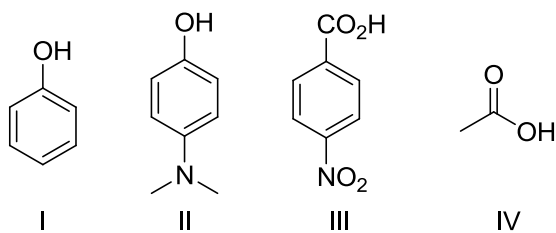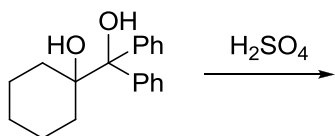# SECTION – A

MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q.10 carry one mark each.

Q.1   The correct order of pKa for the following compounds is
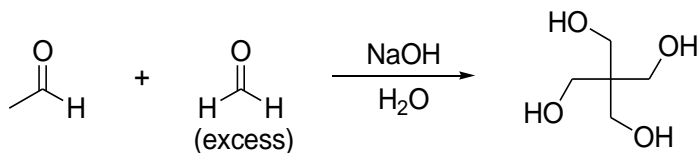

(A) II > I > III > IV
(B) II > I > IV > III
(C) III > IV > I > II
(D) IV > II > I > III

Q.2   The major product formed in the following reaction is


(A)

(B)

(C)

(D)

Q.3   The mechanism of the following transformation involves

(A) Aldol reaction and Cannizzaro reaction
(B) Aldol reaction and Claisen-Schmidt reaction
(C) Knoevenagel condensation and Cannizzaro reaction
(D) Stobbe condensation and Cannizzaro reaction

Q.4   The most basic amino acid among the following is

(A) tyrosine
(B) methionine
(C) arginine
(D) glutamine

Q.5   The crystal field stabilization energy (CFSE) in $[Mn(H_2O)_6]^{2+}$ is

(A) $0 \Delta_O$ (B) $2.0 \Delta_O - 2P$ (C) $0.4 \Delta_O - 2P$ (D) $2.0 \Delta_O$

Q.6   Indicator used in redox titration is

(A) Eriochrome black T
(B) Methyl orange
(C) Phenolphthalein
(D) Methylene blue

Q.7   Among the following, the compound that has the lowest degree of ionic character is

(A) NaCl   (B) $MgCl_2$ (C) $AlCl_3$ (D) $CaCl_2$

Q.8   The correct order of entropy for various states of CO_2 is

(A) $CO_2(s) > CO_2(l) > CO_2(g)$
(B) $CO_2(l) > CO_2(s) > CO_2(g)$
(C) $CO_2(g) > CO_2(l) > CO_2(s)$
(D) $CO_2(g) > CO_2(s) > CO_2(l)$

Q.9   The coordination numbers of Cs^+ and Cl^- ions in the CsCl structure, respectively, are

(A) 4,4   (B) 4,8   (C) 6,6   (D) 8,8

Q.10   Determinant of a square matrix is always

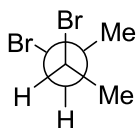(A) a square matrix   (B) a column matrix
(C) a row matrix   (D) a number

Q. 11 – Q. 30 carry two marks each.

Q.11   The correct order of ^{1}H NMR chemical shift (δ) values for the labeled methyl groups in the following compound is
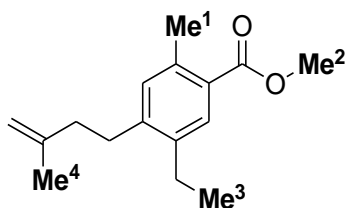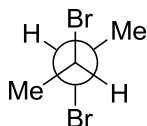

(A) $Me^1 < Me^2 < Me^3 < Me^4$
(B) $Me^3 < Me^4 < Me^1 < Me^2$
(C) $Me^3 < Me^1 < Me^4 < Me^2$
(D) $Me^2 < Me^4 < Me^3 < Me^1$

Q.12   Among the following, the most stable conformation of *meso*-2,3-dibromobutane is

(A)

(B)

(C)

(D)

