1. A compound with molecular weight about 180 amu consists of 40% Carbon, 6.7% Hydrogen and 53.3% Oxygen. What is its molecular formula?
   Ans: \( \text{C}_6\text{H}_{12}\text{O}_6 \)

2. A sample of polystyrene prepared by heating styrene with tribromobenzoyl peroxide in the absence of air has the formula \( \text{Br}_3\text{C}_6\text{H}_3(\text{C}_8\text{H}_8)^n \). The number \( n \) varies with conditions of preparation. One sample of polystyrene prepared in this manner was found to contain 10.46% bromine. What is the value of \( n \)?
   Ans: 19

3. A saturated hydrocarbon contain 82.66% carbon. What is its imperical formula? Its molecular formula is?
   Ans: \( \text{C}_4\text{H}_{10} \)

4. One of the earliest method for determining the molecular weight of protein was based on chemical analysis. A haemoglobin preparation was found to contain 0.335% iron.
   (a) If the haemoglobin molecule contain one atom of iron. What is its molecular weight?
   (b) If the haemoglobin molecule contains four atom of iron. What is its molecular weight?
   Ans: (a) 16700 (b) 66800

5. A polymeric substance, tetrafluoroethylene, can be represented by the formula \( (\text{C}_2\text{F}_4)^x \), where \( x \) is a large number. The material was prepared by polymerizing \( \text{C}_2\text{H}_4 \) in the presence of sulphur bearing catalyst that served as a nucleus upon which polymer grew. The final product was found to contain 0.012% S. What is the value of \( x \) if each polymer molecule contains
   (a) 1 Sulphur atom      (b) 2 Sulphur atom
   In either case assume that the catalyst contributes a negligible amount to the total mass of the polymer.
   Ans: (a) \( 2.7 \times 10^3 \) (b) \( 5.3 \times 10^3 \)

6. A peroxidase enzyme isolated from human red blood cell was found to contain 0.29% selenium. What is the minimum mol.wt of the enzyme.
   Ans: \( 2.7 \times 10^4 \)
7) A purified pepsin isolated from a bovine preparation was subjected to an amino acid analysis. The amino acid present in smallest amount was lysine, \( \text{C}_6\text{H}_{14}\text{N}_2\text{O}_2 \) and the amount of lysine was found to be 0.43 gm per 100 gm protein. What is the minimum mol.wt of protein.

Ans: 34000

8) What volume of 1.71 M NaCl solution contains 0.20 mol NaCl?

Ans: 117 ml

9) What volume of 3.0 M NaCl (formula weight = 40 gm/mol) can be prepared with 84 gm NaOH.

Ans: 0.70 L

10) What is the molarity of NaOH in a solution which contains 24.0 gram NaOH dissolved in 300 ml of solution?

Ans: 2.00 M

11) Calculate the volume of 2.5 M sugar solution which contains 0.400 mol sugar.

Ans: 0.160 L

12) How many ml of water must be added to 200 ml of 0.65 M HCl to dilute the solution to 0.20 M.

Ans: 450 ml

13) How much 1.0 M HCl should be mixed with what volume of 0.250 M HCl in order to prepare 1.0 L of 0.500 M HCl.

Ans: 667 ml of 0.25 M HCl and 333 ml of 1.0 M HCl

14) What volume of 0.30 M \( \text{Na}_2\text{SO}_4 \) solution is required to prepare 2.0 L of a solution 0.40M in \( \text{Na}^+ \)

Ans: 1.3 L

15) Which two of the following solutions contains approximately equal hydrogen ion concentration?

(a) 50 ml of 0.10 M HCl + 25 ml \( \text{H}_2\text{O} \)
(b) 50 ml of 0.10 M \( \text{H}_2\text{SO}_4 \) + 25 ml \( \text{H}_2\text{O} \)
(c) 50 ml of 0.10 M HCl + 50 ml \( \text{H}_2\text{O} \)
(d) 50 ml of 0.10 M \( \text{H}_2\text{SO}_4 \) + 25 ml \( \text{H}_2\text{O} \)

Ans: a and d

16) If 40.00 ml of 1.6 M HCl and 60.00 ml of 2.0 M NaOH are mixed, what are the molar concentrations of \( \text{Na}^+ \), \( \text{Cl}^- \) and \( \text{OH}^- \) in the resulting solution? Assume total volume of 100.00 ml.

Ans: \([\text{Na}^+] = 1.2 \text{ M}, [\text{Cl}^-] = 0.640 \text{ M}, [\text{OH}^-] = 0.560 \text{ M}\)

17) What concentration of NaCl finally results from the mixing of 2.0 L of 4.0 M NaCl with 3.0 L of 1.5 M NaCl plus sufficient water to dilute the solution to 10.0 L.

Ans: 1.25 M

18) Calculate the concentration of all ion in solution when 3.0 L of 4.0 M NaCl and 4.0 L of 2.0 M \( \text{CoCl}_2 \) are combined and diluted to 10.0 L.

