UNIT-1 BASIC CONCEPTS OF CHEMISTRY AND CHEMICAL CALCULATIONS

MY REVISION TIMELINE:-

SUMMARY:-

- Matter - Anything which occupies space and that has mass.
- Physical classification:
  - Solid
  - Liquid
  - Gas
- Chemical classification:
  - Mixtures
    - Homogeneous (Sugar syrup)
    - Heterogeneous (Oil and Water)
  - Pure substances
    - Element (Gold-Au)
    - Compounds (Glucose-$C_6H_{12}O_6$)
- amu or unified atomic mass = $\frac{1}{12}$th [mass of C-12 atom in its ground state
- 1 amu / 1 u ≈1.6605 x 10^{-27} kg.
- RAM = $\frac{\text{average atomic mass}}{\text{unified atomic mass}}$
- One mole:- The amount of substance of a system which contains as many elementary particles as there are in 12g of C-12 isotope.
- One mole of any substance has 6.022 x 1023 entities.
- RMM = $\frac{\text{mass of the molecule}}{\text{unified atomic mass unit}}$
- Molar mass - mass of one mole of substance - expressed in g mol^{-1}.
- Molar volume - Volume occupied by one mole of a substance in the gaseous state at given temperature and pressure
- Gram equivalent mass = $\frac{\text{Molar mass (gmol}^{-1})}{\text{Equivalence factor (eq mol}^{-1})}$
- Elementary analysis:

Empirical formula	Molecular formula
Simplest form of expressing	Actual representation of composition of an element
Simplest ratio	Multiple of empirical formula
CH_2O (Lactic acid)	$C_3H_6O_3$ (Lactic acid)

- Stoichiometry gives the numerical relationship between chemical quantities in a balanced chemical equation.
- When a reaction is carried out using non - stoichiometric quantities of the reactants, the product yield will be determined by the reactant that is completely consumed.
- Reagents:

Limiting reagents	Excess reagents
They limit the further reaction from taking place	Reagents which are in excess

- Redox reactions:
  - Oxidation number of an element changes.
  - Oxidation number – Imaginary charge left on the atom of the compound have been removed in their usual oxidation states.

Oxidation	Reduction
LEO – Loss of electron	GER – Gain of electron
Addition of oxygen	Removal of oxygen
Removal of hydrogen	Addition of hydrogen

FORMULAS:-

- Relative atomic mass (A_r) = $\frac{average\ mass\ of\ the\ atom}{unified\ atomic\ mass}$
- Relative molecular mass = n_1 (relative atomic mass of A) + n_2 (relative atomic mass of B) + n_3 (relative atomic mass of C)

  $A_{n1}B_{n2}C_{n3}$ Unit: u
- Gram equivalent mass = $\frac{\text{Molar mass (gmol}^{-1})}{\text{Equivalence factor (eq mol}^{-1})}$

Equivalent mass of acids, bases, salts, oxidising agents and reducing agents:

- Acids: E = $\frac{Molar\ mass\ of\ the\ acid}{Basicity\ of\ the\ acid}$

  Basicity → No of moles of ionisable H^+ ions present in 1mole of the acid.
- Bases: E = $\frac{Molar\ mass\ of\ the\ base}{Acidity\ of\ the\ base}$

  Acidity → No of moles of ionisable OH^- ions present in 1mole of the base.
- Oxidising or reducing agents:

  E = $\frac{Molar\ mass\ of\ the\ oxidising\ or\ reducing\ agent}{No.of\ moles\ of\ electrons\ gained\ or\ lost\ by\ one\ mole\ of\ the\ oxidising\ or\ reducing\ agent}$
- Relative no. of moles = $\frac{Given\ percent\ of\ the\ atom}{Molar\ mass}$
- Whole number (n) = $\frac{Molar\ mass\ of\ the\ compound}{Calculated\ empirical\ formula\ mass}$
- No. of moles = $\frac{Given\ mass}{Molar\ mass}$
- No. of moles = $\frac{Volume\ at\ 0°C\ and\ at\ 1\ atm}{22.4\ litres}$