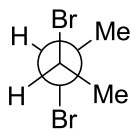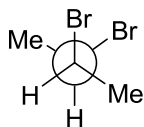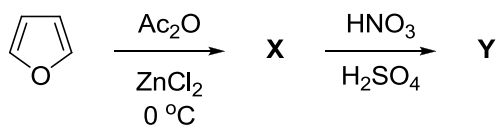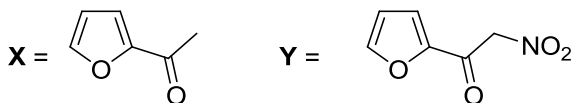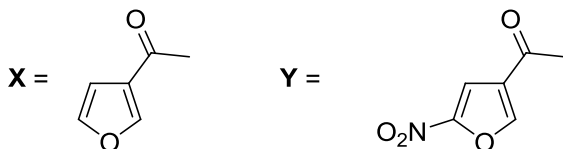Q.13   The major products **X** and **Y** in the following reaction sequence are
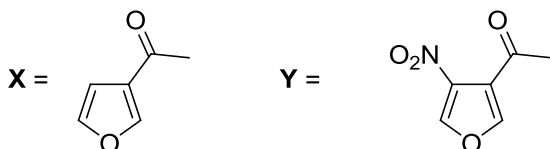
$$\text{furan} \xrightarrow[\substack{\text{ZnCl}_2 \\ 0\ ^\circ\text{C}}]{\text{Ac}_2\text{O}} \textbf{X} \xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3} \textbf{Y}$$

(A)

X =   (2-acetylfuran)   **Y** =   (2-(nitromethyl carbonyl)furan with NO₂)

(B)

X =   (3-acetylfuran)   **Y** =   (3-acetyl-5-nitrofuran, O₂N on ring)

(C)

X =   (3-acetylfuran)   **Y** =   (3-acetyl-4-nitrofuran, O₂N)

(D)

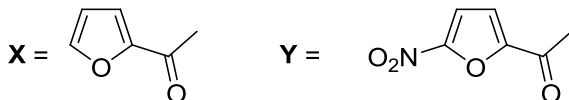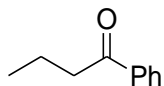**X** =   (2-acetylfuran)   **Y** =   O₂N (5-nitro-2-acetylfuran)

Q.14   The major product formed in the reaction of butanenitrile with phenylmagnesium bromide followed by acidification is

(A)

(butyrophenone, propyl–C(=O)–Ph)

(B)

(pentyl–C(=O)–Ph)

(C)

NH₂
(1-amino-1-phenylbutane)

(D)

H₂N
(amino with two Ph groups)
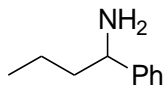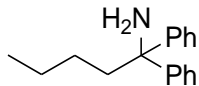
Q.15 An organic compound on reaction with 2,4-dinitrophenylhydrazine (2,4-DNP) gives a yellow precipitate. It also gives silver mirror on reaction with ammoniacal AgNO₃. It gives an alcohol and sodium salt of a carboxylic acid on reaction with concentrated NaOH. It yields benzene-1,2-dicarboxylic acid on heating with alkaline KMnO₄. The structure of the compound among the following is

(A)
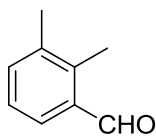
(B)
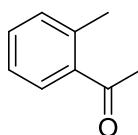
(C)

(D)

Q.16 The major products **X** and **Y** in the following reaction sequence are
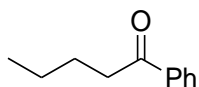

(A)

(B)

(C)

(D)

Q.17   The TRUE statement about $[Cu(H_2O)_6]^{2+}$ is

(A) All Cu–O bond lengths are equal
(B) One Cu–O bond length is shorter than the remaining five
(C) Three Cu–O bond lengths are shorter than the remaining three
(D) Four Cu–O bond lengths are shorter than the remaining two

Q.18   The complexes $[Pt(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$, respectively, are