Ans: \([\text{Na}^+] = 1.2 \text{ M}, [\text{Cl}^-] = 2.8 \text{ M}, [\text{Co}^{2+}] = 0.80 \text{ M}\)

19) Determine the molar concentration of each ionic species in solution after each of the following operation:

(a) 200 ml of 2.0 M NaCl is diluted to 500 ml.
(b) 200 ml of 2.0 M \( \text{BaCl}_2 \) is diluted to 500 ml.
(c) 200 ml of 3.0 M NaCl is added to 300 ml of 4.0 M NaCl.
(d) 200 ml of 2.0 M BaCl₂ is added to 400 ml of 3.0 M BaCl₂ and 400 ml of water.
(e) 300 ml of 3.0 M NaCl is added to 200 ml of 4.0 M BaCl₂.
(f) 400 ml of 2.0 M HCl is added to 150 ml of 4.0 M NaOH.
(g) 100 ml of 2.0 M HCl and 200 ml of 1.5 NaOH are added to 150 ml of 4.0 NaCl and 50 ml of water.

Ans: (a) [Cl⁻] = 0.800 M, [Na⁺] = 0.800 M.
(b) [Ba²⁺] = 0.800 M, [Cl⁻] = 1.6 M.
(c) [Na⁺] = 3.6 M, [Cl⁻] = 3.6 M.
(d) [Ba²⁺] = 1.6 M, [Cl⁻] = 3.2 M.
(e) [Na⁺] = 1.8 M, [Cl⁻] = 5.0 M, [Ba²⁺] = 1.6 M.
(f) [Cl⁻] = 1.45 M, [Na⁺] = 1.09 M, [H⁺] = 0.364 M.
(g) [OH⁻] = 0.20 M, [Na⁺] = 1.8 M, [Cl⁻] = 1.6 M.

20) Calculate the concentration of each type of ion which remains in solution when each of the following set of solutions is mixed.
(a) 100 ml of 0.5 NaCl + 50 ml of 0.25 M KCl.
(b) 100 ml of 0.50 M NaCl + 50 ml of 0.25 M AgNO₃.
(c) 100 ml of 0.50 M NaCl + 50 ml containing 1.0 millimol NaCl + 100 ml of water.

Ans: (a) [Na⁺] = 0.33 M, [K⁺] = 0.083 M, [Cl⁻] = 0.42 M.
(b) [Cl⁻] = 0.25 M, [NO₃⁻] = 0.083 M.
(c) [Na⁺] = 0.20 M, [Cl⁻] = 0.20 M.

21) Calculate the molarity of each type ion remaining in solution after 20.0 ml of 6.0 M HCl is mixed with 50.0 ml of 2.0 M Ba(OH)₂ and 30.0 ml of water.

Ans: [OH⁻] = 0.80 M, [Cl⁻] = 1.20 M, [Ba²⁺] = 1.0 M.

22) From the following reaction sequence:
Cl₂ + 2 KOH → KCl + KClO + H₂O
3 KClO → 2 KCl + KClO₃
4 KClO₃ → 3 KClO₄ + KCl

Calculate the mass of Cl₂ needed to produce 100 g of KClO₄.

Ans: 205 gm

23) From the following reaction sequence:
CaC₂ + H₂O → CaO + C₂H₂
C₂H₂ + H₂ → C₂H₄
n C₂H₄ → (C₂H₄)n

Calculate mass of polyethene which can be produced by 10 kg of CaC₂.

Ans: 4.375 kg
24) From the following reaction:

$$2 \text{CoF}_2 + \text{F}_2 \rightarrow 2 \text{CoF}_3$$

$$(\text{CH}_2)_n + 4n \text{CoF}_3 \rightarrow (\text{CF}_2)_n + 2n \text{HF} + 4n \text{CoF}_2$$

Calculate how much $\text{F}_2$ will be consumed to produce 1 kg of $(\text{CF}_2)_n$.

Ans: 1.52 Kg

25) Calculate total number of atom in 0.5 mol of $\text{K}_2\text{Cr}_2\text{O}_7$.

Ans: $3.31 \times 10^{24}$

26) How many atoms do mercury vapour molecule consist of if the density of mercury vapour relative to air is 6.92 ($\text{Hg} = 200$) The average mass of air is 29 gm/mol.

Ans: One

27) Calculate total number of electrons present in 18 ml of water.

Ans: $6.023 \times 10^{24}$

28) What weight of CO is required to form $\text{Re}_2(\text{CO})_{10}$ from 2.52 gm of $\text{Re}_2\text{O}_7$, according to the unbalanced reaction.

$$\text{Re}_2\text{O}_7 + \text{CO} \rightarrow \text{Re}_2(\text{CO})_{10} + \text{CO}_2$$

(Re= 186.2, C= 12, and O= 16)

Ans: Wt of carbon monooxide = 2.46 gm.

29) Find the charge in coulomb of 1 gm ion (Mol) of $\text{N}^{3-}$.

