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

$[Na_2S_2O_3] = (7.9/158) \div 0.20 = 0.25$ 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 mmol

Moles of I_3^- = 5 mmol (based on equation of reaction)

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

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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 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 chorine and oxygen of approximate ratio 1:1 ?

ClO; ClO_3; ClO_4; Cl_2O_3; Cl_2O_5; Cl_2O_6; and Cl_2O_7.

Ans: Cl_2O_5

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1. Which of CHF_3 and $CHCl_3$ is more acidic? Explain

Ans: $CHCl_3$

Reason: Conjugate ion formed (CCl_3^-) 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).

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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

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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: $C_9H_8O_4$

(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: $NH_3 + O_2 \rightarrow N_2 + H_2O$

Ans: 15

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

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

Ans: Three (3) unpaired electrons

[Ar] $3d^7\ 4s^2$

State <u>one</u> 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 CaC_2O_4 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 × 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 × 4.7 = 2.7

%Ag = 2.7/3 × 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 $CaCO_3$ = 100 g/mol

Mass of $CaCO_3$ = 28/100 × 500 = 140 g

Mass of Ca = 40/100 × 140 = 56 g

1. The specific gravity of concentrated H_2SO_4 is 1.80. What mass of acid will have a volume of 800 cm^3 assuming the density of water is 1.00 g/cm^3?

Ans: 1440 g

Density, ρ = 1.8 × 1.0 = 1.8 g/cm^3

Mass = 1.8 × 800 = 1440 g

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $NH_3 + O_2 \rightarrow NO + H_2O$

Ans: 19

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

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

Ans: 16 (n^2)

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1. How many moles of an ideal gas are present in 2.5 dm^3 of gas at a temperature of 27 °C and 100 kPa? Take the molar gas constant to be 8.3 $JK^{-1}mol^{-1}$

Ans: 0.10 mol

PV=nRT
Mole of gas = PV/RT = 100000 × 0.0025/(8.3 × 300) = 0.10 mol

2. What is the volume in dm^3 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 $JK^{-1}mol^{-1}$

Ans: 80 dm^3

PV=nRT
V= nRT/P = (20 × 8.3 × 400)/830 = 80 dm^3

3. 10.0 moles of an ideal gas is held at a pressure of 500 kPa in a 166 dm^3 container. Determine the temperature of the gas. Take the molar gas constant to be 8.3 $JK^{-1}mol^{-}$

Ans: 1000 K

PV = nRT

T = PV/nR = (500 kPa × 166)/10.0×8.3 = 1000 K

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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

$MgCO_3 \rightarrow MgO + CO_2$

n(MgO) = 2.0/40 = 0.050

Mass of $MgCO_3$ = 0.050 × 84 = 4.1

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $B_2Br_6 + HNO_3 \rightarrow B(NO_3)_3 + HBr$

Ans: 15

$B_2Br_6 + 6\ HNO_3 \rightarrow 2\ B(NO_3)_3 + 6\ HBr$

3. How many electrons are present in quantum number 3 of Calcium 2+ ion (Ca^{2+})?

Ans: 8

$1s^2\ 2s^2\ sp^6\ \mathbf{3s^2\ 3p^6}$

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

1. Heating of copper (II) oxide

Ans: $2\ CuO \rightarrow 2\ Cu + O_2$

2. Heating of magnesium hydroxide

Ans: $Mg(OH)_2 \rightarrow MgO + H_2O$

3. Heating of sodium trixochlorate (V)

Ans: $2\ NaClO_3 \rightarrow 2\ NaCl + 3\ O_2$

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1. You are given the following reactions with their respective enthalpies:
   $C\ (s) + 2H_2\ (g) \rightarrow CH_4\ (g)$ $\Delta H = -75$ kJ
   $C\ (s) + 2Cl_2\ (g) \rightarrow CCl_4\ (l)$ $\Delta H = -135$ kJ
   $H_2\ (g) + Cl_2\ (g) \rightarrow HCl\ (g)$ $\Delta H = -185$ kJ
   Find the enthalpy change for the reaction: $CH_4\ (g) + 4\ Cl_2\ (g) \rightarrow CCl_4\ (l) + 4\ HCl\ (g)$

Ans: – 430 kJ

Reverse eqn 1; Eqn 3 × 2; Add

2. You are given the following reactions with their respective enthalpies:
   $N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$ $\Delta H = 180$ kJ
   $N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$ $\Delta H = -90$ kJ
   $H_2\ (g) + ½\ O_2\ (g) \rightarrow H_2O\ (g)$ $\Delta H = -240$ kJ
   Find the enthalpy change for the reaction: $4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$

Ans: – 900 kJ

Eqn 1 × 2; Reverse eqn 2 × 2; Eqn 3 × 6; Add

3. You are given the following reactions with their respective enthalpies:
   $N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$ $\Delta H = -90$ kJ
   $C\ (s) + 2H_2\ (g) \rightarrow CH_4\ (g)$ $\Delta H = -75$ kJ
   $2C\ (s) + H_2\ (g) + N_2\ (g) \rightarrow 2\ HCN\ (g)$ $\Delta H = 270$ kJ
   Find the enthalpy change for the reaction: $CH_4\ (g) + NH_3\ (g) \rightarrow HCN\ (g) + 3\ H_2\ (g)$