(A) paramagnetic, paramagnetic
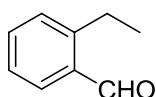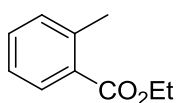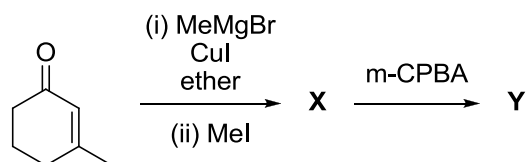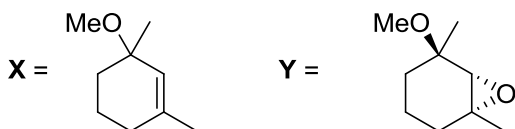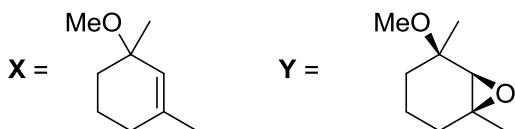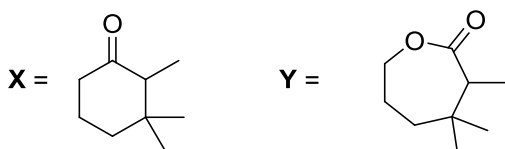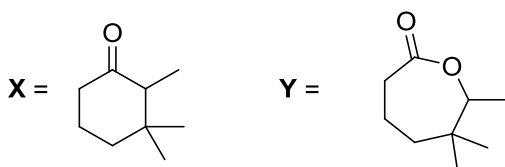(B) diamagnetic, diamagnetic
(C) paramagnetic, diamagnetic
(D) diamagnetic, paramagnetic

Q.19   The value of 'x' in $[Cu(CO)_x]^+$ such that it obeys the 18 electron rule is

(A) 6   (B) 5   (C) 4   (D) 3

Q.20   The correct order of v_{NO} (cm^{-1}) in the following compounds is

(A) $NO^+ > NO > [NiCp(NO)] > [Cr(Cp)_2(NO)_4]$
(B) $[Cr(Cp)_2(NO)_4] > [NiCp(NO)] > NO^+ > NO$
(C) $NO^+ > [Cr(Cp)_2(NO)_4] > NO > [NiCp(NO)]$
(D) $[NiCp(NO)] > NO > [Cr(Cp)_2(NO)_4] > NO^+$

Q.21   The red color of ruby is due to

(A) d-d transition of Cr^{3+} ion in Cr_2O_3 lattice
(B) d-d transition of Cr^{3+} ion in Al_2O_3 lattice
(C) ligand to metal charge transfer transition
(D) metal to metal charge transfer transition

Q.22   The final products in the reaction of BF_3 with water are

(A) $B(OH)_3$ and OF_2
(B) H_3BO_3 and HBF_4
(C) B_2O_3 and HBF_4
(D) B_2H_6 and HF

Q.23   The correct order of bond angles in BF_3, NH_3, NF_3 and PH_3 is

(A) $BF_3 > NH_3 > NF_3 > PH_3$
(B) $PH_3 > BF_3 > NF_3 > NH_3$
(C) $BF_3 > PH_3 > NH_3 > NF_3$
(D) $NH_3 > NF_3 > BF_3 > PH_3$

Q.24   The maximum of a function Ae^{-ax^2} (A > 0; a > 0) is at $x =$

(A) 0   (B) $+\infty$
(C) $-\infty$ (D) $1/\sqrt{a}$

Q.25   At 298 K, 0.1 mol of ammonium acetate and 0.14 mol of acetic acid are dissolved in 1 L of water.
        The pH of the resulting solution is
        [Given: pK_a of acetic acid is 4.75]

(A) 4.9   (B) 4.6   (C) 4.3   (D) 2.3

Q.26   An electrochemical cell consists of two half-cell reactions
        $AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$
        $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
        The mass of copper (in grams) dissolved on passing 0.5 A current for 1 hour is
        [Given: atomic mass of Cu is 63.6; F = 96500 C mol^{-1}]

        (A) 0.88   (B) 1.18   (C) 0.29   (D) 0.59

Q.27   For a zero order reaction, the half-life depends on the initial concentration [C_0] of the reactant as

        (A) [C_0]   (B) [C_0]^0 (C) [C_0]$^{-1}$ (D) [C_0]$^{1/2}$

Q.28   The effective nuclear charge of helium atom is 1.7. The first ionization energy of helium atom in eV is

