

Determine the number of sp ; sp^2 ; and sp^3 hybridized carbons present in each of the following compounds if any.

1. 2-butanone

Ans: $Sp = 0$; $sp^2 = 1$; and $sp^3 = 3$

2. 2,4-pentanediol

Ans: $Sp = 0$; $sp^2 = 0$; and $sp^3 = 5$

3. 1-butyne

Ans: $Sp = 2$; $sp^2 = 0$; and $sp^3 = 2$

The triiodide ion I_3^- is titrated with a known concentration of thiosulfate ion, $S_2O_3^{2-}$.

1. Given that the products of the reaction are I^- and $S_4O_6^{2-}$, provide a balanced equation for the reaction.

Ans: $I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$

2. Given that the $S_2O_3^{2-}$ solution was prepared by dissolving 7.9 g of $Na_2S_2O_3$ in 200 cm^3 of solvent, calculate the concentration of the thiosulfate solution. Take the atomic mass of Na, S, and O (g/mol) as 23, 32 and 16, respectively.

Ans: 0.25 moldm^{-3}

Molar mass of $Na_2S_2O_3 = 158$

$[Na_2S_2O_3] = (7.9/158) \div 0.20 = 0.25 \text{ M}$

3. Given that, 10 cm^3 of the triiodide reacted with 40 cm^3 of 0.25 moldm^{-3} of $Na_2S_2O_3$, determine the concentration of triiodide required if the equation of reaction is $I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$

Ans: 0.50 moldm^{-3}

Moles of $Na_2S_2O_3 = 10 \text{ mmol}$

Moles of $I_3^- = 5 \text{ mmol}$ (based on equation of reaction)

$[I_3^-] = 5/10 = 0.5 \text{ moldm}^{-3}$

1. The mass of 0.40 moles of compound AB_2 is 46 g. Given that the atomic mass of element A is 45 g, determine the atomic mass of B.

Ans: 35 g/mol

Molecular mass of compound = $46/0.4 = 115$

Mass of element B = $(115-45)/2 = 35 \text{ g/mol}$

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products in a balanced equation of the reaction: $NH_4NO_3 \rightarrow N_2 + O_2 + H_2O$

Ans: 9

$2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O$

3. Given that the atomic mass (g/mol) of chlorine and oxygen are 35 and 16 respectively, which of the following oxides of chlorine is most likely to have a percentage chlorine and oxygen of approximate ratio 1:1 ?

Ans: Cl₂O₅

1. Which of CHF₃ and CHCl₃ is more acidic? Explain

Ans: CHCl₃

Reason: Conjugate ion formed (CCl₃⁻) is more stable (being stabilized by resonance due to the presence of d-orbital)

2. Which of cyclohexanol and phenol is more acidic and why?

Ans: Phenol

Reason: The conjugate ion (phenoxide) is more stable, being stabilised by resonance.

3. Which of 2-fluorobutanoic acid and 2-chlorobutanoic acid is more acidic and why?

Ans: 2-fluorobutanoic acid

Reason: More stable conjugate base due to the stronger inductive (electron-withdrawing) effect (because of higher electronegativity of fluorine).

1. The half-life of a radioactive nuclide is 24 minutes. How long will it take for 87.5 % of the nuclide to decay?

Ans: 72 minutes

Amount remaining = 12.5% = 0.125 = 1/8 = 3 half-lives; Hence 24 × 3 = 72

2. After 60 days, only 0.600 g of a radionuclide with a half-life of 12 days remains. Determine the initial mass of the radionuclide sample.

Ans: 19.2 g

60 days represents 5 half-lives. Mass = 0.600 × 32 = 19.2 g

3. A 41.6 g sample of radionuclide decays to 0.65 g in 300 minutes. What is the half-life of this radionuclide?

Ans: 50 minutes

0.65/41.6 = 1/64 = 6 half-lives. Hence 300/6 = 50 minutes

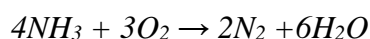
1. An organic compound containing carbon, hydrogen and oxygen has a molecular mass of 180 g/mol. Given that the total mass of carbon is 108 g, give the molecular formula of the compound. Take the atomic mass of C, H and O (g/mol) as 12; 1.0 and 16, respectively.

