**[Time : 3Hours]** **[Total marks :100]**

**N.B. : (1) All questions are compulsory.**
**(2) Figures to the right indicate full marks.**
**(3) Use of logarithmic table/non-programmable calculator is allowed**.

**Physical Constants:**

N = 6.022 $\times 10^{23}$ c = 3.0 $\times 10^{8}$ m/s

R = 8.314 J/K mol h = 6.626 $\times 10^{-34}$ Js

$\frac{2.303\ RT}{nF} = \frac{0.0592}{n}$ at 298K

**1.** Attempt **any four** of the following**:**

**A.** Show that the separation between successive lines in the rotational spectrum of a diatomic molecule are always equally spaced. **5**

**B.** Show that in an anharmonic oscillator the wave number of fundamental and first overtone are in the ratio of 1:2 **5**

**C.** Write a short note on the Rule of Mutual exclusion. **5**

**D.** Distinguish between Stokes and Antistokes line. **5**

**E.** The equilibrium, internuclear distance in NO molecule is $1.15A^0$.Calculate the energy of the first rotational energy level in the molecule(N=14,O=16) **5**

**F.** A substance was exposed to radiation of wavelength 400 nm. The first Stokes line appeared at 500 nm. Calculate the Raman shift and energy change for the molecule. **5**

**2.** Attempt **any four** of the following.

**A.** Derive thermodynamic relationship for osmotic pressure $\pi$ = CRT **5**

**B.** Describe Rast method to determine the depression in freezing point .. **5**

**C.** i) Explain how relative lowering of vapour pressure is related to the mole fraction of solute. **5**
ii) Give any two applications of reverse osmosis

**D.** Calculate the boiling point of a solution containing 1.04 g of anthracene (M=176) in 70 g chloroform. The boiling point of pure chloroform is 334.2 K and its ebullioscopic constant is 3.85 K .Kg.mol $^{-1}$ **5**

**E.** Explain Lindemann's unimolecular theory of reaction rate. **5**

**F.** Explain flash photolysis method to study ultra-fast reactions. **5**

**3.** Attempt **any four** of the following**:**

**A.** Describe the construction and working of G.M. counter. **5**

**B.** What are Phosphors? What are conditions for ideal phosphors and explain its classification. **5**

**C.** What are tracers? Explain it's application in establishing mechanism of Ester hydrolysis and Photosynthesis reaction. **5**

**D.** What is nuclear transmutation? Explain it with two nuclear reactions. **5**



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**E.** For $^{27}Al$ ($n$, $\gamma$) reaction Q value is 7.222 MeV. If the mass of $^{27}Al$ and the neutron is 26.990080 a.m.u. and 1.0089830 a.m.u. respectively. Calculate the mass of the product nucleus? **5**

**F.** What is nuclear fission? Explain the factors controlling fission process. **5**

**4.** Attempt **any four** of the following**:**

**A.** Explain the different types of absorption isotherms. **5**

**B.** What is electro-osmosis ? How is it studied experimentally? **5**

**C.** Absorption of nitrogen on an iron catalyst was determined at 78 K. The BET plot of the data yielded the value of $V_m$ is $8.40 \times 10^{-3}$ $dm^3$ per gram of adsorbent, when reduced to NTP. Assuming that the gas molecules adsorbed in the first layer are closely packed. Calculate the surface area of adsorbent. Molecular area of nitrogen is $0.16 \times 10^{-18}$ $m^2$. **5**

**D.** Explain the terms --- **5**

i) Surfactants

ii) Emulsifier

**E.** Explain the postulates of Langmuir adsorption isotherms. **5**

**F.** Write short note on Donnan membrane equilibrium. **5**

**5. Answer the following:**

**A.** Select whether the following statements are **true** or **false (Any five)** **5**

**a.** The selection rule for the rotational spectrum in a diatomic molecule is $\triangle J = +2$

**b.** Molecules exhibit electronic transitions in IR region

**c.** Benzene has 30 modes of vibrations.

**d.** In Stokes scattering the frequency of the scattered radiation is less than that of the incident radiation.

**e.** For water molecule symmetric stretching vibrational modes are IR Active.

**f.** The isotopic abundance can be determined by intensity of spectra lines.

**g.** For Stokes line, Raman shift is positive.

**h.** The dipole moment of $BF_3$ molecule is zero.

**B.** Fill in the blank with appropriate words **(Any five)** **5**

**a.** Relation between ebullioscopic constant, molecular weight and elevation of boiling point is –

a) $\Delta T_b = K_b \times m$ b) $\Delta T_f = K_f \times m$ c) $\Delta T_b = K_b / m$ d) $\Delta T_b = T - T_0$