        (A) 13.6   (B) 23.1   (C) 39.3   (D) 27.2

Q.29   The relationship between the van der Waals 'b' coefficient of N_2 and O_2 is

        (A) $b(N_2) = b(O_2) = 0$ (B) $b(N_2) = b(O_2) \neq 0$
        (C) $b(N_2) > b(O_2)$ (D) $b(N_2) < b(O_2)$

Q.30   From the kinetic theory of gases, the ratio of most probable speed (C_{mp}) to root mean square speed (C_{rms}) is

        (A) $\sqrt{3}$ (B) $\sqrt{2}/\sqrt{3}$ (C) $\sqrt{3}/\sqrt{2}$ (D) $3/\sqrt{2}$

SECTION - B

MULTIPLE SELECT QUESTIONS (MSQ)

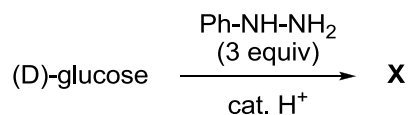# Q. 31 – Q. 40 carry two marks each.

Q.31   The correct statement(s) about the following species is(are)
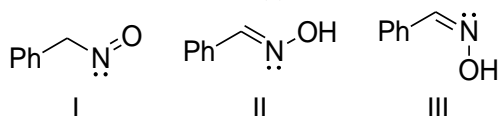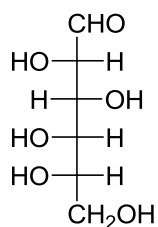

        (A) I and II are resonance structures
        (B) II and III are resonance structures
        (C) II and III are diastereomers
        (D) III is a tautomer of I

Q.32   Consider the following reaction:

$$\text{(D)-glucose} \xrightarrow[\text{cat. H}^+]{\substack{\text{Ph-NH-NH}_2 \\ \text{(3 equiv)}}} \textbf{X}$$

Among the following, the compound(s) whose osazone derivative(s) will have the same melting point as that of **X** is(are)

(A)
```
        CHO
  HO ——— H
   H ——— OH
  HO ——— H
  HO ——— H
       CH₂OH
```

(B)
```
       CH₂OH
        ═O
  HO ——— H
   H ——— OH
   H ——— OH
       CH₂OH
```

(C)
```
        CHO
  HO ——— H
  HO ——— H
   H ——— OH
   H ——— OH
       CH₂OH
```

(D)
```
        CHO
   H ——— OH
   H ——— OH
  HO ——— H
   H ——— OH
       CH₂OH
```
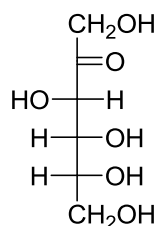
Q.33   The appropriate reagents required for carrying out the following transformation are
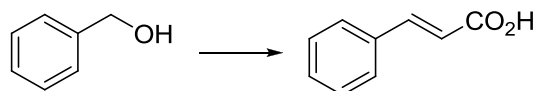
(A) (i) PCC, CH₂Cl₂; (ii) Ph₃P=CHCO₂Et; (iii) aq. NaOH, heat, then acidify
(B) (i) CrO₃, H₂SO₄, aq. acetone (ii) Ac₂O, NaOAc
(C) (i) MnO₂; (ii) CH₂(CO₂H)₂, piperidine, pyridine
(D) (i) PCC, CH₂Cl₂; (ii) BrCH₂CO₂C(CH₃)₃, Zn (iii) H₃O⁺, heat

Q.34   The appropriate reagents required for carrying out the following transformation are