Ans: C₉H₈O₄

(108 g means 12 C atoms present; only appropriate way of distributing the remaining mass of 72 g is to have a maximum of 4 O atoms)

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: NH₃ + O₂ → N₂ + H₂O

Ans: 15



3. How many unpaired electrons are present in the element Cobalt with atomic number 27?

Ans: Three (3) unpaired electrons

State one major difference between cracking and reforming as occurs in the petroleum industry

Ans:	Cracking	Reforming
1.	Breaks large molecules of petroleum into smaller ones	Rearranges molecules into branched chains or cyclic hydrocarbons
2.	May use heat or catalyst	Requires a catalyst
3.	Increases the quantity of useful fuel	Increases the quality of fuel

1. A sample of CaC₂O₄ weighs 8.80 g. Determine the mass of calcium present in the sample given that atomic mass of Ca, C and O (g/mol) as 40.0, 12.0, 16.0, respectively.

Ans: 2.75 g

Molar mass = 128 g/mol

Mass of Ca = $40/128 \times 8.8 = 2.75$ g

2. A student dissolves 3.0 g of a sample containing silver in solution using an acid. She then precipitates out 4.7 g silver bromide, AgBr. What percentage of silver is present in the sample? Take the atomic mass (g/mol) of Ag and Br as 108 and 80, respectively.

Ans: 90%

Molar mass of AgBr = 188 g/mol

Mass of Ag = $108/188 \times 4.7 = 2.7$

%Ag = $2.7/3 \times 100 = 90\%$

3. The percentage of calcium carbonate in eggshell is 28%. Determine the mass of calcium in 500 g of eggshell. Take the atomic mass (g/mol) of Ca, C and O as 40, 12 and 16, respectively.

Ans: 56 g

Molar mass of CaCO₃ = 100 g/mol

Mass of CaCO₃ = $28/100 \times 500 = 140$ g

Mass of Ca = $40/100 \times 140 = 56$ g

1. The specific gravity of concentrated H₂SO₄ is 1.80. What mass of acid will have a volume of 800 cm³ assuming the density of water is 1.00 g/cm³?

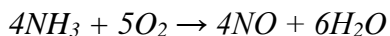
Ans: 1440 g

Density, $\rho = 1.8 \times 1.0 = 1.8$ g/cm³

Mass = $1.8 \times 800 = 1440$ g

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: NH₃ + O₂ → NO + H₂O

Ans: 19



3. What is the total number of orbitals (in a shell) present in an atom with principal quantum number 4?

Ans: 16 (n^2)

1. How many moles of an ideal gas are present in 2.5 dm³ of gas at a temperature of 27 °C and 100 kPa? Take the molar gas constant to be 8.3 JK⁻¹mol⁻¹

Ans: 0.10 mol

$$PV = nRT$$

$$\text{Mole of gas} = PV/RT = 100000 \times 0.0025 / (8.3 \times 300) = 0.10 \text{ mol}$$

2. What is the volume in dm³ occupied by 20 moles of an ideal gas at a temperature of 127 °C and a pressure of 830 kPa? Take the molar gas constant to be 8.3 JK⁻¹mol⁻¹

Ans: 80 dm³

$$PV = nRT$$

$$V = nRT/P = (20 \times 8.3 \times 400) / 830 = 80 \text{ dm}^3$$

3. 10.0 moles of an ideal gas is held at a pressure of 500 kPa in a 166 dm³ container. Determine the temperature of the gas. Take the molar gas constant to be 8.3 JK⁻¹mol⁻¹

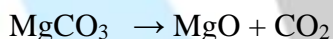
Ans: 1000 K

$$PV = nRT$$

$$T = PV/nR = (500 \text{ kPa} \times 166) / (10.0 \times 8.3) = 1000 \text{ K}$$

1. Determine the mass of magnesium carbonate heated if 2.0 g of magnesium oxide is formed. Take the atomic mass of magnesium, carbon, and oxygen as 24, 12 and 16, respectively.

