl_3 + SnCl_3 + H_2O + KCl$

Oxidation half reaction: (loss of electrons)

$\overset{+2}{SnCl_2} \rightarrow \overset{+4}{SnCl_4} + 2e^-$ .....(1)

Reduction half reaction: (gain of electrons)

$\overset{+7}{KMnO_4} + 5e^- \rightarrow \overset{+2}{MnCl_2}$ .....(2)

Add H_2O to balance oxygen atoms.

$KMnO_4 + 5e^- \rightarrow \overset{+2}{MnCl_2} + 4H_2O$ .....(3)

Add HCl to balance hydrogen atoms

$KMnO_4 + 5e^- + 8HCl \rightarrow MnCl_2 + 4H_2O$ .....(4)

To equalize the number of electrons equation (1) x 5 and equation (2) x 2

$5SnCl_2 \rightarrow 5SnCl_4 + 10e^-$

$2KMnO_4 + 16HCl + 10e^- \rightarrow 2MnCl_2 + 4H_2O + 2KCl$

$2KMnO_4 + 5SnCl_2 + 16HCl \rightarrow 5SnCl_4 + 2MnCl_2 + 4H_2O + 2KCl$

2. $C_2O_4^{2-} + Cr_2O_7^{2-} \rightarrow Cr^{3+} + CO_2$ (in acid medium)

Oxidation half reaction:

$\underset{(+3)}{C_2O_4^{2-}} \rightarrow \underset{(+4)}{2CO_2} + 2e^-$ .....(1)

Reduction half reaction:

$\underset{(+6)}{Cr_2O_7^{2-}} + 6e^- \rightarrow 2Cr^{3+}$ .....(2)

To balance oxygen atoms, H_2O is added on RHS of equation (2)

$Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+} + 7\,H_2O$ .....(3)

To balance Hydrogen atoms, H^+ is added on LHS of equation (1)

$C_2O_4^{2-} + 14H^+ \rightarrow 2CO_2 + 2e^-$ .....(4)

To equalize the number of electrons gained and lost, multiply the equation (4) x 3.

$$(4) \Rightarrow 3C_2O_4^{2-} + 14H^+ \rightarrow 6CO_2 + \cancel{6e^-}$$

$$Cr_2O_7^{2-} + \cancel{6e^-} \rightarrow 2Cr^{3+} + 7H_2O$$

$$Cr_2O_7^{2-} + 3C_2O_4^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 6CO_2 + 7H_2O$$

3. $Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + NaI$ (in acid medium)

Oxidation half reaction: (Loss of electron)

$Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2e^{2-}$ ……..(1)

Reduction half reaction: (Gain of electron)

$I_2 + 2e^{2-} \rightarrow 2NaI$ ……(2)

Adding (1) and (2)

$$Na_2S_2O_3 \rightarrow Na_2S_4O_6 + \cancel{2e^-}$$

$$I_2 + \cancel{2e^-} \rightarrow 2NaI$$

$$Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$

To balance oxygen,

$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_2O_2 + 2NaI$

In acidic medium

4. $Zn + NO_3^- \rightarrow Zn^{2+} + NO$

Half reactions are –

$$\overset{0}{Zn} \rightarrow Zn^{2+} \quad \text{.....(1)}$$

$$\overset{+5}{NO_3^-} \rightarrow \overset{+2}{NO} \quad \text{.....(2)}$$

$$(1) \Rightarrow Zn \rightarrow Zn^{2+} + 2e^- \quad \text{.....(3)}$$

$$(2) \Rightarrow NO_3^- + 4H^+ \rightarrow NO + 2H_2O \quad \text{.....(4)}$$

$$(3)\times 3 \Rightarrow 3Zn \rightarrow 3Zn^{2+} + \cancel{6e^-} \quad \text{.....(5)}$$

$$(4)\times 2 \Rightarrow 2NO_3^- + \cancel{6e^-} + 8H^+ \rightarrow 2NO + 4H_2O \quad \text{.....(6)}$$

$$3Zn + 2NO_3^- + 8H^+ \rightarrow 3Zn^{2+} + 2NO + 4H_2O$$