(A) (i) succinic anhydride, AlCl₃; (ii) Zn/Hg, HCl; (iii) polyphosphoric acid
(B) (i) maleic anhydride, AlCl₃; (ii) H₂N-NH₂, KOH; (iii) H₂SO₄
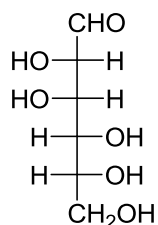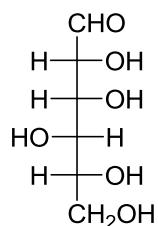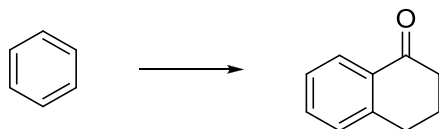(C) (i) succinic anhydride, FeCl₃; (ii) LiAlH₄; (iii) H₂SO₄
(D) (i) phthalic anhydride, F₃B·OEt₂; (ii) HS(CH₂)₂SH, H⁺; (iii) Raney Ni; (iv) polyphosphoric acid

Q.35   The protein(s) that belong to the class of blue copper proteins is(are)

(A) ceruloplasmin
(B) superoxide dismutase
(C) hemocyanin
(D) azurin

Q.36   The ion(s) that exhibit only charge transfer bands in the absorption spectra (UV-visible region) is(are)

(A) $[Cr(C_2O_4)_3]^{3-}$ (B) $[CrO_4]^{2-}$
(C) $[ReO_4]^-$ (D) $[NiO_2]^{2-}$

Q.37   The type(s) of interaction(s) that hold layers of graphite together is(are)

(A) π-π stacking   (B) van der Waals
(C) hydrogen bonding   (D) Coulombic

Q.38   TRUE statement(s) about Langmuir isotherm is(are)

(A) valid for monolayer coverage
(B) all adsorption sites are equivalent
(C) there is dynamic equilibrium between free gas and adsorbed gas
(D) adsorption probability is independent of occupancy at the neighboring sites

Q.39   The $3p_z$ orbital has

(A) one radial node   (B) two radial nodes
(C) one angular node   (D) two angular nodes

Q.40   The diatomic molecule(s) that has(have) two π-type bonds is(are)

(A) B₂   (B) C₂   (C) N₂   (D) O₂

SECTION – C

NUMERICAL ANSWER TYPE (NAT)

Q. 41 – Q. 50 carry one mark each.

Q.41   Among the following, the number of molecules that are aromatic is __.
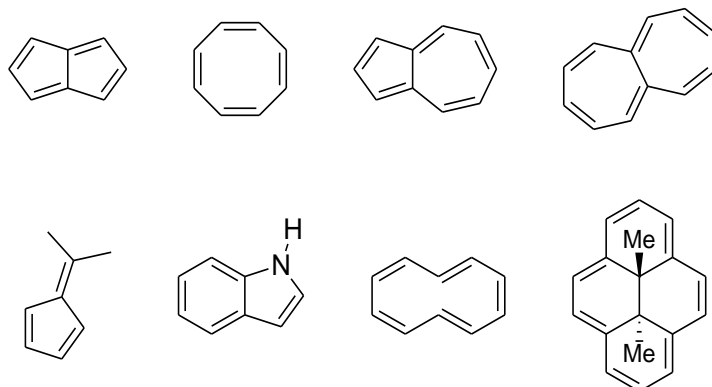
Q.42   The number of all possible isomers for the molecular formula C_6H_{14} is __.

Q.43   Hydrolysis of 15.45 g of benzonitrile produced 10.98 g of benzoic acid. The percentage yield of acid formed is __.

Q.44   Acetic acid content in commercial vinegar was analyzed by titrating against 1.5 M NaOH solution. A 20 mL vinegar sample required 18 mL of titrant to give endpoint. The concentration of acetic acid in the vinegar (in mol L^{-1}) is __.

Q.45   The bond order of Be_2 molecule is __.

Q.46   The number of P–H bonds in hypophosphorus acid is __.

Q.47   The isotope $^{214}_{84}Po$ undergoes one alpha and one beta particle emission sequentially to form an isotope "X". The number of neutrons in "X" is __.

Q.48   In a diffraction experiment with X-rays of wavelength 1.54 Å, a diffraction line corresponding to $2\theta = 20.8°$ is observed. The inter-planar separation in Å is __.

Q.49   The potential energy of interaction between two ions in an ionic compound is given by $U = 1389.4 \left[\dfrac{Z_1 Z_2}{r/Å} \right]$ kJ mol^{-1}. Assuming that $CaCl_2$ is linear molecule of length 5.6 Å, the potential energy for $CaCl_2$ molecule in kJ mol^{-1} is __.