Ans: $2.894 \times 10^8$ coulomb

30) Find the charge in coulomb of 27 gm of $\text{Al}^{3+}$ ions.

Ans: $2.894 \times 10^8$ coulomb

31) If the components of air are $\text{N}_2$ 78%, $\text{O}_2$ 21%, $\text{Ar}$ 0.9% and $\text{CO}_2$ 0.1% by volume what would be the molecular weight of air?

( $\text{N}_2 = 28$, $\text{O}_2 = 32$, $\text{Ar} = 40$, $\text{CO}_2 = 44$)

Ans: 28.964

32) (a) What is the mass of $4.0 \times 10^{-3}$ mol of $\text{C}_6\text{H}_{12}\text{O}_6$?

(b) How many carbon atoms are there in $4.0 \times 10^{-3}$ mol of $\text{C}_6\text{H}_{12}\text{O}_6$?

Ans: (a) 0.720 gm (b) $1.44 \times 10^{22}$ C atoms

33) Which one of the following, if any contains greatest number of oxygen atom? The greatest number of molecules? 1.0 gm of oxygen atoms, 1.0 gm of $\text{O}_2$ or 1.0 gm of ozone $\text{O}_3$.

Ans: All have the same number of atoms. The 1.0 gm sample of $\text{O}$ has the largest no of molecule.

34) How many moles of atoms of each element are there in 1.0 mole of each of following compounds?

(a) $\text{Fe}_3\text{O}_4$ (b) $\text{AsCl}_5$ (c) $\text{Mg}\left(\text{C}_2\text{H}_3\text{O}_2\right)$ (d) $\text{CuSO}_4\cdot5\text{H}_2\text{O}$

Ans: (a) 3 mole Fe, 4 mole O (b) 1 mole As, 5 mole Cl (c) 1 mole Mg, 4 mole C, 6 mole H, 4 mole O (d) 1 mole Cu, 1 mole 5, 9 mole O, 10 mole H
35) How many moles of oxygen atoms are there in each of the following
   (a) 0.17 mole of $O_2$  (b) $6.02 \times 10^{24}$ molecules of CO
   (c) 1.0 mole of $\text{BaS}_2\text{O}_8\text{H}_2\text{O}$  (d) 20 gm of $O_2$  (e) 1.6 gm $\text{CO}_2$

   Ans:  
   (a) 0.34 mole O  
   (b) 10.0 mole O  
   (c) 12 mole  
   (d) 1.25 mole O  
   (e) 0.073 mole O

36) A plant virus is found to consist of uniform cylindrical particles of 150 A° in a diameter and 5000 A° long. The specific volume of the virus is 0.75 cm³/gm. If the virus is considered to be a single particle. Find its molecular weight.

   Ans: $7.09 \times 10^7$ gm/mole

PROBLEM OF SOLID STATE RELATED TO MOLE CONCEPT

37) The density of solid AgCl is 5.56 gm/cc. The solid is made up to of cubic array of alternate $\text{Ag}^+$ and $\text{Cl}^-$ ions at a spacing of 2.773 A° between centres from these data calculate Avogadro No. (Hints :  $\text{Ag}^+$ = centre + edge, $\text{Cl}^-$ = corner + face)

   Ans: $6.04 \times 10^{23}$

38) Copper crystallises in face-centred cubic lattice and has a density of 8.930 g cm⁻³ at 293 K. Calculate the radius of copper atom. [At. mass of Cu = 63.55 a.m.u., Avogadro's constant $N_A = 6.02 \times 10^{23}$]

   Ans: 127.7pm

39) The edge length of NaCl unit cell is 564 pm. What is the density of NaCl in g/cm³ ?

   Ans: 2.165g cm⁻³

40) NaCl crystallises in face-centred cubic lattice. If the density is 2.165 g cm⁻³ and the distance between the adjacent $\text{Na}^+$ and $\text{Cl}^-$ is 281 pm. Calculate Avogadro’s constant.

   [Molar mass of NaCl = 58.5 g mol⁻¹]

   Ans: $6.02 \times 10^{23}$

41) A metallic element exists as body-centred cubic lattice. Each edge of the unit cell is 288 pm. The density of metal is 7.2 g cm⁻³. How many atoms and unit cells are there in 100 g of the metal ?

   Ans: $1.1632 \times 10^{24}, 5.816 \times 10^{23}$

42) Calcium metal reacts with hydrochloric acid to yield hydrogen and calcium chloride. Write a balanced chemical equation for the reaction. Determine the volume of hydrogen gas at 1.0 atm pressure and 18°C produced from the reaction of 12.2 gm of calcium with excess HCl.

   Ans: 7.27 L

43) (a) Determine the volume of oxygen gas at 27°C and 0.821 atm produced by decomposition of 2.44 gm KClO₃. KCl is the other product.

   (b) How many atoms of oxygen are there in this quality of product ?

