

Paper Specific Instructions

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, **A, B and C**. All sections are compulsory. Questions in each section are of different types.
2. **Section – A** contains a total of 30 **Multiple Choice Questions (MCQ)**. Each MCQ type question has four choices out of which only **one** choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.
3. **Section – B** contains a total of 10 **Multiple Select Questions (MSQ)**. Each MSQ type question is similar to MCQ but with a difference that there may be **one or more than one** choice(s) that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.
4. **Section – C** contains a total of 20 **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.
5. In all sections, questions not attempted will result in zero mark. In **Section – A (MCQ)**, wrong answer will result in **NEGATIVE** marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In **Section – B (MSQ)**, there is **NO NEGATIVE** and **NO PARTIAL** marking provisions. There is **NO NEGATIVE** marking in **Section – C (NAT)** as well.
6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are **NOT** allowed in the examination hall.
7. The Scribble Pad will be provided for rough work.

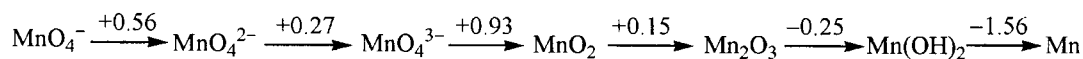
SECTION – A
MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q.10 carry one mark each.

Q.1 The correct order of the boiling points of the compounds is

- (A) $\text{CH}_4 > \text{SiH}_4 > \text{SnH}_4 > \text{GeH}_4$
 (B) $\text{SiH}_4 > \text{CH}_4 > \text{GeH}_4 > \text{SnH}_4$
 (C) $\text{SnH}_4 > \text{GeH}_4 > \text{CH}_4 > \text{SiH}_4$
 (D) $\text{SnH}_4 > \text{GeH}_4 > \text{SiH}_4 > \text{CH}_4$

Q.2 In the following Latimer diagram, the species that undergoes disproportionation reaction is

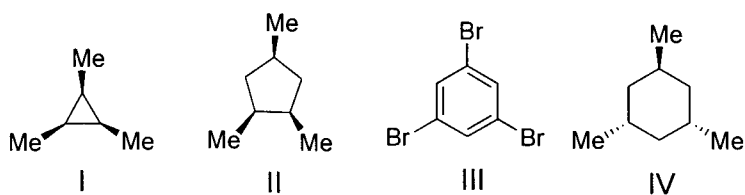


- (A) MnO_4^{2-} (B) MnO_4^{3-} (C) Mn_2O_3 (D) Mn(OH)_2

Q.3 A yellow precipitate is formed upon addition of aqueous AgNO_3 to a solution of

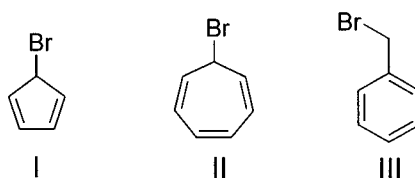
- (A) phosphite (B) pyrophosphate
 (C) metaphosphate (D) orthophosphate

Q.4 The compounds having C_3 -axis of symmetry are



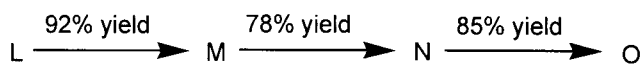
- (A) I, III and IV (B) I, II and III (C) I and III (D) III and IV

Q.5 The correct order of rate of solvolysis for the following compounds is



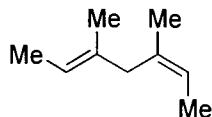
- (A) $\text{III} > \text{II} > \text{I}$ (B) $\text{II} > \text{I} > \text{III}$ (C) $\text{III} > \text{I} > \text{II}$ (D) $\text{II} > \text{III} > \text{I}$

Q.6 In the following sequence of reactions, the overall yield (%) of **O** is



- (A) 61 (B) 85 (C) 74 (D) 68

- Q.7 Catalytic hydrogenation of the following compound produces saturated hydrocarbon(s). The number of stereoisomer(s) formed is