Q.50   The enthalpy of formation for $CH_4(g)$, $C(g)$ and $H(g)$ are –75, 717 and 218 kJ mol^{-1}, respectively. The enthalpy of the C–H bond in kJ mol^{-1} is __.

Q. 51 – Q. 60 carry two marks each.

Q.51   Specific rotation of the (R)-enantiomer of a chiral compound is 48. The specific rotation of a sample of this compound which contains 25% of (S)-enantiomer is ____.

Q.52   Among the following, the number of compounds, which can participate as '**diene**' component in a Diels-Alder reaction is __.
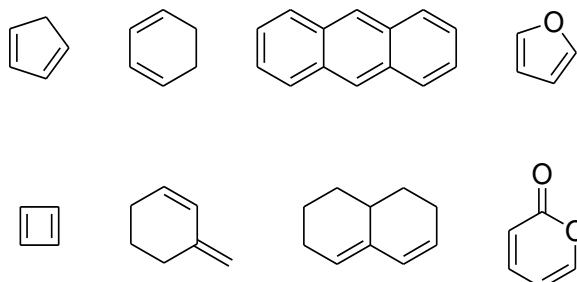
Q.53   Among the following, the number of molecules that possess C_2 axis of symmetry is __.

BF_3 $CHCl_3$ 2,5-dimethylthiophene
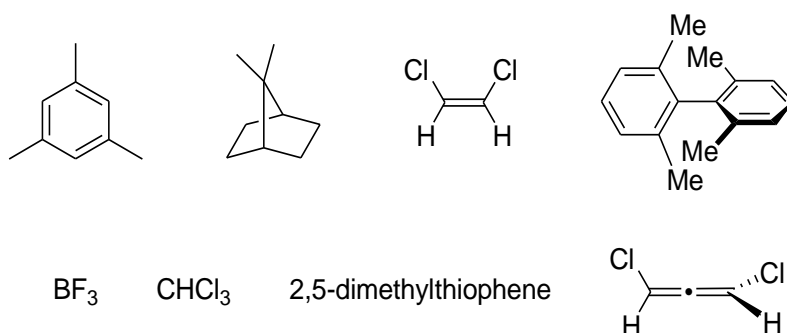
Q.54   Effective nuclear charge for 3d electron in vanadium (atomic number = 23) according to Slater's rule is __.

Q.55   The total number of isomers possible for the molecule $[Co(NH_3)_4Cl(NO_2)]^+$ is __.

Q.56   The bond angle in PBr_3 is 101°. The percent 's' character of the central atom is __.

Q.57 $Cu(s) + 4 H^+(aq) + 2NO_3^-(aq) \rightarrow 2NO_2(g) + Cu^{2+}(aq) + 2H_2O(l)$
In the above reaction at 1 atm and 298 K, if 6.36 g of copper is used. Assuming ideal gas behavior, the volume of NO_2 produced in liters is __.
[Given: atomic mass of Cu is 63.6; R = 0.0821 L atm K^{-1} mol^{-1}]

Q.58   The ΔH^o for the reaction $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ at 400 K in kJ mol^{-1} is __.
Given at 298 K:

	ΔH_f^o kJ mol^{-1}	C_p^o J mol^{-1} K^{-1}
O_2	0	29.4
CO	−110	29.1
CO_2	−394	37.1

Q.59   The rate constants for a reaction at 300 and 350 K are 8 and 160 L mol^{-1} s^{-1}, respectively. The activation energy of the reaction in kJ mol^{-1} is __.
[Given R = 8.314 J K^{-1} mol^{-1}]

Q.60   A 10 L flask containing 10.8 g of N_2O_5 is heated to 373 K, which leads to its decomposition according to the equation 2 $N_2O_5(g) \rightarrow$ 4 $NO_2(g)$ + $O_2(g)$. If the final pressure in the flask is 0.5 atm, then the partial pressure of $O_2(g)$ in atm is __.
[Given R = 0.0821 L atm K^{-1} mol^{-1}]

END OF THE QUESTION PAPER