HINTS TO SOLVE PROBLEMS:-

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Conditions	Volume occupied by one mole of any substance of any gaseous substances (in litres)
273 K and 1 bar pressure (STP)	22.71
273 K and 1 atm pressure	22.4
298 K and 1 atm pressure (Room temperatute and pressure [SATP])	24.5

- 1 mole = 6.023×10^{23} entities.
- 1 amu / 1u ≈ 1.6605×10^{-27} kg

- Molar mass of some frequently used elements:

Element	Molar mass (in g/mol)	Element	Molar mass (in g/mol)
H	1.0008	Ba	137.4
C	12	P	31
N	14.04	K	39
O	16	Mn	55
Ca	40.1	Cr	51.99
Mg	24.3	Na	23.5
Cl	35.45	Au	197.2
Ag	107.9		

- To find oxidation number and few important points to remember:
  - The oxidation state of a free element (i.e. in its uncombined state) is zero. Example: H_2, Cl_2, Na, K, S_8
  - For a monoatomic ion, the oxidation state = net charge on the ion. Example: Na^+ = +1, F^- = -1, Cl^- = -1, K^+ = +1, Be^{+2} = +2 and O^{2-} = -2
  - In molecules → Sum of all oxidation state = 0
  - In charged molecules → Sum of all oxidation state = net charge on the ion.
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Oxidation number of hydrogen	In metal hydrides	-1
	In other compounds	+1

  - Fluorine oxidation state is -1 in all its compounds.
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Oxygen	In peroxides (e.g H_2O_2)	-1
	In super oxides (e.g KO_2)	-1/2
	With fluorine (e.g OF_2)	+2
	In most of its compound	-2

  - Alkali metals → +1 (Li, Na, K, Rb, Cs)
  - Alkaline Earth metals → +2 (Be, Mg, Ca, Sa, Ba)
- Tips to find oxidation state of unknown element in a molecule:
  - Denote the unknown oxidation state as x.
  - Write the oxidation numbers.
  - Algebraic sum will be equal to
    - Zero (if it's a neutral molecule)
    - Charge on the compound (if it's not a neutral molecule)
  - Example 1: CO_2 => x + 2(-2) = 0 => x = +4
  - Example 2: $Cr_2O_7^{2-}$ => 2x + 7(-2) = -2 => x = +6
- Chemical formula of few important compounds:

Compounds	Chemical formula
Urea	O || H_2N-C-NH_2
Ethanol	C_2H_5OH

Potassium permanganate	$KMnO_4$
Potassium dichromate	$K_2Cr_2O_7$
Glucose	$C_6H_{12}O_6$
Fructose	$C_6H_{12}O_6$
Sucrose	$C_{12}H_{22}O_{11}$

TEXTBOOK EVALUATION

Multiple choice questions:-

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

Explanation:

$CH_{4(g)} + 2O_{2(g)}\ CO_{2(g)} + 2\ H_2O_{(l)}$

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.

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**

Explanation:

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

= 200 u

3. Assertion: Two mole of glucose contains 12.044 × 10^{23} molecules of glucose.
Reason: 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 assertion
(b) both assertion and reason are true but reason is not the correct explanation of assertion
(c) assertion is true but reason is false
(d) both assertion and reason are false

Explanation:

Total number of entities present in one mole of any substance is equal to 6.022 x 10^{23}

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

Explanation:

$2\ C + O_2 \rightarrow 2\ CO_2$
2 × 12 g carbon combines with 32 g of oxygen.
Hence, Equivalent mass of carbon $= 2 \times \frac{12}{32} \times 8$

= 6

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

Explanation:
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

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}

Explanation:
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 ¡n I mole of water = 6.022×10^{23}
"No. water molecules in one drop of water (10 mole) = $6.022 \times 10^{23} \times 10^{-3}$

= 6.022×10^{20}

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 %

Explanation:
$Mg\ CO_3 \rightarrow MgO + CO_2\uparrow$
$Mg\ CO_3$: (1 × 24) + (1 × 12) + (3 × 16) = 84 g
CO_2 : (1 × 12) + (2 × 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 $= \frac{100\%}{44gCO2} \times 36.96$ g CO_2 = 84%

Percentage of impurity = 16%

8. When 6.3 g of sodium bicarbonate is added to 30 g of 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

Explanation:
The amount of CO_2 released, x = 3.3 g
No. of moles of CO_2 released = 3.3 / 44

= 0.075 mol

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)**

Explanation:

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

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 reactant reacted and product formed	0.5	0.5	1

Amount of HCl formed is 1 mol.