**b.** In --------method to determine lowering of vapour pressure, $CaCl_2$ is used as adsorbent.

a) Rast b) Beckmann c) Dynamic d) Berkeley

**c.** For a solute undergoing dissociation the Vant Hoff's factor "i "has value----

a) i=1 b) i>1 c) i<1 d) i=0

**d.** Which if the following is not colligative property?

a) Vapour pressure b) Elevation of boiling point

c) Depression in freezing point d)Lowering of vapour pressure



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**e.** Reaction of heamoglobin with $O_2$ and $CO_2$ is example of----------
a)Fast reaction b) slow reaction c) ultra slow reaction d) moderate reaction

**f.** The number of collisions per second per cubic centimeter in any gas given by kinetic theory of gases as ----------

a) $Z= 2\ n^2\ \sigma^2 \sqrt{\frac{\pi RT}{M}}$ b) $Z= n^2\ \sigma^2 \sqrt{\frac{\pi RT}{M}}$

c) $k= Z\ .-e^{-Ea/RT}$ d) ) $k = 2\ Z\ .-e^{-Ea/RT}$

**g.** In Stop flow method mixing of reactants occurs for time of----seconds
a) $10^{-3}$ b) $10^{-4}$ c) $10^{-5}$ d) $10^{-6}$

**C.** Select and write the appropriate answer. **(Any five )** **5**

**a.** Average life of radioactive nuclei is ----------times its half-life period
a) 1/0.693 b) 0.693 c) 1.14 d) 8.314

**b.** If 10 grams and 100 grams radioactive samples of same radioactive element is taken. Which of the following is correct about its half-life?
a) 10 grams will have more half-life b)100 grams will have more half life
c) Both will have same half-life c) depend upon temperature of the sample

**c.** 1 Curie is equal to ---------- dps.
a) 3.7 b) $3.7 \times 10^{10}$ c) $3.14 \times 10^{6}$ d) $3.7 \times 10^{4}$

**d.** Which of the following isotopes is not a radioisotope?
a) $^{14}C$ b) $^{18}O$ c) $^{2}H$ d) $^{14}N$

**e.** Which one of the following processes results in an increase in the atomic number?
a) gamma emission b) positron emission c) beta emission d) alpha emission

**f.** Nuclear detectors don't measure ------- of radiation
a) Energy b) Count c) Type d) Source

**g.** Using Carbon dating, age of which of the following sample cannot be determined
a) Human bodies b) Teakwood c) Iron rod d) Coal sample

**h.** If $\Delta m$ is 0.1 amu, Q value is -----
a) 93.1MeV b) 1.966MeV c) 200.6MeV d) 931x $10^4$MeV

**D.** **Match the column: (Any five )** **5**

| | | | |
|---|---|---|---|
| **a.** | Adsorbent | i. | Gum arabic |
| **b.** | Electrophoresis | ii. | Nickel |
| **c.** | Gel | iii. | Retards the rate of reaction |
| **d.** | Milk | iv | O/W emulsion |
| **e.** | Lyophobic sol | v. | Helmholtz model |
| **f.** | Electric double layer | vi. | Micelle |
| **g.** | Inhibitor | vii. | The migration of ion under the influence of applied electric field |
| | | viii. | Silica gel |
| | | ix. | Sterns model |
| | | x. | Cold cream |

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**[Time: 3 Hours]** **[Marks: 100]**

1. **All questions are compulsory.**
2. **All questions carry equal marks.**
3. **Figures to the right indicate full marks.**
4. **Use of log table/ non-programmable calculator is allowed.**

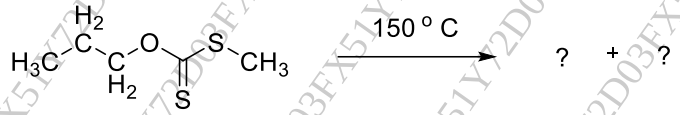
**Q.1** **Attempt any four of the following.** **20**

**A)** a) Discuss the $B_{AC}2$ mechanism of hydrolysis of esters. 3

b) Explain the Chugaev reaction with a suitable example. 2

**B)** a) Discuss the stereochemistry of NGP with a suitable example. 3

b) Complete the following reaction and name the reaction involved. 2




**C)** Distinguish between: 5

i) Nucleophilicity and basicity

ii) Transition state and Reaction intermediate

**D)** What are pericyclic reactions? List how they are classified? Explain electrocyclic reactions with a suitable example. 5

**E)** With the help of a well labelled Jablonski diagram explain any three relaxation (decay) processes which an electronically excited molecule undergoes to loose energy. 5