Ans: 255 kJ

Reverse eqn 1 ÷ 2; Reverse eqn 2; eqn 3 ÷ 2; Add

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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}

Moles of methane = 6.4/16 = 0.40 mol

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

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: $ZnS + AlP \rightarrow Zn_3P_2 + Al_2S_3$

Ans: 7

$3ZnS + 2AlP \rightarrow Zn_3P_2 + Al_2S_3$

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

Number of H_2O 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. $Kc = \dfrac{[CO_2]^4\,[H_2O]^2}{[C_2H_2]^2\,[O_2]^5}$

Ans: $2\,C_2H_2 + 5\,O_2 \rightleftharpoons 4\,CO_2 + 2\,H_2O$

2. $Kc = \dfrac{[CS_2]\,[H_2]^4}{[CH_4]\,[H_2S]^2}$

Ans: $CH_4 + 2\,H_2S \rightleftharpoons CS_2 + 4\,H_2$

3. $Kc = \dfrac{[N_2]^2\,[H_2O]^6}{[NH_3]^4\,[O_2]^3}$

Ans: $4\,NH_3 + 3\,O_2 \rightleftharpoons 2\,N_2 + 6\,H_2O$

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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

Molar mass of XSO_4 = 30.2/0.20 = 151

Mass of X = 151 – 96 = 55

2. The mass of 0.10 moles of a hypothetical compound $H_2X_2O_8$ 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

Molar mass of $H_2X_2O_8$ = 18.2/0.10 = 182

Mass of X = (182 – 130)/2 = 26

3. The mass of 0.020 moles of a hypothetical compound $Mg(XO_3)_2$ 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

Molar mass of $H_2X_2O_8$ = 3.48/0.020 = 174

Mass of X = (174 – 120)/2 = 27

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1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $Li_3N \rightarrow Li + N_2$

Ans: 9

$2\,Li_3N \rightarrow 6\,Li + N_2$

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

N umber 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

$2S + 3\ O_2 \rightleftharpoons 2\ SO_3$

$n(S) = n(O_2) = 9.6/32 = 0.30$ mole.

$n(SO_3) = 0.20$ moles from O_2 (limiting reagent)

mass of $SO_3 = 0.20 \times 80 = 16$ g

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

1. $Ti^{3+} \rightarrow TiO_2$

Ans: $Ti^{3+} + 2\ H_2O \rightarrow TiO_2 + 4\ H^+ + e$ oxidizing half reaction

2. $NO_3^- \rightarrow NH_4^+$

Ans: $NO_3^- + 10\ H^+ + 8\ e \rightarrow NH_4^+ + 3\ H_2O$ reducing half reaction

3. $Bi^{3+} \rightarrow BiO_3^-$

Ans: $Bi^{3+} + 3\ H_2O \rightarrow BiO_3^- + 6\ H^+ + 2\ e$ oxidizing half reaction

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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: C_5H_4O

C = $\frac{75}{12} = 6.25$ H = $\frac{5}{1} = 5$ 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 = $C_{15}H_{12}O_3$

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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

$H_2SO_4 + 8HI \rightarrow H_2S + 4I_2 + 4H_2O$

2. When 1 dm^3 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}

$CaSO_4 \rightleftharpoons Ca^{2+} + SO_4^{2-}$

Molar solubility = 0.00272 / 136 = 2.0×10^{-5} mol

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

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: Ksp = $4s^3$

$Ag_2CO_3 \rightarrow 2\ Ag^+ + CO_3^{2-}$
Ksp = $[Ag^+]^2\ [CO_3^{2-}] = (2s)^2\ s = 4s^3$

2. Ag_3PO_4

Ans: Ksp = $27\ s^4$

$Ag_3PO_4 \rightarrow 3\ Ag^+ + PO_4^{3-}$
$Ksp = [Ag^+]^3\ [PO_4^{3-}] = (3s)^3\ s = 27s^3 \bullet s = 27\ s^4$

3. $Pb_3(PO_4)_2$

Ans: Ksp = $108s^5$

$Pb_3(PO_4)_2 \rightarrow 3\ Pb^{2+} + 2\ PO_4^{3-}$
$Ksp = [Pb^{2+}]^3\ [PO_4^{3-}]^2 = (3s)^3\ (2s)^2 = 27s^3 \bullet 4s^2 = 108s^5$

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1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: $Si_2H_3 + O_2 \rightarrow SiO_2 + H_2O_3$

Ans: 35

$4Si_2H_3 + 17O_2 \rightarrow 8SiO_2 + 6H_2O_3$

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

$Li_2CO_3 \rightarrow Li_2O + CO_2$

Moles of $Li_2CO_3 = 18.5/74 = 0.250$

Mass of $Li_2O = 0.250 \times 30 = 7.50$ g/mol

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

Ans: sp and sp3