   Ans:  
   (a) 0.030 mole O₂  
   (b) $3.60 \times 10^{22}$ O atoms

44) What mass of $C_6H_{12}B_6$ will be produced by a reaction giving 65% yield if 12.5 ml liquid $C_6H_{12}$ (d = 0.673 gm/ml) is treated with 2.70 L HBr(g) at STP.

   Ans: 10.7 gm
45) Chemical absorbers can be used to remove exhaled CO\textsubscript{2} of space travelers in short space flights. Li\textsubscript{2}O is one of the most efficient in terms of absorbing capacity per unit weight. If the reaction is Li\textsubscript{2}O + CO\textsubscript{2} $\rightarrow$ Li\textsubscript{2}CO\textsubscript{3}, What is the absorption efficiency of pure Li\textsubscript{2}O in L CO\textsubscript{2} (STP) per kg?

**Ans:** 750 L

46) Calcium carbide, CaC\textsubscript{2} reacts with water to produce acetylene, C\textsubscript{2}H\textsubscript{2} and calcium hydroxide Ca (OH)\textsubscript{2}. Calculate the volume of C\textsubscript{2}H\textsubscript{2}(g) at 25ºC and 0.950 atm produced from the reaction of 128 gm CaC\textsubscript{2} with 45 gm water.

\[ \text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca (OH)}_2 + \text{C}_2\text{H}_2 \]

**Ans:** 32.2 Litre

47) When 0.75 mole solid “A\textsubscript{4}” and 2 mole gaseous O\textsubscript{2} are heated in a sealed vessel (Bomb) completely using up the reactants and producing only one compound, it is found that when the temperature is reduced to the initial temperature, the contents of the vessel exhibit a pressure equal to half the original pressure. What is molecular formula of the product.

**Ans:** A\textsubscript{3}O\textsubscript{4}

48) Calculate orally,
(i) How many moles of CaCO\textsubscript{3} shall be produced from 5 moles of Ca atom ?
(ii) How many moles of BaSO\textsubscript{4} shall be formed from 5 moles of BaCl\textsubscript{2} ?
(iii) How many moles of Na\textsubscript{2}O shall be produced from 5 moles of Na atom ?

**Ans:** (i) 5, (ii) 5 and (iii) 2.5

49) What weight of oxygen will react with 40 g of Ca ?

**Ans:** 16 g

50) Calculate the volume of acetylene at NTP produced by 100 g of CaC\textsubscript{2} with water.

**Ans:** 35 litre

51) 4.90 g of KClO\textsubscript{3}, on heating, shows a weight loss of 0.384 g. What percent of the original KClO\textsubscript{3} has decomposed ?

**Ans:** 20%

52) Calculate the weight of V\textsubscript{2}O\textsubscript{5} produced from 2 g of VO and 5.75 g of Fe\textsubscript{2}O\textsubscript{3}.

\[ \text{VO} + \text{Fe}_2\text{O}_3 \rightarrow \text{FeO} + \text{V}_2\text{O}_5 \]

**Ans:** 2.18 g

53) 1 g of dry green algae absorbs $4.7 \times 10^{-3}$ mole of CO\textsubscript{2} per hour by photosynthesis. If the fixed carbon atoms were all stored after photosynthesis as starch, (C\textsubscript{6}H\textsubscript{10}O\textsubscript{5}n), how long would it take for the algae to double their own weight assuming photosynthesis takes place at a constant rate ?

**Ans:** 7.88 hour

54) The mixture of MgCO\textsubscript{3} and CaCO\textsubscript{3}, when heated decompose to give CO\textsubscript{2} and MgO. What is the percentage of MgCO\textsubscript{3} in the mixture which decreases in weight by 50% when heated for a long time to expel all the CO\textsubscript{2} ?

**Ans:** 95.5%
55) Box (a) represents 1.0 mL of a solution of particles at a given concentration. Which of the boxes (b) - (d) represents 1.0 mL of the solution that result after (a) has been diluted by doubling the volume of its solvent?

Ans: (b)

56) Reaction of A (white spheres) with B (black spheres) is shown schematically in the following diagram:

Which equation best describes the stoichiometry of the reaction?
(a) \[ A_2 + 2B \rightarrow A_2B_2 \]  (b) \[ 10A + 5B_2 \rightarrow 5A_2B_2 \]
(c) \[ 2A + B_2 \rightarrow A_2B_2 \]  (d) \[ 5A + 5B_2 \rightarrow 5A_2B_2 \]

Ans: (c)

57) If white spheres represent nitrogen atoms and black spheres represent oxygen atoms, which box represents reactants and which represents products for the reaction

\[ 2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) \]?

Ans: Reactant = d, Product = c
Assume that the black spheres in the buret represent H\(^+\) ions, the white spheres in the flask represent OH\(^-\) ions, and you are carrying out a titration of the base with the acid. If the volumes in the buret and the flask are identical and the concentration of the acid in the buret is 1.00 M, what is the concentration of base in the flask?