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

Explanation:

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

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) $Cr_2O_3\ (s) + 2Al\ (s) \rightarrow A_2O_3\ (s) + 2Cr\ (s)$

Explanation:

$$\overset{0}{P_4}\ (s) + 3NaOH + 3H_2 \rightarrow \overset{-3}{PH_3}(g) + 3Na\overset{+1}{H_2PO_2}\ (aq)$$

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

Explanation:

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

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

(a) 5 Moles of water (b) 90 moles of water

(c) $\frac{6.022 \times 10^{23}}{180}$ Molecules of water **(d) 6.022×10^{24} Molecules of water**

Explanation:

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

$= 6.022 \times 10^{23}$ water molecules

10 mole of water contains $= 6.022 \times 10^{23} \times 10$

$= 6.022 \times 10^{24}$ water molecules

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

Explanation:

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 –

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

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

15. Total number of electrons present in 1.7 g of ammonia is

(a) 6.022×10^{23} (b) $\frac{6.022\times10^{22}}{1.7}$

(c) $\frac{6.022\times10^{24}}{1.7}$ (d) $\frac{6.022\times10^{23}}{1.7}$

Explanation:

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

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

$= 6.022 \times 10^{23}$

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

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

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

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 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

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

Explanation:

50 mL of 8.5% solution contains 4.25 g of AgNO3
No. of moles of AgNO3 present in 50 mL of 8.5% AgNO3 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

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}

Explanation:

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 × 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}

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

Explanation:

No. of moles of carbon present in 6 g of C – 12 = Mass / Molar mass
= 6/12 = 0.5 moles = 0.5 × 6.022 × 10^{23} carbon atoms.
No. of moles in 8 g of methane = 8 116 = 0.5 moles
= 0.5 × 6.022 × 10^{23} carbon atoms.
No. of moles in 7.5 g of ethane = 7.5 / 16 = 0.25 moles
= 2 × 0.25 × 6.022 × 10^{23} carbon atoms.

23. Which of the following compound(s) has/have percentage of carbon same as that in ethylene (C_2H_4)?

(a) propene (b) ethyne
(c) benzene (d) ethane

Explanation:

Percentage of carbon in ethylene(C_2H_6) = $\frac{Molar\ mass\ of\ carbon}{Molar\ mass} \times 100$

= $\frac{24}{28} \times 100$ = 85.71%

Percentage of carbon in propene (C_3H_6) = 2428 × 100 = 85.71%

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

25. Which one of the following is used as a standard for atomic mass?

(a) $_6C^{12}$ (b) $_7C^{12}$

(c) $_6C^{13}$ (d) $_6C^{14}$

Write brief answers to the following questions:-

26. Define relative atomic mass.

- The relative atomic mass is defined as the ratio of **average atomic mass** factor to the **unified atomic mass** unit.
- **Relative atomic mass =** $\frac{\textbf{average atomic mass}}{\textbf{unified atomic mass}}$

27. What do you understand by the term mole.

One mole is defined as the amount of substance of the system which contains as many **elementary particles** (i.e. molecules, atoms, ions, electrons or any other specified particles.) as there are atoms in **12 g of carbon-12 isotope**.

28. Define equivalent mass.

Gram equivalent mass of an element, compound or ion is the mass that **combines** or **displaces 1.008g hydrogen** or **8g oxygen** or **35.5g chlorine**.

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

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.