Ans: 4.1 g

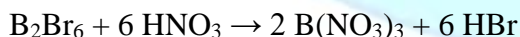


$$n(\text{MgO}) = 2.0 / 40 = 0.050$$

$$\text{Mass of MgCO}_3 = 0.050 \times 84 = 4.1$$

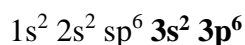
2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $\text{B}_2\text{Br}_6 + \text{HNO}_3 \rightarrow \text{B}(\text{NO}_3)_3 + \text{HBr}$

Ans: 15



3. How many electrons are present in quantum number 3 of Calcium 2+ ion (Ca²⁺)?

Ans: 8

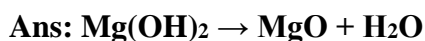


Provide the products formed and a balanced reaction equation for the following decompositions:

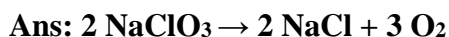
1. Heating of copper (II) oxide

Ans: 2 CuO → 2 Cu + O₂

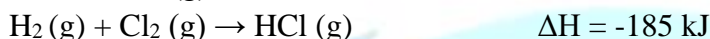
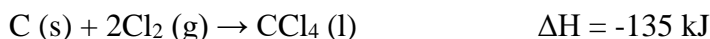
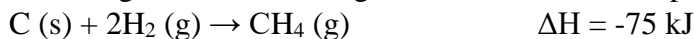
2. Heating of magnesium hydroxide



3. Heating of sodium trioxochlorate (V)



1. You are given the following reactions with their respective enthalpies:

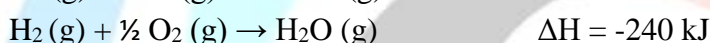
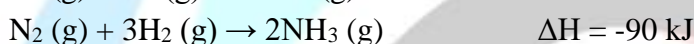
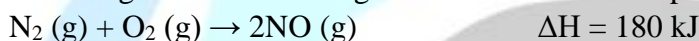


Find the enthalpy change for the reaction: $\text{CH}_4 \text{ (g)} + 4 \text{Cl}_2 \text{ (g)} \rightarrow \text{CCl}_4 \text{ (l)} + 4 \text{HCl (g)}$

Ans: - 430 kJ

Reverse eqn 1; Eqn 3 \times 2; Add

2. You are given the following reactions with their respective enthalpies:

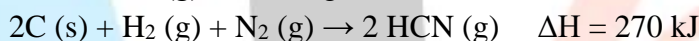
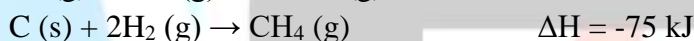
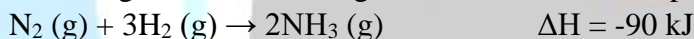


Find the enthalpy change for the reaction: $4 \text{NH}_3 \text{ (g)} + 5 \text{O}_2 \text{ (g)} \rightarrow 4 \text{NO (g)} + 6 \text{H}_2\text{O (g)}$

Ans: - 900 kJ

Eqn 1 \times 2; Reverse eqn 2 \times 2; Eqn 3 \times 6; Add

3. You are given the following reactions with their respective enthalpies:



Find the enthalpy change for the reaction: $\text{CH}_4 \text{ (g)} + \text{NH}_3 \text{ (g)} \rightarrow \text{HCN (g)} + 3 \text{H}_2 \text{ (g)}$

Ans: 255 kJ

Reverse eqn 1 \div 2; Reverse eqn 2; eqn 3 \div 2; Add

1. Given that, 6.0×10^{22} molecules of methane are released from a vessel containing an original amount of 6.4 g, determine the number of molecules of methane remaining in the container. Take the molecular mass of methane as 16 g/mol and Avogadro's number as 6.0×10^{23} .

Ans: 1.8×10^{23}

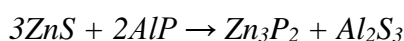
$$\text{Moles of methane} = 6.4/16 = 0.40 \text{ mol}$$

$$\text{Original number of molecules} = 0.40 \times 6.0 \times 10^{23} = 2.4 \times 10^{23}$$

$$\text{Number of molecules remaining} = 2.4 \times 10^{23} - 6.0 \times 10^{22} = 1.8 \times 10^{23}$$

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $\text{ZnS} + \text{AlP} \rightarrow \text{Zn}_3\text{P}_2 + \text{Al}_2\text{S}_3$

Ans: 7



3. How many molecules of water are present in hydrated Na_2HPO_4 given that the molecular mass of the hydrated salt is 268.1 g. You are given atomic mass (g/mol) of Na, P, O and H as 23, 31, 16, and 1.0.

