

## 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:  $\text{BF}_3$ ,  $\text{BF}_4^-$ ,  $\text{NH}_3$ ,  $\text{NH}_4^+$ . The correct statement regarding bond angles is:

- (A)  $\text{NH}_3 > \text{NH}_4^+ = \text{BF}_3 > \text{BF}_4^-$
- (B)  $\text{BF}_4^- < \text{BF}_3 < \text{NH}_4^+ < \text{NH}_3$
- (C)  $\text{NH}_4^+ = \text{BF}_4^- > \text{BF}_3 > \text{NH}_3$
- (D)  $\text{BF}_3 > \text{BF}_4^- = \text{NH}_4^+ > \text{NH}_3$
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#### 27. [MULTI-STEP ORGANIC SYNTHESIS]

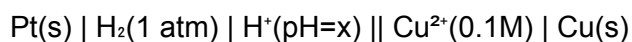
Benzene  $\rightarrow$  (i)  $\text{CH}_3\text{Cl}/\text{AlCl}_3 \rightarrow \text{A} \rightarrow$  (ii)  $\text{KMnO}_4/\text{OH}^-/\Delta \rightarrow \text{B} \rightarrow$  (iii)  $\text{H}_3\text{O}^+ \rightarrow \text{C} \rightarrow$  (iv)  $\text{SOCl}_2 \rightarrow \text{D} \rightarrow$  (v)  $\text{NH}_3 \rightarrow \text{E} \rightarrow$  (vi)  $\text{Br}_2/\text{NaOH} \rightarrow \text{F}$

The compound F is:

- (A) Methylamine
- (B) Aniline
- (C) Benzylamine
- (D) N-methylaniline
- 

#### 28. [ELECTROCHEMISTRY ADVANCED]

The following electrochemical cell is set up:



If  $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$  and the measured cell potential is  $0.456 \text{ V}$  at  $298 \text{ K}$ , 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  $\text{CH}_3\text{CH}=\text{CH}-\text{CHBr}-\text{CHCl}-\text{CH}_3$ ?

- (A) 4
  - (B) 6
  - (C) 8
  - (D) 12
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### 30. [THERMODYNAMICS CONCEPTUAL]

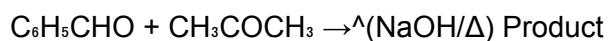
For the reaction:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ ,  $\Delta H = -92 \text{ kJ}$ .

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  $-92 \text{ kJ}$
  - (B) Less than  $-92 \text{ kJ}$
  - (C) Equal to  $-92 \text{ kJ}$
  - (D) Cannot be determined
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### 31. [REACTION MECHANISM - EXPERT]

Consider the reaction:



Which intermediate is MOST stabilized during this aldol condensation?

- (A)  $\text{C}_6\text{H}_5\text{CH}=\text{CH}-\text{CO}-\text{CH}_3$
  - (B)  $\text{C}_6\text{H}_5\text{CH}(\text{OH})-\text{CH}_2-\text{CO}-\text{CH}_3$
  - (C)  $^-\text{CH}_2-\text{CO}-\text{CH}_3$
  - (D)  $\text{C}_6\text{H}_5\text{CH}^--\text{CHO}$
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### 32. [KINETICS - COMPLEX]

For a reaction:  $2\text{A} + \text{B} \rightarrow \text{products}$ , the rate law is  $r = k[\text{A}][\text{B}]$ .

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
- 

### 33. [INORGANIC CONCEPTUAL]

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

- (A)  $[\text{Co}(\text{en})_2\text{Cl}_2]^+$
  - (B)  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
  - (C)  $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$
  - (D)  $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$
- 

### 34. [CFSE CALCULATION]

For the complex ion  $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]^{2+}$ , 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  $(\text{CH}_3)_3\text{C}-\text{CH}(\text{OH})-\text{CH}_3$  is heated with concentrated  $\text{H}_2\text{SO}_4$ , the major product formed is:

(A)  $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$

(B)  $(\text{CH}_3)_3\text{C}-\text{CH}=\text{CH}_2$

(C)  $(\text{CH}_3)_2\text{CH}-\text{CH}=\text{CH}-\text{CH}_3$

(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  $\text{CCl}_4$  boils at  $77.8^\circ\text{C}$ . The boiling point of pure  $\text{CCl}_4$  is  $76.8^\circ\text{C}$ . If  $K_b$  for  $\text{CCl}_4$  is  $5 \text{ K kg mol}^{-1}$ , 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

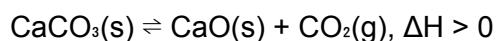
(C) 125 g/mol

(D) 150 g/mol

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### 37. [PHASE DIAGRAM CONCEPTUAL]

For the reaction at equilibrium:



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)  $\text{NO}_2$

(B)  $\text{SO}_2$

(C)  $\text{CO}_2$

(D)  $\text{N}_2\text{O}_5$

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**39. [MOLECULAR STRUCTURE]**