30. Distinguish between oxidation and reduction.

Oxidation	Reduction
Addition of oxygen	Addition of hydrogen
Removal of hydrogen	Removal of oxygen
Addition of an electronegative element	Addition of an electropositive element
Removal of an electropositive element	Addition of an electronegative element
Loss of electron	Gain of electron
Increase in oxidation state/ number	Decrease in oxidation state/ number

31. Calculate the molar mass of the following compounds.

i) Urea [CO(NH2)2]

ii) Acetone [CH3COCH3]

iii) Boric acid [H3BO3]

iv) Sulphuric acid [H2SO4]

Solution:

i) Molar mass = 1(C) + 2(N) + 4(H) + 1(O)
= 1(12) + 2(14) + 4(1) + 1(16)
= 12 + 28 + 4 + 16

= 60

ii) Molar mass = 3(C) + 6(H) + 1(O)
= 3(12) + 6(1) + 1(16)
= 36 + 6 + 16

= 58

iii) Molar mass = 3(H) + 1(B) + 3(O)
= 3(1) + 1(11) + 3(16)

= 3 + 11 + 48

= 62

iv) Molar mass = 2(H) + 1(S) + 4(O)
= 2(1) + 1(32) + 4(16)
= 2 + 32 + 64

= 98

32. The density of carbon dioxide is equal to 1.965 kgm^{-3} at 273 K and 1 atm pressure. Calculate the molar mass of CO_2.

Given:

Density = 1.965kgm^{-3}

Molar mass = ?

Formula used:

Molar mass = density × molar volume

Solution:

Molar mass = density × molar volume

Molar mass = 1.9625 × 22.4 × 10^{-2}

Molar mass = 44.016g/mol

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

i) 1 mol of ethanol

ii) 1 mol of formic acid

iii) 1 mol of H_2O

i) 1 mol of ethanol

C_2H_5OH (ethanol) – Molar mass = 24 + 6 + 16 = 46

46 g of ethanol contains 1 × 6.023 × 10^{23} number of oxygen atoms.

ii) 1 mol of formic acid.

HCOOH (formic acid) – Molar mass = 2+12 + 32 = 46

46 g of HCOOH contains 2 × 6.023 × 10^{23} number of oxygen atoms.

iii) 1 mol of H_2O

H_2O (water) – Molar mass = 2 + 16 = 18

18 g of water contains 1 × 6.023 × 10^{23} number of oxygen atoms.

∴ 1 mole of formic acid contains the greatest number of oxygen atoms.

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^{25}	24.99	10.00
Mg^{26}	25.98	11.01

Solution:

Average atomic mass = $\frac{(78.99\times23.99)+(10\times24.99)+(11.01\times25.98)}{100} = \frac{2430.9}{100}$

= 24.31u

35. In a reaction x + y + z_2 → 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

Question	Number of moles of reactants allowed to react			Number of moles of reactants consumed during reaction			Limiting reagent
	x	y	z_2	x	y	z_2	
(a)	200 atoms	200 atoms	50 molecules	50 atoms	50 atoms	50 molecules	z_2
(b)	1 mol	1 mol	3 mol	1 mol	1 mol	1 mol	x and y
(c)	50 atom	25 atom	50 molecules	25 atom	25 atom	25 molecules	y
(d)	2.5 mol	5 mol	5 mol	2.5 mol	2.5 mol	2.5 mol	x

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?

Given:

Mass of one atom of an element = 6.645 × 10^{-23} g = Atomic mass.

Mass of given element = 0.320 kg

Formula used:

Number of moles = $\frac{Mass}{Atomic\ mass}$

Solution:

Number of moles = $\frac{Mass}{Atomic\ mass}$

Number of moles = $\frac{0.320 \times 1000g}{6.645 \times 10^{-23}}$

Number of moles = 4.8156 × 10^{24} moles

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

Molecular mass	Molar mass
Molecular mass is mass of one molecule	Molar mass is mas of one mole of molecule. (6.022 x 10^{23})
Unit: Atomic mass unit (amu)	Unit: g/mol
Molecular mass of CO_2 = 1(C) + 2(O) = 12 + 32 = 44amu	Molar mass of CO_2 = 44 g mol^{-1}

38. What is the empirical formula of the following?
i) Fructose ($C_6H_{12}O_6$) found in honey
ii) Caffeine ($C_8H_{10}N_4O_2$) a substance found in tea and coffee.