Ans: 0.67 M

The following diagrams represent the reaction of A\(_2\) (black spheres) with B\(_2\) (white spheres)

(a) Indentify the limiting reactant.
(b) Write a balanced equation for the reaction.
(c) How many moles of product can be made from 1.0 mole of A\(_2\) and 1.0 mole of B\(_2\)

Ans: (a) B\(_2\) (b) A\(_2\) + 3B\(_2\) \rightarrow 2AB\(_3\) (c) 2/3 mole AB\(_3\)

Magnesium metal burns in oxygen to form magnesium oxide, MgO.

(a) Write a balanced equation for the reaction.
(b) How many grams of oxygen are needed to react with 25.0 g of Mg? How many grams of MgO will result?
(c) How many grams of Mg are needed to react with 25.0 g of O\(_2\)? How many grams of MgO will result?

Ans: (a) 2Mg + O\(_2\) \rightarrow 2MgO
(b) 16.5 g O\(_2\), 41.5 g MgO
(c) 38g Mg, 63 g MgO

Assume that you have 1.39 mole of H\(_2\) and 3.44 mole of N\(_2\). How many grams of ammonia(NH\(_3\)) can you make, and how many grams of which reactant will be felt over?

3 H\(_2\) + N\(_2\) \rightarrow 2 NH\(_3\)

Ans: 15.8 g NH\(_3\), 83.3 g N\(_2\) left over

Pure oxygen was first made by heating mercury (II) oxide;

HgO \rightarrow Hg + O\(_2\) \text{ Heat} \rightarrow \text{Unbalanced}

(a) Balance the equation
(b) How many grams of mercury and how many grams of oxygen are formed from 45.5 g of HgO?
(c) How many grams of HgO would you need to obtain 33.3 g of O\(_2\)?

Ans: (a) Do yourself (b) 42.1 g Hg, 3.36 O\(_2\) (c) 451 g HgO
63) Silver metal reacts with chlorine (Cl₂) to yield silver chloride. If 2.00 g of Ag reacts with 0.657 g of Cl₂, what is the empirical formula of silver chloride?

**Ans:** AgCl

64) How many grams of the dry-cleaning solvent ethylene chloride, C₂H₄Cl₂, can be prepared by reaction of 15.4 g of ethylene, C₂H₄, with 3.74 g of Cl₂?

\[ C₂H₄ + Cl₂ \rightarrow C₂H₄Cl₂ \]

**Ans:** 5.22 g C₂H₄Cl₂

65) Limestone (CaCO₃) reacts with hydrochloric acid according to the equation;

\[ CaCO₃ + 2 HCl \rightarrow CaCl₂ + H₂O + CO₂ \]

If 1.00 mole of CO₂ has a volume of 22.4 L under the reaction conditions, how many liters of gas can be formed by reaction of 2.35 g of CaCO₃ with 2.35 g of HCl? Which reaction is limiting?

**Ans:** 0.526 L CO₂, CaCO₃ is the limiting reactant

66) How many moles of solute are present in each of the following solutions?
(a) 35.0 mL of 1.200 M HNO₃
(b) 175 mL of 0.67 M glucose (C₆H₁₂O₆)

**Ans:** (a) 0.042 mole (b) 0.12 mole

67) How many milliliters of a 0.45 M BaCl₂ solution contain 15.0 g of BaCl₂?

**Ans:** 160 mL

68) The sterile saline solution used to rinse contact lenses can be made by dissolving 400 mg of NaCl in sterile water and diluting to 100 mL. What is the molarity of the solution?

**Ans:** 0.0685 M

69) *Ringer’s solution*, used in the treatment of burns and wounds, is prepared by dissolving 4.30 g of NaCl, 0.150 g of KCl, and 0.165 g of CaCl₂ in water and diluting to a volume of 500.0 mL. What is the molarity of each of the component ions in the solution?

**Ans:** Na⁺ = 0.147 M, Ca²⁺ = 0.00298 M, K⁺ = 0.0040 M, Cl⁻ = 0.157 M

70) A bottle of 12.0 M hydrochloric acid has only 35.7 mL left in it. What will the HCl concentration be if the solution is diluted to 250.0 mL?

**Ans:** 1.71 M

71) Potassium permanganate (KMnO₄) reacts with oxalic acid (H₂C₂O₄) and aqueous sulfuric acid according to the equation.

\[ 2 KMnO₄ + 5 H₂C₂O₄ + 3 H₂SO₄ \rightarrow 2 MnSO₄ + 10 CO₂ + 8 H₂O + K₂SO₄ \]

How many milliliters of a 0.250 M KMnO₄ solution are needed to react completely with 3.225 g of oxalic acid?

**Ans:** 15.5 g

72) Cytochrome C is an iron-containing enzyme found in the cells of all aerobic organisms. If cytochrome c is 0.43% Fe by weight, what is its minimum molecular weight?

**Ans:** 13000 amu

73) Disilane, Si₂H₄, is analyzed and found to contain 90.28% by weight silicon. What is the value of x?