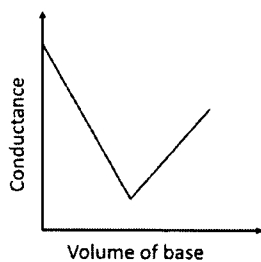


- (A) 1 (B) 2 (C) 3 (D) 4
- Q.8 The number of normal modes of vibration in naphthalene is
 (A) 55 (B) 54 (C) 48 (D) 49
- Q.9 The number of degrees of freedom of liquid water in equilibrium with ice is
 (A) 0 (B) 1 (C) 2 (D) 3
- Q.10 A straight line having a slope of $-\Delta U^0/R$ is obtained in a plot between
 (A) $\ln K_p$ versus T (B) $\ln K_C$ versus T
 (C) $\ln K_p$ versus $1/T$ (D) $\ln K_C$ versus $1/T$

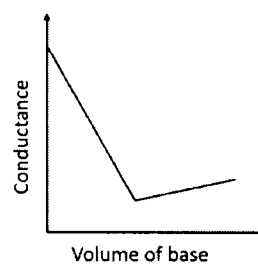
Q. 11 – Q. 30 carry two marks each.

- Q.11 In a typical conductometric titration of a strong acid with a weak base, the curve resembles

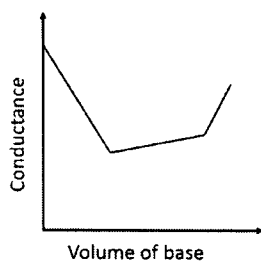
(A)



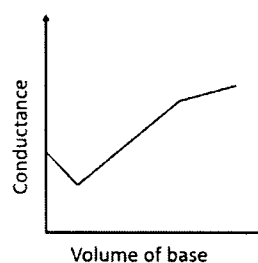
(B)



(C)

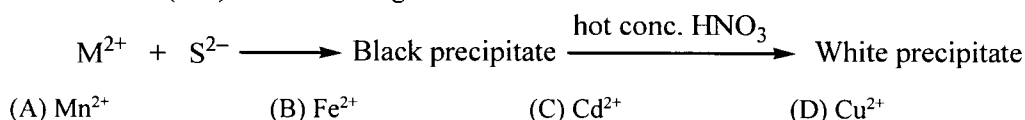


(D)



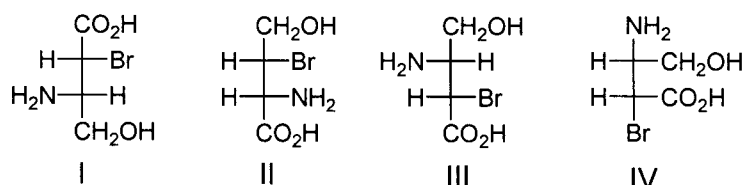
- Q.12 The coordination number of Al in crystalline AlCl_3 and liquid AlCl_3 , respectively, is
 (A) 4 and 4 (B) 6 and 6 (C) 6 and 4 (D) 3 and 6

- Q.13 The homogeneous catalyst used in water-gas shift reaction is
 (A) PdCl_2 (B) Cr_2O_3
 (C) $[\text{RhCl}(\text{PPh}_3)_3]$ (D) $[\text{RuCl}_2(\text{bipyridyl})_2]$
- Q.14 Nitrosyl ligand binds to d-metal atoms in linear and bent fashion and behaves, respectively, as
 (A) NO^+ and NO^+ (B) NO^+ and NO^- (C) NO^- and NO^- (D) NO^- and NO^+
- Q.15 The metal ion (M^{2+}) in the following reaction is