Ans: 7

$$\text{Number of H}_2\text{O molecules} = (268.1 - 142)/18 = 7$$

Given the following equilibrium constant expressions, provide the balanced equation for the reactions assuming they all occur in the gaseous phase:

1.
$$K_c = \frac{[\text{CO}_2]^4 [\text{H}_2\text{O}]^2}{[\text{C}_2\text{H}_2]^2 [\text{O}_2]^5}$$

Ans: $2 \text{C}_2\text{H}_2 + 5 \text{O}_2 \rightleftharpoons 4 \text{CO}_2 + 2 \text{H}_2\text{O}$

2.
$$K_c = \frac{[\text{CS}_2] [\text{H}_2]^4}{[\text{CH}_4] [\text{H}_2\text{S}]^2}$$

Ans: $\text{CH}_4 + 2 \text{H}_2\text{S} \rightleftharpoons \text{CS}_2 + 4 \text{H}_2$

3.
$$K_c = \frac{[\text{N}_2]^2 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^3}$$

Ans: $4 \text{NH}_3 + 3 \text{O}_2 \rightleftharpoons 2 \text{N}_2 + 6 \text{H}_2\text{O}$

1. The mass of 0.20 moles of the compound XSO_4 is 30.2 g. Determine the atomic mass of element X. You are given atomic mass of S and O as 32 and 16 respectively.

Ans: 55 g/mol

$$\text{Molar mass of XSO}_4 = 30.2/0.20 = 151$$

$$\text{Mass of X} = 151 - 96 = 55$$

2. The mass of 0.10 moles of a hypothetical compound $\text{H}_2\text{X}_2\text{O}_8$ is 18.2 g. Determine the atomic mass of element X. You are given atomic mass of H and O as 1.0 and 16 respectively.

Ans: 26 g/mol

$$\text{Molar mass of H}_2\text{X}_2\text{O}_8 = 18.2/0.10 = 182$$

$$\text{Mass of X} = (182 - 130)/2 = 26$$

3. The mass of 0.020 moles of a hypothetical compound $\text{Mg}(\text{XO}_3)_2$ is 3.48 g. Determine the atomic mass of element X. You are given atomic mass of Mg and O as 24 and 16 respectively.

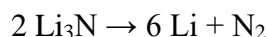
Ans: 27 g/mol

$$\text{Molar mass of H}_2\text{X}_2\text{O}_8 = 3.48/0.020 = 174$$

$$\text{Mass of X} = (174 - 120)/2 = 27$$

1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $\text{Li}_3\text{N} \rightarrow \text{Li} + \text{N}_2$

Ans: 9



2. Two vessels, A and B containing 1.4×10^{23} molecules and 8.0 g of oxygen gas are allowed to mix. Determine the combined number of molecules of oxygen present. Take the atomic mass of oxygen as 16 g/mol and Avogadro's number as 6.0×10^{23} .

Ans: 2.9×10^{23}

Number of molecules in vessel A = 1.4×10^{23}

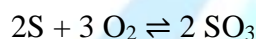
Moles in vessel B = $8.0/32 = 0.25$

Number of molecules in vessel B = $0.25 \times 6.0 \times 10^{23} = 1.5 \times 10^{23}$

Total number of molecules = $1.4 \times 10^{23} + 1.5 \times 10^{23} = 2.9 \times 10^{23}$

3. Determine the maximum amount (in grams) of SO_3 formed when 9.6 g each of Sulphur and oxygen gas react. Take atomic mass of Sulphur and oxygen as 32 and 16, respectively.

Ans: 16 g

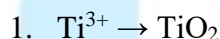


$n(\text{S}) = n(\text{O}_2) = 9.6/32 = 0.30$ mole.

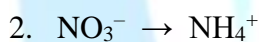
$n(\text{SO}_3) = 0.20$ moles from O_2 (limiting reagent)

mass of $\text{SO}_3 = 0.20 \times 80 = 16$ g

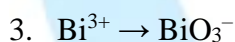
Balance the following half-reactions in an acidic medium and indicate whether it is an oxidizing or reducing half:



Ans: $\text{Ti}^{3+} + 2\text{H}_2\text{O} \rightarrow \text{TiO}_2 + 4\text{H}^+ + e$ oxidizing half reaction



Ans: $\text{NO}_3^- + 10\text{H}^+ + 8e \rightarrow \text{NH}_4^+ + 3\text{H}_2\text{O}$ reducing half reaction



Ans: $\text{Bi}^{3+} + 3\text{H}_2\text{O} \rightarrow \text{BiO}_3^- + 6\text{H}^+ + 2e$ oxidizing half reaction

