FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

INTRODUCTION TO CHEMISTRY

EMG 1104

END OF SEMESTER PAPER

DECEMBER 2023

This examination paper consists of 5 printed pages

Time Allowed : 3 hours

Marks : 100

Examiners Name : S Maphosa

INSTRUCTIONS

ANSWER ALL QUESTIONS IN SECTION A AND ANY THREE (3) QUESTIONS IN SECTION B

MARK ALLOCATION

QUESTION	MARKS
1	40
2	20
3	20
4	20
5	20
TOTAL	100

SECTION A

1. a) Define the following terms
   i) Relative isotopic mass   [1 mark]
    ii)   Use the helium-4 isotope to define atomic number and mass number

                                                                                [2 marks]

b)i) Chalcopyrite ($CuFeS_2$) is a principal mineral of copper, calculate the number of kilograms of copper in 3.71×10^3 kg of chalcopyrite

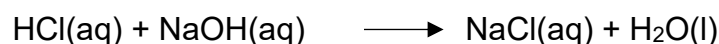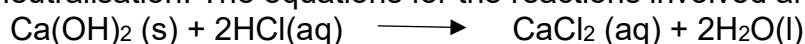   [3 marks]

ii)   Oxidising roasting is a type of roasting in metallurgy. Briefly explain why this
        process in carried out   [3 marks]

iii)   5.70g of Copper metal was reacted with HNO_3 . The reaction was incomplete
        and only 14.80g of $Cu(NO_3)_2$ was formed. What is the percentage yield of the
        reaction?
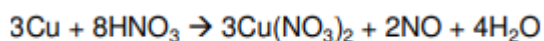
        $$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$
                                                                                [3 marks]

iv)   1.13 g of an impure sample of calcium hydroxide was dissolved in 50.0 cm3 of
        hydrochloric acid, concentration 1.00 mol dm–3. The resulting solution was
        made up to 250 cm3 with water in a volumetric flask. A 25.0 cm3 portion of
        this solution required 30.7 cm3 of 0.100 mol dm-3 sodium hydroxide for
        neutralisation. The equations for the reactions involved are shown below.
        $Ca(OH)_2$ (s) + 2HCl(aq) $\longrightarrow$ $CaCl_2$ (aq) + $2H_2O$(l)

        HCl(aq) + NaOH(aq) $\longrightarrow$ NaCl(aq) + H_2O(l)

        Calculate the percentage purity of the Calcium hydroxide.

                                                                                [3 marks]

2. State four assumptions of the kinetic theory and for each assumption discuss the
    limitations and deviations
    [10 marks]

3 a) Determine the hybridisation state of the underlined atom in each of the following
molecules: <u>Be</u>H2, <u>C</u>H4 and <u>P</u>F3. Describe the hybridisation process and determine
the molecular geometry in each case
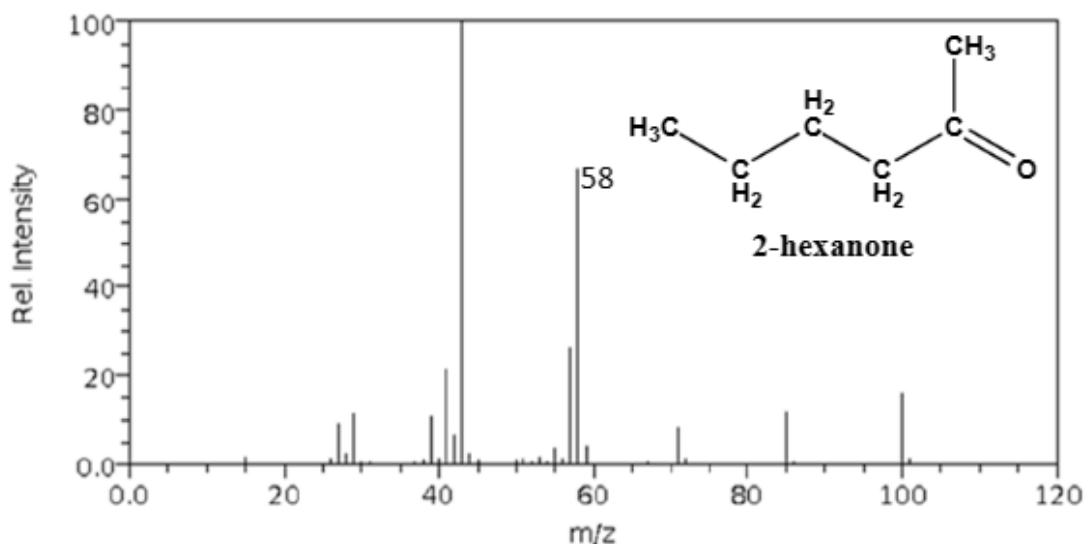
                                                                                [9 marks}

        a. Predict the geometries of the following species using the VSEPR
            theory: PCl3, CHCl3, SiH4,