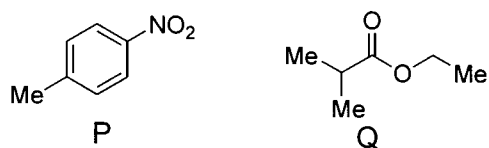
- Q.16 The correct order of wavelength of absorption (λ_{max}) of the Cr-complexes is (en = ethylenediamine)
 (A) $[\text{CrF}_6]^{3-} > [\text{Cr}(\text{H}_2\text{O})_6]^{3+} > [\text{Cr}(\text{en})_3]^{3+} > [\text{Cr}(\text{CN})_6]^{3-}$
 (B) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} > [\text{CrF}_6]^{3-} > [\text{Cr}(\text{en})_3]^{3+} > [\text{Cr}(\text{CN})_6]^{3-}$
 (C) $[\text{Cr}(\text{CN})_6]^{3-} > [\text{Cr}(\text{en})_3]^{3+} > [\text{Cr}(\text{H}_2\text{O})_6]^{3+} > [\text{CrF}_6]^{3-}$
 (D) $[\text{Cr}(\text{en})_3]^{3+} > [\text{Cr}(\text{CN})_6]^{3-} > [\text{Cr}(\text{H}_2\text{O})_6]^{3+} > [\text{CrF}_6]^{3-}$
- Q.17 The correct order of enthalpy of hydration for the transition metal ions is
 (A) $\text{Cr}^{2+} > \text{Mn}^{2+} > \text{Co}^{2+} > \text{Ni}^{2+}$
 (B) $\text{Ni}^{2+} > \text{Co}^{2+} > \text{Mn}^{2+} > \text{Cr}^{2+}$
 (C) $\text{Ni}^{2+} > \text{Co}^{2+} > \text{Cr}^{2+} > \text{Mn}^{2+}$
 (D) $\text{Cr}^{2+} > \text{Mn}^{2+} > \text{Ni}^{2+} > \text{Co}^{2+}$

- Q.18 Among the following compounds, the pair of enantiomers is



- (A) I and IV (B) I and III (C) II and III (D) III and IV

- Q.19 The number of proton NMR signals for the compounds **P** and **Q**, respectively, is



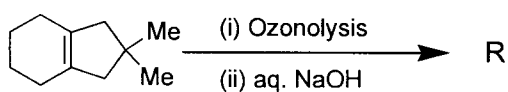
- (A) 3 and 4 (B) 3 and 5 (C) 4 and 3 (D) 5 and 4

Q.20 The correct set of reagents for the following conversion is



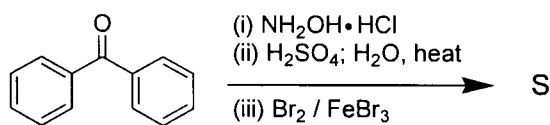
- (A) (i) $\text{NaNH}_2/\text{liq. NH}_3$; (ii) $\text{NaNO}_2/\text{dil. HCl}$; (iii) CuCN , heat
 (B) (i) $\text{HNO}_3/\text{H}_2\text{SO}_4$; (ii) Zn/HCl ; (iii) $\text{NaNO}_2/\text{dil. HCl}$; (iv) CuCN , heat
 (C) (i) Mg/ether , H_3O^+ ; (ii) $(\text{EtO})_2\text{CO}$; (iii) NH_4OH ; (iv) PCl_5
 (D) (i) Mg/ether , H_3O^+ ; (ii) $\text{HNO}_3/\text{H}_2\text{SO}_4$; (iii) $\text{NaNO}_2/\text{dil. HCl}$; (iv) CuCN , heat

Q.21 The product **R** in the following reaction is



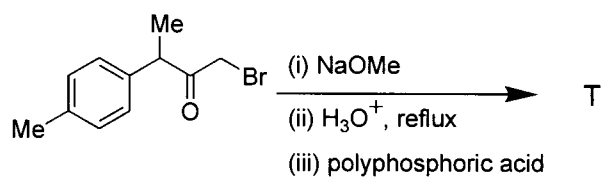
- (A)
- (B)
- (C)
- (D)

Q.22 The major product **S** of the following reaction is

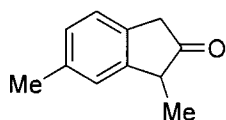


- (A)
- (B)
- (C)
- (D)

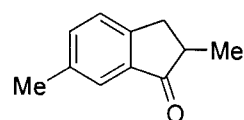
Q.23 In the following reaction, the major product **T** is



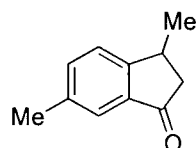
(A)



