Q.1. Select the best option/answer and fill in the appropriate box on the Answer Sheet. (1 x 20 = 20)

(i) The geometry associated with $sp^3d^2$ hybridization is:
   (a) Octahedral    (b) Tetrahedral    (c) Trigonal planar    (d) Trigonal biplanar

(ii) Which of the following molecules has a dipole movement?
   (a) $CH_4$       (b) $CO_2$       (c) $H_2O$       (d) $CCl_4$

(iii) Which of the following represents the shape of $NH_3$ molecule?
   (a) Trigonal planar    (b) Angular    (c) Trigonal Pyramidal    (d) Tetrahedral

(iv) Which of the following is the largest ion?
   (a) $Li^+$    (b) $Cs^+$    (c) $Rb^+$    (d) $Na^+$

(v) Which of the following represent different isotopes of the same element?
   1. 12 protons, 11 neutrons, 12 electrons
   2. 11 protons, 12 neutrons, 11 electrons
   3. 10 protons, 12 neutrons, 12 electrons
   4. 11 protons, 12 neutrons, 10 electrons
   5. 12 protons, 12 neutrons, 12 electrons
   (a) 1 and 5    (b) 2 and 4    (c) 2, 3, 4 and 5    (d) None of these

(vi) Which of the following represents the correct number of particles in $^{79}_{34}Se^{2-}$?
   (a) 34 protons, 79 neutrons, 2 electrons
   (b) 34 protons, 45 neutrons, 32 electrons
   (c) 34 protons, 45 neutrons, 2 electrons
   (d) 34 protons, 45 neutrons, 36 electrons

(vii) Which one of the following is correct equation for the reaction of chlorine with water?
   (a) $2Cl^{-} + H_2O \rightarrow 2HCl + \frac{1}{2}O_2$
   (b) $Cl_2 + 2H_2O \rightarrow 2HCl + H_2O_2$
   (c) $Cl_2 + 3H_2O \rightarrow HClO_3 + 5HCl$
   (d) $Cl_2 + H_2O \rightarrow HCl + HOCl$

(viii) Faraday’s laws of electrolysis are related to the:
   (a) Atomic number and speed of the cation
   (b) Atomic number and speed of the anion
   (c) Quantity of electricity and equivalent weight of the electrolyte
   (d) None of these
(ix) When Pt and Co are electrically connected, which one is corroded:
(a) Pt  (b) Co  (c) Both of these  (d) None of these

(x) For the reaction (Zn + Cu^{2+} → Zn^{2+} + Cu), which of the following statements is correct?
(a) Zn is dissolved and Cu is deposited  (b) Cu is reduced and Zn is oxidized
(c) Cu is the cathode and Zn the anode  (d) All statements are correct

(xi) What is the pH of 0.0001 M NaOH solution?
(a) 4  (b) 10  (c) 5  (d) 14

(xii) What is the pH of 1.0 × 10^{-3} M HCl solution?
(a) 10  (b) 30  (c) 3  (d) 0.3

(xiii) Which of the following is the correct equilibrium expression for the reaction
\[ N_2(g) + 3H_2(g) → 2NH_3(g) \]?
(a) \[ 2NH_3 ] / [N_2][H_2] \  (b) \[ 2NH_3 ] / [N_2][3H_2] \  
(c) \[ NH_3 ]^2 / [N_2][H_2]^3 \  (d) \[ NH_3 ]^2 / [N_2]+[H_2]^3 \]

(xiv) Which of the following best describes how a catalyst works?
(a) It changes the potential energies of the reactants and products.
(b) It decreases the temperature of the reaction which leads to a faster rate.
(c) It lowers the activation energy for the reaction by providing a different reaction mechanism.
(d) It raises the activation energy for the reaction which produces a faster rate.