Compound	Molecular formula	Empirical formula
Fructose	$C_6H_{12}O_6$	CH_2O
Caffeine	$C_8H_{10}N_4O_2$	$C_4H_5N_2O$

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 → Al_2O_3 + 2Fe; If, in this process, 324 g of aluminium is allowed to react with 1.12 kg of ferric oxide.
i) Calculate the mass of Al_2O_3 formed.
ii) How much of the excess reagent is left at the end of the reaction?
Given:

$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

54g 160g 102g 112g

Solution:

i) 54g of Al gives 102g of Al_2O_3

So, 324g of Al will give $\frac{102}{54} \times 324$

= 612g of Al_2O_3

ii) 54g of Al requires 160g of Fe_2O_3 for welding reaction

So, 324g of Al will require $\frac{160}{54} \times 324$ = 960g of Fe_2O_3

Therefore, excess Fe_2O_3 – unreacted Fe_2O_3 = 1120 – 960 = 160g

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

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

Solution:

$C_2H_6 + 3\,{}^1/_2\, O_2 \rightarrow 2CO_2 + 3H_2O$

1 mole of ethane on combustion gives 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 = $\frac{1}{2}$ x 1

= 0.5 mole of ethane.

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

Solution:

$H_2O_2 + 2H^+ +$ ~~$2e^-$~~ $\rightarrow 2H_2O$

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

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

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

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.

Solution:

Element	Percentage	Atomic mass	Relative no. of atoms	Simple ratio	Whole number
C	76.6%	12	$\frac{76.6}{12}$ = 6.38	$\frac{6.38}{1.06}$ = 6	6
H	6.38%	1	$\frac{6.38}{1}$ = 6.38	$\frac{6.38}{1.06}$ = 6	6
O	17.02%	16	$\frac{17.02}{16}$ = 1.06	$\frac{1.06}{1.06}$ = 1	1

Empirical formula = C_6H_6O

n = $\frac{Molar\ mass}{Calculated\ empirical\ formula\ mass}$

n = $\frac{2 \times vapour\ density}{94}$

n = $\frac{2 \times 47}{94}$

n = 1

Molecular formula = 1 × C_6H_6O

Molecular formula = C_6H_6O

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).

Solution:

Element	Percentage	Atomic mass	Relative no. of atoms	Simple ratio	Whole number
Na	14.31%	23	$\frac{14.31}{23} = 0.622$	$\frac{0.622}{0.311} = 6$	6
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	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.311} = 14$	14

All H combines with 10 oxygen atoms to form as $10H_2O$.

So the empirical formula is $\mathbf{Na_2SO_4 \cdot 10H_2O}$

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. $10H_2O$

44. Balance the following equations by oxidation number method

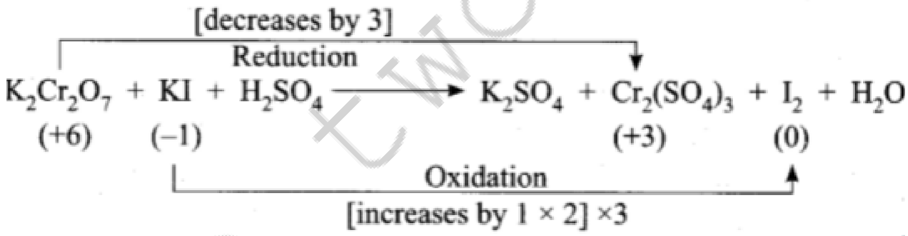
i) $K_2Cr_2O_7 + KI + H_2SO_2 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$

