SECTION B: CHEMISTRY (100 Marks)

Part I: Multiple Choice Questions (MCQs)

20 Questions × 4 Marks = 80 Marks

Instructions:

- Each question has four options (A), (B), (C), and (D)
- Only ONE option is correct
- Marking Scheme: +4 for correct answer, -1 for incorrect answer

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26. [BONDING CONCEPTUAL]

Consider the following species: BF_3, BF_4^-, NH_3, NH_4^+. The correct statement regarding bond angles is:

(A) $NH_3 > NH_4^+ = BF_3 > BF_4^-$

(B) $BF_4^- < BF_3 < NH_4^+ < NH_3$

(C) $NH_4^+ = BF_4^- > BF_3 > NH_3$

(D) $BF_3 > BF_4^- = NH_4^+ > NH_3$

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27. [MULTI-STEP ORGANIC SYNTHESIS]

Benzene → (i) $CH_3Cl/AlCl_3$ → A → (ii) $KMnO_4/OH^-/\Delta$ → B → (iii) H_3O^+ → C → (iv) $SOCl_2$ → D → (v) NH_3 → E → (vi) $Br_2/NaOH$ → F

The compound F is:

(A) Methylamine

(B) Aniline

(C) Benzylamine

(D) N-methylaniline

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28. [ELECTROCHEMISTRY ADVANCED]

The following electrochemical cell is set up:

$Pt(s) \mid H_2(1\ atm) \mid H^+(pH=x) \parallel Cu^{2+}(0.1M) \mid Cu(s)$

If $E°(Cu^{2+}/Cu) = +0.34$ V and the measured cell potential is 0.456 V at 298 K, the pH of the solution in the anode compartment is approximately:

(A) 1

(B) 2

(C) 3

(D) 4

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29. [STEREOCHEMISTRY TRICKY]

How many stereoisomers are possible for the compound $CH_3CH=CH-CHBr-CHCl-CH_3$?

(A) 4

(B) 6

(C) 8

(D) 12

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30. [THERMODYNAMICS CONCEPTUAL]

For the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92$ kJ.

If the reaction is carried out at constant volume instead of constant pressure (both at same temperature), the change in enthalpy would be:

(A) Greater than -92 kJ

(B) Less than -92 kJ

(C) Equal to -92 kJ

(D) Cannot be determined

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31. [REACTION MECHANISM - EXPERT]

Consider the reaction:

$C_6H_5CHO + CH_3COCH_3 \rightarrow^{(NaOH/\Delta)}$ Product

Which intermediate is MOST stabilized during this aldol condensation?

(A) $C_6H_5CH=CH-CO-CH_3$

(B) $C_6H_5CH(OH)-CH_2-CO-CH_3$

(C) $^-CH_2-CO-CH_3$

(D) $C_6H_5CH^--CHO$

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32. [KINETICS - COMPLEX]

For a reaction: 2A + B → products, the rate law is r = k[A][B].

The reaction is carried out in a container where initial concentration of A is 0.1 M and B is 0.2 M. When half of A is consumed, if we add A to restore its concentration to 0.1 M instantaneously, the rate of reaction at that instant compared to initial rate is:

(A) Same

(B) Half

(C) Three-fourth

(D) Double

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33. [INORGANIC CONCEPTUAL]

Among the following complex ions, the one that can exhibit geometrical isomerism but NOT optical isomerism is:

(A) $[Co(en)_2Cl_2]^+$

(B) $[Pt(NH_3)_2Cl_2]$

(C) $[Cr(C_2O_4)_3]^{3-}$

(D) $[Co(NH_3)_3(NO_2)_3]$

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34. [CFSE CALCULATION]

For the complex ion $[Fe(H_2O)_5(NO)]^{2+}$, given that NO acts as a neutral ligand with effectively 3 electrons donated, and assuming strong field, the effective magnetic moment (in B.M.) would be closest to:

(A) 0

(B) 1.73

(C) 2.83

(D) 3.87

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35. [ADVANCED ORGANIC REACTION]

When compound $(CH_3)_3C\text{-}CH(OH)\text{-}CH_3$ is heated with concentrated H_2SO_4, the major product formed is:

(A) $(CH_3)_2C{=}C(CH_3)_2$

(B) $(CH_3)_3C\text{-}CH{=}CH_2$

(C) $(CH_3)_2CH\text{-}CH{=}CH\text{-}CH_3$

(D) A mixture of rearranged products

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36. [COLLIGATIVE PROPERTY - TRICKY]

A solution of 2 g of a substance X in 100 g of CCl_4 boils at 77.8°C. The boiling point of pure CCl_4 is 76.8°C. If K_b for CCl_4 is 5 K kg mol^{-1}, and the substance X associates in solution forming dimers to the extent of 80%, the molar mass of X is:

(A) 50 g/mol

(B) 100 g/mol

(C) 125 g/mol

(D) 150 g/mol

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37. [PHASE DIAGRAM CONCEPTUAL]

For the reaction at equilibrium:

$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, $\Delta H > 0$

If the temperature is increased at constant volume, which statement is correct?