(xv) Which of the following will not act as Lewis acid;
(a) AlCl_3  (b) BF_3  (c) FeBr_3  (d) CCl_4

(xvi) Which of the following is the strongest acid?
(a) HF  (b) HCl  (c) HBr  (d) HI

(xvii) Which of the following could be used for cathodic protection:
(a) Al  (b) Cd  (c) Cu  (d) None of these

(xviii) Hybridization of XeF_4 is:
(a) sp^3d  (b) sp^2d^2  (c) sp^3 d^2  (d) sp^3

(xix) Which of the following will increase the rate of the reaction?
(a) Decreased temperature and increased concentration of reactants
(b) Decreased temperature and decreased concentration of reactants
(c) Increased temperature and decreased concentration of reactants
(d) Increased temperature and increased concentration of reactants

(xx) Silicones are polymeric substances with linkage:
(a) Si – S – Si  (b) Si – O – Si  (c) Si (CH_3)_4  (d) O = Si = O
Q.2. (a) Explain with suitable examples the difference between electrochemical cell and electrolytic cell? (07)

For the cell, Ni(s)/Ni^+ (aq)//Ag^+ (aq)/Ag(s), write half cell reactions at each electrode and balanced redox reaction that occurs in the cell.

(b) For the given reaction, Fe_2 O_3(s) + 2Al(s) → Al_2 O_3(s) + 2Fe(s), the heat of formation of Fe_2 O_3 and Al_2 O_3 are -822.25 and -1669.84 kJ at 298 K, calculate the change in enthalpy. (03)

(c) Write comprehensive note on Fuel cells. (10)

Q.3. (a) How do buffers resist changes in pH? Write any two applications of buffers in Chemistry? (05)

(b) Calculate pH of 0.1 N solution of NaOH. (02)

(c) Give a brief account of Debye-Hückel theory of strong electrolytes? (05)

(d) What is hydrogen over voltage, how it is related to corrosion rate? (08)

Q.4. (a) Explain the terms Gibbs free energy, enthalpy and entropy of a reaction. What is the relationship between these terms? (08)

(b) The heat of reaction for the following reaction at 298K is – 92.466 kJ.

\[ \frac{1}{2} \text{H}_2 \ (g) + \frac{1}{2} \text{Cl}_2 \rightarrow \text{HCl}(g) \]

Calculate the heat of this reaction at 323 K. (04)

(c) Define heat of combustion. How it is measured experimentally? (08)

Q.5. (a) Explain the terms spontaneous and non-spontaneous reactions with suitable examples. (05)

(b) Describe moving boundary method for the determination of transference number. (10)

(c) Write a note on concentration cells. (05)

Q.6. (a) Describe main features of crystal field theory, How this theory explains colour of coordination complexes? (10)

(b) Write the electronic configuration for each of the following:

Ni^{2+}, Cu, Mn^{2+}, Cr^{3+}

(c) Write coordination and oxidation numbers for the transition metal atom in each of the following coordination compounds. (06)

<table>
<thead>
<tr>
<th>Coordination No</th>
<th>Oxidation No</th>
</tr>
</thead>
<tbody>
<tr>
<td>K[Ag(CN)_2]</td>
<td>K[CuCl_2]</td>
</tr>
</tbody>
</table>

Q.7. (a) State the method by which NaOH is manufactured industrially using NaCl as raw material? (06)

(b) Describe different allotropic forms of carbon? Discuss structure and chemical properties of each. (08)

(c) Discuss chemistry of Hard and Soft water. (06)

Q.8. (a) Write an essay on the Oxides of Nitrogen and Environmental Pollution. (08)

(b) Write structure and chemical properties of Interhalogen compounds. (07)

(c) With the help of equations, outline the manufacture of glass. (06)

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(PART-I MCQs) (COMPULSORY)

Q.1. Select the best option/answer and fill in the **appropriate box** on the **Answer Sheet**. \( (1 \times 20 = 20) \)

(i) Carbon atoms in p-xylene are:
   (a) \( \text{sp}^2 \) hybridized \hspace{1cm} (b) \( \text{sp}^3 \) hybridized \hspace{1cm} (c) Sp hybridized \hspace{1cm} (d) Both (a) and (b)

(ii) Which of the following sugars is found in milk?
   (a) Lactose \hspace{1cm} (b) Sucrose \hspace{1cm} (c) Maltose \hspace{1cm} (d) Fructose

(iii) Glucose when heated with Benedict’s reagent (\( \text{CuSO}_4, \text{NaOH}, \) and tartaric acid) forms a brick red precipitate due to formation of:
   (a) \( \text{Cu}_2\text{O} \) \hspace{1cm} (b) \( \text{Cu(OH)}_2 \) \hspace{1cm} (c) Copper tartrate \hspace{1cm} (d) None of these