                                                                                [6 marks]

1a) Describe the function of the mass spectrometer outlining briefly what happens in each chamber.   [7 marks]

b) The mass spectrum of 2-hexanone ($C_6H_{12}O$) is shown below

Draw the structure that is likely responsible for m/z of i) 58 ii) 85
                                                                                [6 marks]

   b. Define the first ionisation energy of an element using an equation. [1 mark]
   c. Discuss using examples how the following factors affect the ionisation energies of atoms
        i. Shielding effect
        ii. Charge on the nucleus
        iii. Size of atom
                                                                                [6 marks]

2.a) Define the following terms: i) specific heat capacity

                              ii) enthalpy of reaction   [2 marks]

b) A 466g sample of water is heated from 8.5 °C to 74.6 °C .

Calculate the amount of heat absorbed by the water in kilojoules.

Specific heat capacity of water is 4.184J/g.°C   [4 marks]
c) State what is meant by the terms 'endothermic' and 'exothermic' in

c) i) State what is meant by the terms 'endothermic' and 'exothermic' in relation to chemical reactions and how the enthalpy would be expected to change in each case.   [4 Marks]

ii) For a certain chemical reaction, $\Delta H° = -35.4$ kJ and $\Delta S° = -85.5$ J/K. Is the reaction exothermic or endothermic?   [1 mark]

      iv. Does the reaction lead to an increase or decrease in the randomness or disorder of the system?
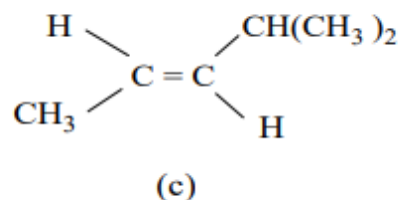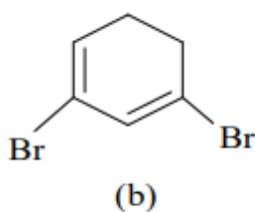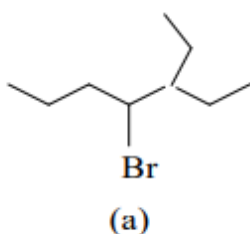[4 marks]
      v. Calculate $\Delta G°$ for the reaction at 298 K.   [3 marks]
      vi. Is the reaction spontaneous at 298 K under standard thermodynamic conditions?
[2 mark]

3. a)i) What are hydrocarbons?   [1mark]

ii) 1- bromopropane s used in the vapor degreasing of metals. Draw the structural and skeletal formula of 1- bromopropane   [2 marks]
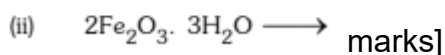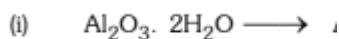
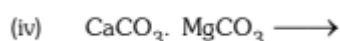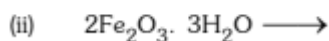b) i) Give the IUPAC names of the following structures

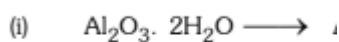(a)   (b)   (c)

[6 marks]

ii) Use methane to explain sp3 hybridization   [3 marks]

c) Describe metallic bonding and explain how it determines the following characteristics of metals: high melting point, electrical conductivity, ductility , malleability   [3

(i) $Al_2O_3.\ 2H_2O \longrightarrow$ ↓

(ii) $2Fe_2O_3.\ 3H_2O \longrightarrow$ marks]

d) Complete and balance the following equations for the calcination of ores

(i) $Al_2O_3.\ 2H_2O \longrightarrow$ ↓

(ii) $2Fe_2O_3.\ 3H_2O \longrightarrow$

(iii) $CaCO_3 \longrightarrow$

(iv) $CaCO_3.\ MgCO_3 \longrightarrow$

(v) $MgCO_3 \longrightarrow$

[5 marks]

Atomic Number

2	
He	
4.0026	Atomic Weight

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03															

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk 247	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)