**Ans:** Si₂H₆
74) Sodium borohydride, NaBH₄, a substance used in the synthesis of many pharmaceutical agents, can be prepared by reaction of NaH with B₂H₆ according to the equation 2 NaH + B₂H₆ → 2 NaBH₄. How many grams of NaBH₄ can be prepared by reaction between 8.55 g of NaH and 6.75 g of B₂H₆? Which reactant is limiting, and how many grams of the excess reactant will be left over?

Ans: 13.5 g NaBH₄ produced, NaH is the limiting reactant, B₂H₆ left over = 1.82 g

75) What is the molarity of each ion in a solution prepared by dissolving 0.550 g of Na₂SO₄, 1.188 g of Na₃PO₄, and 0.223 g of Li₂SO₄ in water and diluting to a volume of 100.00 mL?

Ans: Na⁺ = 0.295 M, Li⁺ = 0.0406 M, SO₄²⁻ = 0.059 M, PO₄³⁻ = 0.0725 M

76) When eaten, dietary carbohydrates are digested to yield glucose (C₆H₁₂O₆), which is then metabolized to yield carbon dioxide and water:

\[ \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \quad \text{Heat} \quad \text{Unbalanced} \]

Balance the equation, and calculate both the mass in grams and the volume in liters of the CO₂ produced from 66.3 g of glucose, assuming that 1 mole of CO₂ has a volume of 25.4 L at normal body temperature.

Ans: 97.2 g CO₂, 56.1 L CO₂

77) Aluminum and elemental oxygen will react to form aluminum oxide, Al₂O₃. The chemical equation is:

\[ 4\text{Al}(s) + 3\text{O}_2(g) \rightarrow 2\text{Al}_2\text{O}_3(s) \]

How many moles of oxygen are required to react with 1.86 mole of aluminum?

Ans: 1.4 mole

78) Ethanol, C₂H₅OH, is a component of the fuel called gasohol. The unbalanced chemical equation for the combustion of ethanol is

\[ \text{C}_2\text{H}_5\text{OH}(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g) \]

How many moles of oxygen will be required with 8.24 moles of ethanol?

Ans: 24.7 mole

79) Aluminum will react with iodine to form aluminum iodide. The chemical equation is

\[ 2\text{Al}(s) + 3\text{I}_2(s) \rightarrow 2\text{AlI}_3(s) \]

How many moles of aluminum iodide can be obtained from 5.6 mole of iodine and the required amount of aluminum?

Ans: 3.7 mole

80) Sodium hydroxide reacts with sulfuric acid to form sodium sulfate and water. The chemical equation is:

\[ 2\text{NaOH}(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{Na}_2\text{SO}_4(aq) + 2\text{H}_2\text{O}(l) \]

Ans: 1.5 mole

81) Nitric acid, HNO₃, is manufactured by a process that allows nitrogen dioxide to react with water. The chemical equation is:

\[ 3\text{NO}_2(g) + \text{H}_2\text{O}(l) \rightarrow 2\text{HNO}_3(aq) + \text{NO}(g) \]

How many moles of nitrogen dioxide are required to produce 3.56 mole of nitric acid?

Ans: 5.34 mole

82) Sodium hydrogen carbonate is the chemical name for baking soda. This substance can be prepared by dissolving gaseous carbon dioxide in an aqueous solution of sodium carbonate. The chemical equation is:

\[ \text{Na}_2\text{CO}_3(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \rightarrow 2\text{NaHCO}_3(aq) \]
How many moles of sodium carbonate and carbon dioxide will be required in the preparation of 1.60 mole of sodium hydrogen carbonate?

Ans: 0.8 mole Na₂CO₃, 0.8 mole CO₂

83) Sodium will react readily with chlorine according to the chemical equation

$$2\text{Na}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s)$$

Calculate the mass of sodium that is needed to react with 1.00 g of chlorine.

Ans: 0.649 g

84) Chromium will dissolve in hydrochloric acid to form chromium (II) chloride and hydrogen. The chemical equation is:

$$\text{Cr}(s) + 2\text{HCl}(aq) \rightarrow \text{CrCl}_2(aq) + \text{H}_2(g)$$

How many grams of hydrochloric acid are needed to react with 1.00 g of chromium?

Ans: 1.40 g

85) If 1.62 g of calcium carbonate is heated, how many grams of calcium oxide will be obtained when the reaction is finished? The chemical equation is:

$$\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$$

Ans: 0.908 g

86) Mercury (II) oxide decomposes when it is heated. The chemical equation is

$$2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g)$$

How many grams of mercury can be obtained from 10.3 g HgO?

Ans: 9.45 g

87) Ammonia will react with hydrochloric acid to yield ammonium chloride according to the chemical equation:

$$\text{NH}_3(aq) + \text{HCl}(aq) \rightarrow \text{NH}_4\text{Cl}(aq)$$

How many grams of HCl are consumed if 2.36 g NH₄Cl is formed?