(iv) Which of the following can not be used as solvent in polarimetry?
   (a) Methanol \hspace{1cm} (b) Ethanol \hspace{1cm} (c) 1-butanol \hspace{1cm} (d) 2-butanol

(v) Polarimetry is a technique to analyze:
   (a) Chiral compounds \hspace{1cm} (b) Unsaturated compounds \hspace{1cm} (c) Polar compounds \hspace{1cm} (d) All of these

(vi) Which of the following is not an aromatic compound?
   (a) Pyrrole \hspace{1cm} (b) Pyridine \hspace{1cm} (c) Furan \hspace{1cm} (d) Piperidine

(vii) Which of the following is not a heterocyclic compound?
   (a) \hspace{1cm} (b) \hspace{1cm} (c) \hspace{1cm} (d)

(viii) Which of the following will show optical isomerism?
   (a) 2,3-dimethylbutane \hspace{1cm} (b) 3,4-dimethylhexane \hspace{1cm} (c) 3,4-diethylhexane \hspace{1cm} (d) 1,4-dimethylcyclohexane

(ix) What type of reaction takes place when a ketone is treated with HCN?
   (a) Electrophilic substitution \hspace{1cm} (b) Nucleophilic substitution \hspace{1cm} (c) Nucleophilic addition \hspace{1cm} (d) Electrophilic addition
CHEMISTRY, PAPER-II

(x) What is the major product in the following reaction?

\[
\text{CH}_3\text{CHCH}_2\text{CH}_3 + \text{excess CH}_3\text{OH} \xrightarrow{H_2SO_4} \]

(a) \(\text{OCH}_3\)  (b) \(\text{OCH}_3\)
(c)  (d) \(\text{OCH}_3\) \(\text{OCH}_3\)

(xi) What are the expected products from the following reactions?

\[
\text{CH}_3\text{CHCH}_2\text{CH}_3 + 1) O_3 \xrightarrow{2) Zn, H_2O^+} \]

(a) \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\) + \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\)
(b) \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\) + \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\)
(c)  (d) \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\) \(\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3\)

(xii) Which of the following will undergo Aldol condensation?

(a) Formaldehyde  (b) Acetaldehyde  (c) Benzaldehyde  (d) All of these

(xiii) Which of the following is the most acidic?

(a) Ethanol  (b) Butanol  (c) Cyclohexanol  (d) Phenol

(xiv) Which of the following is the most basic?

(a) Aniline  (b) m-chloroaniline  (c) N,N-dimethylaniline  (d) m-nitroaniline

(xv) Which of the following are correctly matched?

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Na Metal</td>
<td>Witting reaction</td>
</tr>
<tr>
<td>(b) ((\text{C}_6\text{H}_5)_3\text{P = C(CH}_3)_2)</td>
<td>Wurtz reaction</td>
</tr>
<tr>
<td>(c) KOH/NH\textsubscript{2} -NH\textsubscript{2}</td>
<td>Wolff-Kishner reduction</td>
</tr>
<tr>
<td>(d) Se + (\Delta 250 \degree) C</td>
<td>Birch reduction</td>
</tr>
</tbody>
</table>

(xvi) What is the correct configuration at chiral centers in the following molecule?

(a) 2R, 3R  (b) 2R, 3S  (c) 2S, 3R  (d) 2S, 3S

(xvii) The reaction acetone with phosphonium ylide \([\text{C}_6\text{H}_5)_3\text{P = C(CH}_3)_2] \) produces:

(a) 2,3-dimethyl-2-butanol  (b) 2,3-dimethyl-2-butene
(c) 2-chloro-2,3-dimethylbutane  (d) Both (a) and (b)

(xviii) Which of the following reactions are used to prepare amines:

(a) Gabrial synthesis  (b) Hofmann reaction  (c) Reductive amination  (d) All of these
The active agent in the nitration of benzene is:

(a) $\text{NO}_2^-$  (b) $\text{NO}_2^+$  (c) NO  (d) $\text{HNO}_2$

The most probable intermediate in Favorskii rearrangement is:

(a) Lactone  (b) Lactam  (c) Cyclopropanone  (d) None of these

Q.2. (a) Differentiate between Inter-molecular and Intra-molecular hydrogen bonding. Discuss effects of hydrogen bonding on any two properties of organic compounds. Support your answer with suitable examples. (08)

(b) Arrange following compounds in decreasing order of their base strength (strongest first). Give a brief explanation in support of your answer:

\[ \begin{align*}
\text{pK}_a \text{ values} & \rightarrow 11 & 40 & 9 & 36 & 5 & 18 \\
\end{align*} \]

(c) How would you account for the following:

i. Picric acid (2,4,6-trinitrophenol) liberates CO\(_2\) from aqueous solution of Na\(_2\)CO\(_3\) but phenol does not?

ii. Benzene undergo Friedel Craft alkylation in the presence of Lewis acid while pyridine does not?

iii. Benzene is an aromatic compound while cyclooctatetraene is nonaromatic?

Q.3. (a) Discuss how a catalyst changes the rate and path of the reaction? (06)

(b) Reaction of 1, 3-butadiene with HBr gives two products, draw reaction coordinate diagram to illustrate thermodynamic and kinetic products of the reaction. (07)

(c) For the following reaction:

\[ \begin{align*}
\text{CH}_3(\text{CH}_2)_3\text{Br} + \text{OH}^- & \rightarrow \text{CH}_3(\text{CH}_2)_3\text{OH} + \text{Br}^- \\
\end{align*} \]

Discuss rate law and various factors that affect the rate of reaction.

Q.4. (a) Starting from benzene how would you prepare the following compounds: Benzoic acid, 4-Bromonitobenzene, Maleic anhydride (06)

(b) Show reaction of C\(_2\)H\(_2\)MgBr with each of the following:

i. CH\(_3\)CHO followed by hydrolysis

ii. CH\(_3\)C ≡ C — H followed by reaction with CH\(_3\) — I

iii. CH\(_3\)COOC\(_2\)H\(_5\) followed by hydrolysis.
(c) Assign hybridization at each carbon in the following compound: (04)

(d) Suggest two methods to prepare aromatic amines. (04)

Q.5. (a) Discuss stereoisomerism in compounds having 2-similar asymmetric carbon atoms. (06)
(b) Draw Fisher projection formulae for the following compounds: (08)
   i. R and S 2 - bromopentane
   ii. R and S 3 - chloro-1-pentene
   iii. R and S 3 - chloro-3-methylctane
   iv. R and S 2 - pentanol
(c) What do you understand by the terms Z and E isomer? Illustrate your answer by quoting suitable examples. (06)

Q.6. (a) Illustrate giving suitable examples the difference between Homogenous and Heterogeneous catalysis. (06)
(b) Outline synthesis of azo dye starting with phenol and a suitable aromatic amine. (04)
(c) Write notes on the following: (05+ 05 = 10)
   i. Octane number
   ii. Catalytic cracking

Q.7. Write structure of product(s) obtained from each of the following reactions: (2 x 10 = 20)
   i. CH₃CH₂COOH + CH₃CH₂OH + H₂SO₄ →
   ii. C₆H₅COCH₃ + LiAlH₄ →
   iii. C₆H₅COOH + SOCl₂ →
   iv. (CH₃)₂CBr + NaOH(aq) →
   v. C₆H₅NH₂ + NaNO₂ + HCl (conc) →
   vi. CH₃CH₂COCH₃ →¹C₆H₅MgBr
   vii) C₆H₅NO₂ + Sn/HCl →
   viii) C₆H₆ + Na/NH₃ →
   ix) CH₃CH = CH₂ + HBr →
   x) CH₃COCH₃ + NH₂OH →

Q.8. (a) Write main steps in the formation of following polymers: (03 + 03 = 06)
   i. Nylon 6,6 and Polyester via Condensation Polymerization.
   ii. Polyethylene via Free Radical Polymerization.
   (b) What are alkaloids, describe chemical properties and structure of any two alkaloids. (07)
   (c) Differentiate between oil, fat and wax. Draw structure of triglyceride containing oleic acid [CH₃(CH₂)₇CH = CH(C₆H₅)COOH] as fatty acid and write reaction triglyceride with H₂/Ni followed by NaOH(aq). (06)