ii) $KMnO_4 + Na_2SO_3 \rightarrow Mn0_2 + Na_2SO_4 + KOH$

iii) $Cu + HNO_3 \rightarrow Cu(N0_3)_2 + NO_2 + H_2O$

iv) $H_2C_2O_4 + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

i) 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

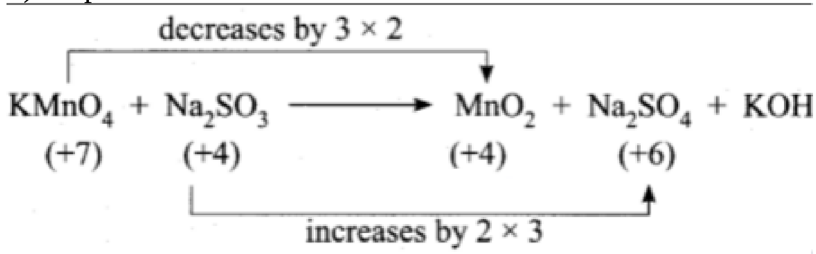
To balance other atoms

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

Step – 4

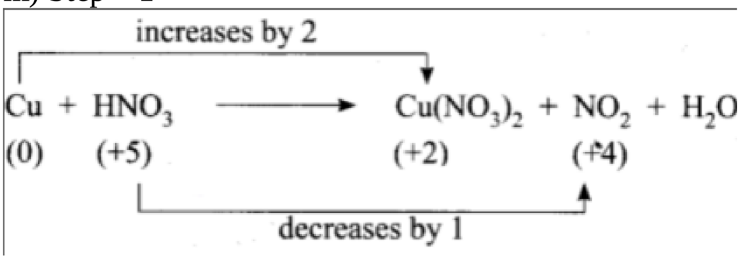
$K_2Cr_2O_7 + 6KI + 7H_2SO_4 \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + 7H_2O$

ii) Step – 1



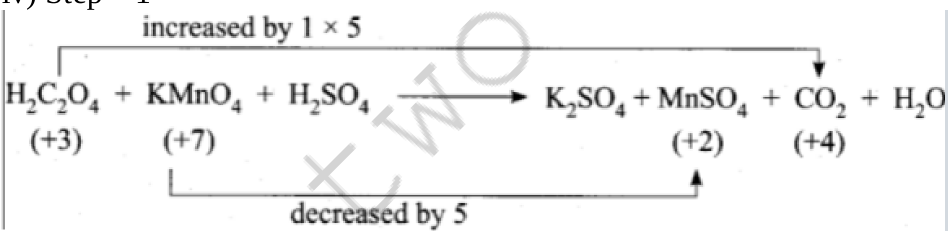
Step – 2
$2KMnO_4 + 3Na_2SO_3 \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$
Step – 3
balancing potassium, KOH is multiplied by 2
$2KMnO_4 + 3Na_2SO_3 \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$
Step – 4
To balance H atom, H_20 is added on reactant side.
$2KMnO_4 + 3Na_2SO_3 + H_2O \rightarrow 2MnO_2 + 3Na_2SO_4 + KOH$

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

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

45. Balance the following equations by ion electron method.
i) $KMnO_4 + SnCl_2 + HCl \rightarrow MnCl_2 + SnCl_4 + H_2O + KCl$
ii) $C_2O_4^{2-} + Cr_2\ O_{7\ 2-} \rightarrow Cr^{\ 3+} + CO_2$ (in acid medium)
iii) $Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + NaI$
iv) $Zn + NO_3^{-} \rightarrow Zn^{2+} + NO$ (in acid medium)

i) Oxidation half reaction: (loss of electrons)

+2 +4

$SnCl_2 \rightarrow SnCl_4 + 2e^-$ ➔ 1

Reduction half reaction: (gain of electrons)

+7 +2

$KMnO_4 + 5e^- \rightarrow MnCl_2$ ➔ 2

Add H_2O to balance oxygen atoms.

+2

$KMnO_4 + 5e^- \rightarrow MnCl_2 + 4H_2O$ ➔ 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

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

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

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

ii) Oxidation half reaction:

$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$ ➔ 1

(+3) (+4)

Reduction half reaction:

$Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+}$ ➔ 2

(+6)

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.

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

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

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

iii) 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,

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

iv) Half reactions are:

$$\overset{0}{Zn} \rightarrow Zn^{2+}$$

$$\overset{+5}{N}O_3^- \rightarrow \overset{+2}{N}O$$

(1)⇒ $Zn \rightarrow Zn^{2+} + 2e^-$

(2)⇒ $NO_3^- + 4H^+ \rightarrow NO + 2H_2O$

(3)×3⇒ $3Zn \rightarrow 3Zn^{2+} + 6e^-$

(4)×2⇒ $2NO_3^- + 6e^- + 8H^+ \rightarrow 2NO + 4H_2O$

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