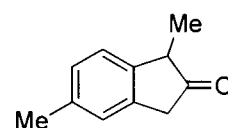
(B)



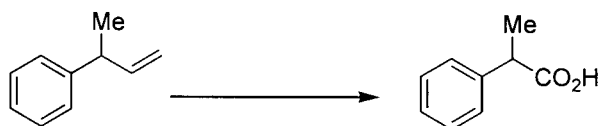
(C)



(D)

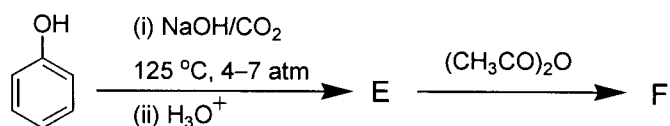


Q.24 The following conversion is carried out using

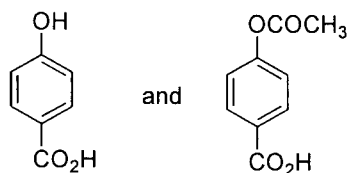


- (A) hydroboration-oxidation followed by Jones oxidation
 (B) Wacker oxidation followed by haloform reaction
 (C) oxymercuration-demercuration followed by Jones oxidation
 (D) ozonolysis followed by haloform reaction

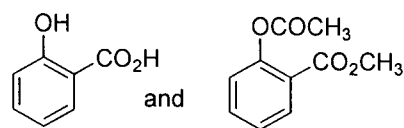
Q.25 In the following reactions, the major products **E** and **F**, respectively, are



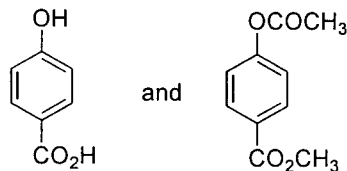
(A)



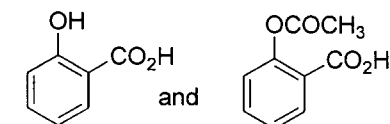
(B)



(C)



(D)



- Q.26 $\frac{dy}{dx} = -\frac{y}{x}$ is a differential equation for a/an
 (A) circle (B) ellipse
 (C) bell-shaped curve (D) hyperbola
- Q.27 Value of the given determinant is

$$\begin{bmatrix} 1 & 3 & 0 \\ 2 & 6 & 4 \\ -1 & 0 & 2 \end{bmatrix}$$

 (A) -12 (B) 0 (C) 6 (D) 12
- Q.28 Ionisation energy of hydrogen atom in ground state is 13.6 eV. The energy released (in eV) for third member of Balmer series is
 (A) 13.056 (B) 2.856 (C) 0.967 (D) 0.306
- Q.29 For a first order reaction $A(g) \rightarrow 2B(g) + C(g)$, the rate constant in terms of initial pressure (p_0) and pressure at time t (p_t), is given by
 (A) $\frac{1}{t} \ln \frac{p_0}{p_t - p_0}$ (B) $\frac{1}{t} \ln \frac{2p_0}{3p_0 - p_t}$ (C) $\frac{1}{t} \ln \frac{3p_0}{p_t - p_0}$ (D) $\frac{1}{t} \ln \frac{3p_0}{3p_t - p_0}$
- Q.30 For a particle in one-dimensional box of length L with potential energy $V(x) = 0$ for $L > x > 0$ and $V(x) = \infty$ for $x \geq L$ and $x \leq 0$, an acceptable wave function consistent with the boundary conditions is (A, B, C and D are constants)
 (A) $A \cos\left(\frac{n\pi x}{L}\right)$ (B) $B(x + x^2)$ (C) $Cx^3(x - L)$ (D) $\frac{D}{\sin\left(\frac{n\pi x}{L}\right)}$

SECTION - B

MULTIPLE SELECT QUESTIONS (MSQ)

Q. 31 – Q. 40 carry two marks each.

- Q.31 The “heme” containing protein(s) is/are
 (A) cytochrome C (B) hemocyanin (C) hemerythrin (D) myoglobin
- Q.32 Among the following, the species having see-saw shape is/are
 (A) SF_4 (B) XeF_4 (C) ClF_4^+ (D) ClF_4^-
- Q.33 The indicator(s) appropriate for the determination of end point in the titration of a weak acid with a strong base is/are
 (A) phenolphthalein (B) thymol blue
 (C) bromophenol blue (D) methyl orange