Ans: 1.61 g HCl

88) Sodium will react violently with water according to the chemical equation

$$2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g)$$

What mass of sodium takes part in this reaction if 3.5 g of hydrogen is formed?

Ans: 80 g

89) Potassium superoxide, KO₂, is used as a source of oxygen in rebreathing masks. The chemical equation for the reaction is

$$4\text{KO}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow 4\text{KOH}(s) + 3\text{O}_2(g)$$

Identify the limiting reactant, if any, in each of the following mixtures of reactants.

(a) 6.4 mole KO₂ and 2.1 mole H₂O  
(b) 8.4 mole KO₂ and 1.5 mole H₂O  
(c) 8.4 mole KO₂ and 2.1 mole H₂O

Ans: (a) H₂O  
(b) H₂O  
(c) H₂O

90) Consider the following unbalanced chemical equations. If 2.0 mole of each reactant are used, which reactant, if any, is the limiting reactant?

(a) P₄(s) + Cl₂(g) \rightarrow PCl₄(s)  
(b) Al(s) + Cl₂(g) \rightarrow AlCl₃(s)  
(c) C(s) + Cl₂(g) \rightarrow CCl₄(l)

Ans: (a) Cl₂  
(b) Cl₂  
(c) Cl₂
Methanol, CH₃OH, is prepared industrially by the reaction shown in the chemical equation
\[ \text{CO(g)} + 2\text{H}_2(g) \rightarrow \text{CH}_3\text{OH(g)} \]
In a laboratory test, 30.0 g of each reactant are added to reaction vessel. Which reactant, if any, is not completely consumed at the end of the reaction? How many grams of this reactant will be left, and how many grams of methanol will be formed?
Ans: 34.3 g CH₃OH, 25.7 g H₂ (remaining)

The element magnesium (Mg) has three stable isotopes with the following masses and abundances:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Mass (amu)</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>²⁴Mg</td>
<td>23.9850</td>
<td>78.99%</td>
</tr>
<tr>
<td>²⁵Mg</td>
<td>24.9858</td>
<td>10.00%</td>
</tr>
<tr>
<td>²⁶Mg</td>
<td>25.9826</td>
<td>11.01%</td>
</tr>
</tbody>
</table>

Calculate the average atomic mass (the atomic weight) of magnesium from these data.
Ans: 24.31 amu

The element europium exists in nature as two isotopes: ⁱ⁵¹Eu has a mass of 150.9196 amu, and ⁱ⁵³Eu has a mass of 152.9209 amu. The average atomic mass of europium is 151.96 amu. Calculate the relative abundance of the two europium isotopes.
Ans: 48%ⁱ⁵¹Eu and 52%ⁱ⁵³Eu

An element consists of 90.51% of an isotope with a mass of 19.992 amu, 0.27% of an isotope with a mass of 20.994 amu, and 9.22% of an isotope with a mass of 21.990 amu. Calculate the average atomic mass and identify the element.
Ans: neon; 20.18

Give the number of moles of each element present in 1.0 mol of each of the following substances:
(a) NH₃ (b) N₂H₄ (c) (NH₄)₂Cr₂O₇ (d) CoCl₂·6H₂O
Ans: (a) 1.0 mol N; 3 mol H (b) 2.0 mol; 4.0 mol H (c) 2.0 mol N; 8.0 mol H; 2.0 mol Cr; 7.0 mol O (d) 1.0 mol CO; 2.0 mol Cl; 12.0 mol H; 6.0 mol O

Determine the mass in grams of:
(a) 3.00 × 10⁻²² N₂ molecules (b) 3.00 × 10⁻³ mol of N₂ (c) 1.5 × 10² mol of N₂ (d) a single N₂ molecule
Ans: (a) 1.40×10⁻² g N₂ (b) 8.40× 10⁻² g N₂ (c) 4.20×10² g N² (d) 4.65×10⁻²³ g N₂

Ascorbic acid, or vitamin C (C₆H₈O₆), is an essential vitamin. It cannot be stored by the body and must be present in the diet. What is the molecular weight of ascorbic acid? Vitamin C tablets are often taken as a dietary supplement. If a typical tablet contains 500.0 mg of vitamin C, how many moles and how many molecules of vitamin C does it contain?
Ans: 2.841× 10⁻³; 1.711×10²¹ molecules

How many moles are represented by each of these samples?
(a) 100 molecules (exactly) of H₂O (b) 100.0 g of H₂O (c) 500 atoms (exactly) of Fe (d) 500.0 g of Fe
Ans: (a) 1.66×10⁻²² mol (b) 5.549 mol (c) 8.30×10⁻²² mol (d) 8.953 mol
Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed as Nutra-Sweet. The molecular formula of aspartame is $\text{C}_{14}\text{H}_{18}\text{N}_{2}\text{O}_{5}$.

(a) Calculate the molecular weight of aspartame.

(b) How many moles of molecules are in 10.0 g of aspartame?