(A) Pressure increases, equilibrium shifts right, K_p increases

(B) Pressure increases, equilibrium shifts left, K_p decreases

(C) Pressure decreases, equilibrium shifts right, K_p increases

(D) Pressure constant, equilibrium unaffected, K_p increases

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38. [PERIODIC TRENDS ADVANCED]

Among the following, the oxide that can act as both oxidizing and reducing agent is:

(A) NO_2

(B) SO_2

(C) CO_2

(D) N_2O_5

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39. [MOLECULAR STRUCTURE]

In XeF_2, the Xe-F bond order considering three-center four-electron bonding model is:

(A) 1

(B) 0.5

(C) 1.5

(D) 2

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40. [CONDUCTANCE COMPLEX]

The equivalent conductance of NaCl, HCl and CH_3COONa at infinite dilution are 126.5, 426.2, and 91.0 S cm² equiv^{-1} respectively. The equivalent conductance of CH_3COOH at infinite dilution is:

(A) 208.7

(B) 390.7

(C) 543.7

(D) 643.7

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41. [NAME REACTION MECHANISM]

In the Hofmann bromamide degradation reaction, when benzamide is treated with Br_2 in aqueous NaOH, the mechanism involves formation of intermediate X which then undergoes rearrangement. The intermediate X is:

(A) C_6H_5-CO-NH-Br

(B) C_6H_5-CO-N̈-Br (with lone pair)

(C) C_6H_5-N=C=O

(D) C_6H_5-NH_2

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42. [ACIDITY CONCEPTUAL]

Arrange the following in increasing order of acidity:

(I) CH_3CH_2OH
(II) CH_3CH_2COOH
(III) $ClCH_2COOH$
(IV) FCH_2COOH

(A) I < II < III < IV

(B) II < I < III < IV

(C) I < III < II < IV

(D) II < III < I < IV

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43. [ORGANOMETALLIC]

In the Grignard reagent preparation, if water is present as impurity, which of the following reactions does NOT occur?

(A) $RMgX + H_2O \rightarrow RH + Mg(OH)X$

(B) $2RMgX + H_2O \rightarrow R_2Mg + Mg(OH)X$

(C) $RMgX \rightarrow R_2Mg + MgX_2$ (Schlenk equilibrium)

(D) $R_2Mg + H_2O \rightarrow RH + RMgOH$

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44. [KINETICS - ADVANCED]

A first-order reaction has activation energy 50 kJ/mol. The rate constant doubles when temperature is increased from 300 K to 310 K. Using this information, the rate constant at 320 K compared to that at 300 K will be approximately:

(A) 3 times

(B) 4 times

(C) 5 times

(D) 8 times

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45. [AMINE BASICITY - TRICKY]

In aqueous solution, the correct order of basicity is:

(A) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$

(B) $CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N > NH_3$

(C) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$

(D) $NH_3 > CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

Part II: Numerical Value Type Questions

5 Questions × 4 Marks = 20 Marks

Instructions:

- Answer should be a numerical value rounded to the nearest integer (0-9999)
- Marking Scheme: +4 for correct answer, -1 for incorrect answer

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46. [STEREOISOMER COUNTING]

The total number of stereoisomers (including enantiomers and diastereomers) possible for 3-bromo-2-chloro-4-methylhexane is _____.

Answer: _____

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47. [COMPLEX EQUILIBRIUM]

At 500 K, the equilibrium constant K_p for the reaction:

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

is 2.5×10^{10} Pa^{-1}. If the reaction is started with 2 moles SO_2 and 1 mole O_2 in a 1 L container, and at equilibrium 90% conversion of SO_2 occurs, the equilibrium pressure (in atm) is approximately _____.

(R = 0.082 L atm K^{-1} mol^{-1})

Answer: _____

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48. [REDOX STOICHIOMETRY]

In the reaction:

$MnO_4^- + C_2O_4^{2-} + H^+ \rightarrow Mn^{2+} + CO_2 + H_2O$ (in acidic medium)

When 1.58 g of $KMnO_4$ (M = 158 g/mol) reacts completely with oxalate, the volume of CO_2 produced at STP (in mL) is _____.

Answer: _____

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49. [COMPLEX FREEZING POINT]

A solution is prepared by dissolving 3 g of a mixture of NaCl (50% by mass) and glucose (50% by mass) in 500 g of water. The depression in freezing point (in $K \times 10^2$) is _____.

(K_f = 1.86 K kg mol^{-1}, M(NaCl) = 58.5 g/mol, M(glucose) = 180 g/mol)

Answer: _____

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50. [OXIDATION STATE CALCULATION]

In the compound $Na_4[Fe(CN)_5(NOS)]$, if the oxidation state of Fe is x and the oxidation state of N in the NOS ligand is y, then |x - y| = _____.

Answer: _____