1. The analysis of 4.8 g of an organic compound produced 13.2 g of carbon dioxide following combustion. Determine the percentage of carbon present in the compound. (C = 12.0; O = 16.0, H = 1.00)

Ans: 75%

Mass of C = $12/44 \times 13.2 = 3.60$ g

% C = $3.6/4.80 \times 100 = 75\%$

2. Given that the organic compound contains 75% of Carbon, 20% of oxygen and 5% of hydrogen, determine the empirical formula of the compound. (C = 12.0; O = 16.0, H = 1.00)

Ans: $\text{C}_5\text{H}_4\text{O}$

$$\text{C} = \frac{75}{12} = 6.25$$

$$\text{H} = \frac{5}{1} = 5$$

$$\text{O} = \frac{20}{16} = 1.25$$

Hence ratio = 5:4:1

3. Given that the molecular mass of the compound is 241 g, determine the molecular formula of the compound given its empirical formula as C_5H_4O . (C = 12.0; O = 16.0, H = 1.00)

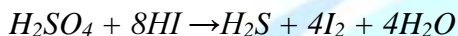
Ans: $C_{15}H_{12}O_3$

Empirical formula mass = 80 g/mol

$241/80 = 3$ Hence Molecular formula = $C_{15}H_{12}O_3$

1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $H_2SO_4 + HI \rightarrow H_2S + I_2 + H_2O$

Ans: 18



2. When 1 dm³ solution of a saturated solution of $CaSO_4$ is evaporated to dryness, 2.72 mg of residue is obtained. Take atomic mass of Ca, O and S (g/mol) as 40, 16 and 32 g/mol respectively. Calculate the solubility product for $CaSO_4$ at 25 °C.

Ans: 4.0×10^{-10}



Molar solubility = $0.00272 / 136 = 2.0 \times 10^{-5}$ mol

$$K_{sp} = (2.0 \times 10^{-5})^2 = 4.0 \times 10^{-10}$$

3. The elements A and B have 5 and 2 electrons respectively in their outermost shell. What is likely to be the formula of the compound found between A and B?

Ans: B_3A_2

Give the identity of the following species

1. A transition element with 23 protons and 21 electrons

Ans: V^{2+} (V for Vanadium)

2. A halogen with 35 protons and 36 electrons

Ans: Br^- (Br for Bromine)

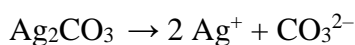
3. An alkali earth metal with 38 protons and 36 electrons

Ans: Sr^{2+} (Sr for Strontium)

Indicate the solubility product expression for the following salts in terms of solubility 's':

1. Ag_2CO_3

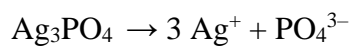
Ans: $K_{sp} = 4s^3$



$$K_{sp} = [Ag^+]^2 [CO_3^{2-}] = (2s)^2 s = 4s^3$$

2. Ag_3PO_4

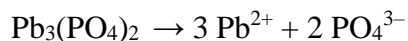
Ans: $K_{sp} = 27 s^4$



$$K_{\text{sp}} = [\text{Ag}^+]^3 [\text{PO}_4^{3-}] = (3s)^3 s = 27s^3 \cdot s = 27s^4$$

3. $\text{Pb}_3(\text{PO}_4)_2$

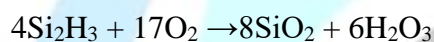
Ans: $K_{\text{sp}} = 108s^5$



$$K_{\text{sp}} = [\text{Pb}^{2+}]^3 [\text{PO}_4^{3-}]^2 = (3s)^3 (2s)^2 = 27s^3 \cdot 4s^2 = 108s^5$$

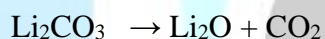
1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $\text{Si}_2\text{H}_3 + \text{O}_2 \rightarrow \text{SiO}_2 + \text{H}_2\text{O}_3$

Ans: 35



2. Determine the mass of lithium oxide formed when 18.5 g of lithium carbonate is heated. Take the atomic mass of lithium, carbon, and oxygen as 7.00, 12.0 and 16.0, respectively.

Ans: 7.50 g



$$\text{Moles of Li}_2\text{CO}_3 = 18.5/74 = 0.250$$

$$\text{Mass of Li}_2\text{O} = 0.250 \times 30 = 7.50 \text{ g/mol}$$

3. What is the hybridized state of carbon in carbon dioxide and ethene?

Ans: sp and sp³