In  $\text{XeF}_2$ , 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  $\text{NaCl}$ ,  $\text{HCl}$  and  $\text{CH}_3\text{COONa}$  at infinite dilution are 126.5, 426.2, and  $91.0 \text{ S cm}^2 \text{ equiv}^{-1}$  respectively. The equivalent conductance of  $\text{CH}_3\text{COOH}$  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  $\text{Br}_2$  in aqueous  $\text{NaOH}$ , the mechanism involves formation of intermediate X which then undergoes rearrangement. The intermediate X is:

- (A)  $\text{C}_6\text{H}_5\text{-CO-NH-Br}$
  - (B)  $\text{C}_6\text{H}_5\text{-CO-}\ddot{\text{N}}\text{-Br}$  (with lone pair)
  - (C)  $\text{C}_6\text{H}_5\text{-N=C=O}$
  - (D)  $\text{C}_6\text{H}_5\text{-NH}_2$
- 

#### 42. [ACIDITY CONCEPTUAL]

Arrange the following in increasing order of acidity:

- (I)  $\text{CH}_3\text{CH}_2\text{OH}$
- (II)  $\text{CH}_3\text{CH}_2\text{COOH}$
- (III)  $\text{ClCH}_2\text{COOH}$
- (IV)  $\text{FCH}_2\text{COOH}$

- (A)  $\text{I} < \text{II} < \text{III} < \text{IV}$
  - (B)  $\text{II} < \text{I} < \text{III} < \text{IV}$
  - (C)  $\text{I} < \text{III} < \text{II} < \text{IV}$
  - (D)  $\text{II} < \text{III} < \text{I} < \text{IV}$
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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)  $\text{RMgX} + \text{H}_2\text{O} \rightarrow \text{RH} + \text{Mg(OH)X}$
  - (B)  $2\text{RMgX} + \text{H}_2\text{O} \rightarrow \text{R}_2\text{Mg} + \text{Mg(OH)X}$
  - (C)  $\text{RMgX} \rightarrow \text{R}_2\text{Mg} + \text{MgX}_2$  (Schlenk equilibrium)
  - (D)  $\text{R}_2\text{Mg} + \text{H}_2\text{O} \rightarrow \text{RH} + \text{RMgOH}$
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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)  $(\text{CH}_3)_2\text{NH} > \text{CH}_3\text{NH}_2 > (\text{CH}_3)_3\text{N} > \text{NH}_3$
  - (B)  $\text{CH}_3\text{NH}_2 > (\text{CH}_3)_2\text{NH} > (\text{CH}_3)_3\text{N} > \text{NH}_3$
  - (C)  $(\text{CH}_3)_3\text{N} > (\text{CH}_3)_2\text{NH} > \text{CH}_3\text{NH}_2 > \text{NH}_3$
  - (D)  $\text{NH}_3 > \text{CH}_3\text{NH}_2 > (\text{CH}_3)_2\text{NH} > (\text{CH}_3)_3\text{N}$
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### 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]

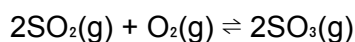
The total number of stereoisomers (including enantiomers and diastereomers) possible for 3-bromo-2-chloro-4-methylhexane is \_\_\_\_\_.

Answer: \_\_\_\_\_

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#### 47. [COMPLEX EQUILIBRIUM]

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



is  $2.5 \times 10^{10} \text{ Pa}^{-1}$ . If the reaction is started with 2 moles  $\text{SO}_2$  and 1 mole  $\text{O}_2$  in a 1 L container, and at equilibrium 90% conversion of  $\text{SO}_2$  occurs, the equilibrium pressure (in atm) is approximately \_\_\_\_\_.

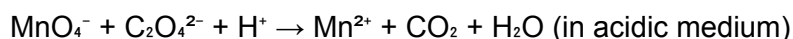
( $R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$ )

**Answer:** \_\_\_\_\_

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#### 48. [REDOX STOICHIOMETRY]

In the reaction:



When 1.58 g of  $\text{KMnO}_4$  ( $M = 158 \text{ g/mol}$ ) reacts completely with oxalate, the volume of  $\text{CO}_2$  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  $\text{NaCl}$  (50% by mass) and glucose (50% by mass) in 500 g of water. The depression in freezing point (in  $\text{K} \times 10^2$ ) is \_\_\_\_\_.

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

**Answer:** \_\_\_\_\_

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#### 50. [OXIDATION STATE CALCULATION]

In the compound  $\text{Na}_4[\text{Fe}(\text{CN})_5(\text{NOS})]$ , if the oxidation state of Fe is  $x$  and the oxidation state of N in the NOS ligand is  $y$ , then  $|x - y| =$  \_\_\_\_\_.

**Answer:** \_\_\_\_\_