Q.34 Jahn-Teller distortion is observed in octahedral complexes with d-electron configuration of

- (A) d^5 - high spin (B) d^5 - low spin (C) d^6 - high spin (D) d^6 - low spin

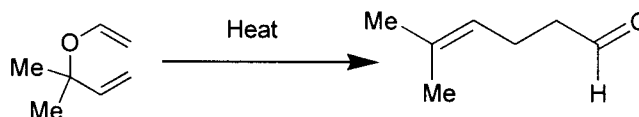
Q.35 Among the following, the correct statement(s) is/are

- (A) Guanine is a purine nucleobase
(B) Glycine and proline are achiral amino acids
(C) DNA contains glycosidic bonds and pentose sugars
(D) Sucrose is a non-reducing sugar

Q.36 The **INCORRECT** statement(s) among the following is/are

- (A) $[4\pi + 2\pi]$ cycloaddition reactions are carried out in presence of light
(B) $[2\pi + 2\pi]$ cycloaddition reaction between a keto group and an alkene is photochemically allowed
(C) $[4\pi + 2\pi]$ cycloaddition reactions are thermally allowed
(D) Transoid dienes undergo Diels-Alder reactions

Q.37 The following conversion is an example of



- (A) oxy-Cope rearrangement (B) sigmatropic rearrangement
(C) Claisen rearrangement (D) pericyclic reaction

Q.38 IR active molecule(s) is/are

- (A) CO_2 (B) CS_2
(C) OCS (D) N_2

Q.39 Intensive variable(s) is/are

- (A) temperature (B) volume
(C) pressure (D) density

Q.40 Wave nature of electromagnetic radiation is observed in

- (A) diffraction (B) interference
(C) photoelectric effect (D) Compton scattering

SECTION – C
NUMERICAL ANSWER TYPE (NAT)

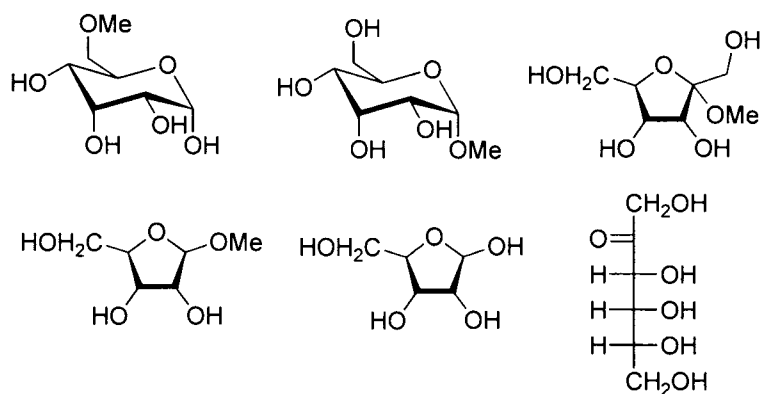
Q. 41 – Q. 50 carry one mark each.

Q.41 The number of isomeric structures of di-substituted borazine ($B_3N_3H_4X_2$) is _____

Q.42 The number of S–S bond(s) in tetrathionate ion is _____

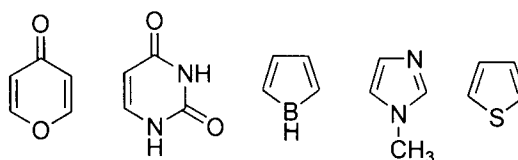
Q.43 The number of unpaired electron(s) in K_2NiF_6 is _____

Q.44 The number of reducing sugars among the following is _____



Q.45 The maximum number of dipeptides that could be obtained by reaction of phenylalanine with leucine is _____

Q.46 Among the following, the number of aromatic compound(s) is _____



Q.47 At an operating frequency of 350 MHz, the shift (in Hz) of resonance from TMS (tetramethylsilane) of a proton with chemical shift of 2 ppm is _____