(c) What is the mass in grams of 1.56 mol of aspartame?

(d) How many molecules are in 5.0 mg of aspartame?

Ans : (a) 294 g/mol

(b) $3.40 \times 10^{-2}$ mol

(c) 459 g

(d) $1.0 \times 10^{19}$ molecules

The molecular formula of acetylsalicylic acid (aspirin), one of the most commonly used pain relievers, is $\text{C}_9\text{H}_8\text{O}_4$.

(a) Calculate the molecular weight of aspirin.

(b) A typical aspirin tablet contains 500 mg of $\text{C}_9\text{H}_8\text{O}_4$. How many moles of $\text{C}_9\text{H}_8\text{O}_4$ molecules and how many molecules of acetylsalicylic acid are in a 500-mg tablet?

Ans : 180.0 g/mol (b) $3 \times 10^{-3}$ mol; $2 \times 10^{21}$ molecules

Chloral hydrate ($\text{C}_2\text{H}_3\text{Cl}_3\text{O}_2$) is a drug that is used as a sedative and hypnotic. It is the compound used to make “Mickey Finns” in detective stories.

(a) Calculate the molecular weight of chloral hydrate.

(b) How many moles of $\text{C}_2\text{H}_3\text{Cl}_3\text{O}_2$ molecules one in 500.0 g of chloral hydrate?

(c) What is the mass in grams of $2.0 \times 10^{-2}$ mol of chloral hydrate?

(d) How many chlorine atoms one in 5.0 g of chloral hydrate?

Ans : (a) 165.4 g/mol

(b) 3.023 mol

(c) 3.3 gm

(d) $5.5 \times 10^{22}$ atoms of chlorine

Vitamin B$_{12}$ cyanocobalamin, is essential for human nutrition. It is concentrated in animal tissue but not in higher plants. Although nutritional requirements for the vitamin are quite low, people who abstain completely from animal products may develop a deficiency anemia. Cyanocobalamin is the form used in vitamin supplements. It contains 4.34% cobalt by mass. Calculate the molecular weight (molar mass) of cyanocobalamin assuming there is one atom of cobalt in every molecule of cyanocobalamin.

Ans : 1360 g/mol

Consider the reaction:

$$\text{Mg (s) + I}_2(s) \rightarrow \text{MgI}_2(s)$$

Identify the limiting reagent in each of the reaction mixtures below:

(a) 100 atoms of Mg and 100 molecules of I$_2$  (b) 150 atoms of Mg and 100 molecules of I$_2$

(c) 200 atoms of Mg and 300 molecules of I$_2$  (d) 0.16 mol Mg and 0.25 mol I$_2$
104) Consider the reaction:
\[2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g)\]
Identify the limiting reagent in each of the reaction mixtures given below:
(a) 50 molecules H\textsubscript{2} and 25 Molecules O\textsubscript{2}
(b) 100 molecules H\textsubscript{2} and 40 Molecules O\textsubscript{2}
(c) 100 molecules H\textsubscript{2} and 100 Molecules O\textsubscript{2}
(d) 0.50 mole H\textsubscript{2} and 0.70 Mole O\textsubscript{2}

Ans: (a) Stoichiometric mixture. Neither is limiting
(b) O\textsubscript{2} is limiting
(c) H\textsubscript{2} is limiting
(d) H\textsubscript{2} is limiting

105) Ammonia is produced from the reaction of nitrogen and hydrogen according to the following balanced chemical equation:
\[\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)\]
(a) What mass of ammonia is produced from a mixture of 1.00 \times 10^3 g of N\textsubscript{2} and 5.00 \times 10^2 g of H\textsubscript{2}?
(b) What mass of which starting material remains unreacted?

Ans: 1210 g NH\textsubscript{3} (b) 290 g H\textsubscript{2} is unreacted

106) A student prepared aspirin in a laboratory experiment using the reaction in Exercise 70. The student reacted 1.50 g salicylic acid with 2.00 g of acetic anhydride. The yield was 1.50 g of aspirin. Calculate the theoretical yield and the percent yield for this experiment.

Ans: The theoretical yield is; 1.96 g aspirin; % yield : 76.5%

107) Hexamethylenediamine, C\textsubscript{6}H\textsubscript{16}N\textsubscript{2}, is one of the starting materials for the production of nylon. It can be prepared from adipic acid, C\textsubscript{6}H\textsubscript{10}O\textsubscript{4}, by the following overall reaction:
\[\text{C}_6\text{H}_{10}\text{O}_4(l) + 2\text{NH}_3(g) + 4\text{H}_2(g) \rightarrow \text{C}_6\text{H}_{16}\text{N}_2(l) + 4\text{H}_2\text{O}(l)\]
(a) What mass of hexamethylenediamine can be produced from 1.00 \times 10^3 g of adipic acid?
(b) What is the percent yield if 765 g of hexamethylenediamine is made from 1.00 \times 10^3 g of adipic acid?

Ans: (a) 795 (g) HMD (b) % yield : 962%