Q.48 At 298 K and 1 atm, the molar enthalpies of combustion of cyclopropane and propene are $-2091 \text{ kJ mol}^{-1}$ and $-2058 \text{ kJ mol}^{-1}$, respectively. The enthalpy change (in kJ mol^{-1}) for the conversion of one mole of propene to one mole of cyclopropane is _____

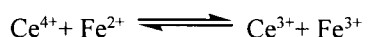
Q.49 For a cell reaction, $\text{Pb}(s) + \text{Hg}_2\text{Cl}_2(s) \rightarrow \text{PbCl}_2(s) + 2\text{Hg}(l)$, $\left(\frac{\partial E^0}{\partial T}\right)_p$ is $1.45 \times 10^{-4} \text{ VK}^{-1}$. The entropy change (in $\text{J mol}^{-1} \text{ K}^{-1}$) for the reaction is _____

[Given: $1 \text{ F} = 96500 \text{ C mol}^{-1}$]

Q.50 For a reaction $2A + B \rightarrow C + D$, if rate of consumption of A is $0.1 \text{ mol L}^{-1}\text{s}^{-1}$, the rate of production of C (in $\text{mol L}^{-1}\text{s}^{-1}$) is _____

Q. 51 – Q. 60 carry two marks each.

Q.51 The standard reduction potentials of $\text{Ce}^{4+}/\text{Ce}^{3+}$ and $\text{Fe}^{3+}/\text{Fe}^{2+}$ are 1.44 and 0.77 V, respectively. The $\log_{10}K$ (K is the equilibrium constant) value for the following reaction is _____ (final answer should be rounded off to two decimal places)



[Given: $RT/F = 0.0257 \text{ V}$]

Q.52 A radioactive element undergoes 80% radioactive decay in 300 min. The half-life for this species in minutes is _____

Q.53 Silver crystallizes in a face-centered cubic lattice. The lattice parameter of silver (in picometer) is _____

[Given: Avogadro's number = $6.023 \times 10^{23} \text{ mol}^{-1}$, molar mass of silver = $107.87 \text{ g mol}^{-1}$ and density of crystal = 10.5 g cm^{-3}]

Q.54 The amount of bromine (atomic wt. = 80) required (in gram) for the estimation of 42.3 g of phenol (molecular wt. = 94 g mol^{-1}) is _____

Q.55 The total number of pair of enantiomers possible with molecular formula $\text{C}_5\text{H}_{12}\text{O}$ is _____

- Q.56 In 200 g of water, 0.01 mole of NaCl and 0.02 mole of sucrose are dissolved. Assuming solution to be ideal, the depression in freezing point of water (in °C) will be _____
(final answer should be rounded off to two decimal places)

[Given: $K_f(H_2O) = 1.86 \text{ K kg mol}^{-1}$]

- Q.57 The adsorption of a gas follows the Langmuir isotherm with $K = 1.25 \text{ kPa}^{-1}$ at 25 °C. The pressure (in Pa) at which surface coverage is 0.2 is _____

- Q.58 The separation of 123 planes (in nm) in an orthorhombic cell with $a = 0.25 \text{ nm}$, $b = 0.5 \text{ nm}$ and $c = 0.75 \text{ nm}$ is _____
(final answer should be rounded off to two decimal places)

- Q.59 A vessel contains a mixture of H_2 and N_2 gas. The density of this gas mixture is 0.2 g L^{-1} at 300 K and 1 atm. Assuming that both the gases behave ideally, the mole fraction of N_2 (g) in the vessel is _____
(final answer should be rounded off to two decimal places)

[Given: $R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$, atomic wt. of hydrogen = 1.0 and atomic wt. of nitrogen = 14.0]

- Q.60 Consider an isothermal reversible compression of one mole of an ideal gas in which the pressure of the system is increased from 5 atm to 30 atm at 300 K. The entropy change of the surroundings (in J K^{-1}) is _____
(final answer should be rounded off to two decimal places)

[Given: $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$]

END OF THE QUESTION PAPER