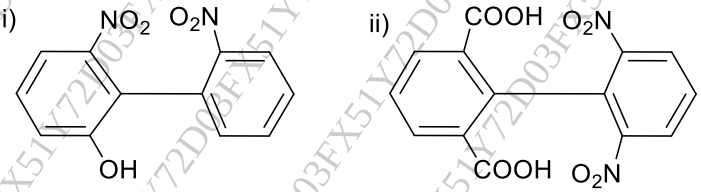
**F)** a) Explain the Norrish type-I reaction at room temperature. 3

b) Distinguish between thermal and photochemical reactions. 2

**Q.2** **Attempt any four of the following.** **20**

**A)** Write a note on stereochemistry of allenes. 5

**B)** a) State whether the following compounds are optically active or optically inactive. Justify your answer. 3




b) Define centre of symmetry with an example. 2

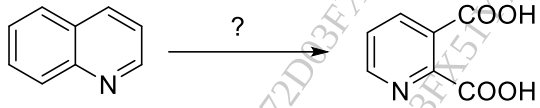
**C)** Give the Skraup synthesis for the preparation of quinoline. Write the reaction of quinoline with nitrating mixture. 5

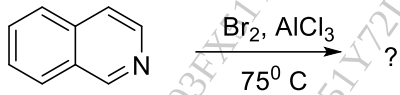
**D)** Convert pyridine to pyridine-N-oxide. Draw its resonating structures. What is the action of pyridine-N-oxide on: 1) $SO_2Cl_2$ and 2) $NaNH_2$ in Liq.$NH_3$ 5

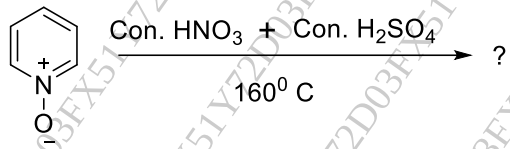


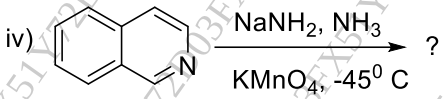
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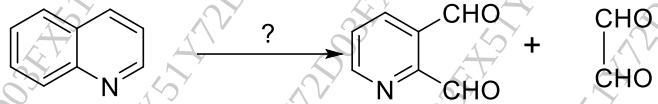
**E)** Complete the following reactions: - 5

i) 


ii) 


iii) 


iv) 


v) 

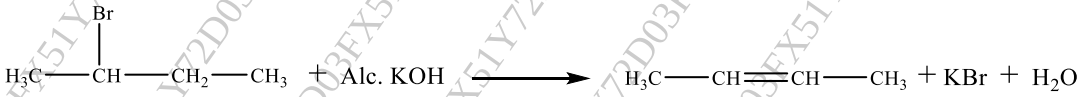

**F)** What are Agrochemicals? How are they classified? Write the synthesis of Indole-3-acetic acid. 5

**Q.3.** **Attempt any four of the following.** **20**

**A)** a) Explain chemoselective reaction with a suitable example. 3
b) How is the theoretical yield calculated? 2

**B)** a) Define multicomponent synthesis? Write the Biginelli pyrimidone synthesis. 3
b) Mention any two criteria for an ideal organic synthesis. 2

**C)** a) Explain how adipic acid is prepared from D-glucose using green chemical reactions. 3
b) Calculate the percentage atom economy of the following reaction? 2




(Atomic Weights: C=12, H=1, O=16, K=39, Br=80)

**D)** Give the synthesis of the following compounds using a suitable starting material. 5

a) o-nitroaniline and p-nitroaniline.

b) Tert-butyl alcohol using a suitable Grignard reagent.

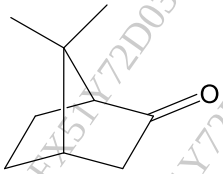
**E)** Write the structural formula for each of the following compounds: 5

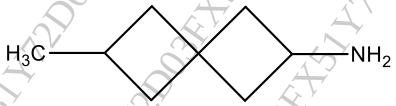
1. Bicyclo [3.3.0] octane.
2. Spiro [2.4] hept-4, 6-diene.
3. 6, 6'-difluorodiphenyl-2, 2'-dicarboxylic acid.
4. 1-chloro-1, 2-pentadiene.
5. Quinoline-3-carboxaldehyde.

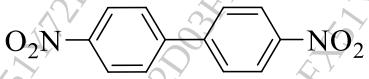


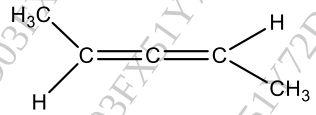
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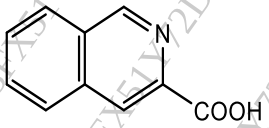
**F)** Give the IUPAC names for each of the following compounds. 5

1. 


2. 


3. 


4. 


5. 


**Q.4** **Attempt any four of the following.** **20**

**A)** a) Give the synthesis of citral from methyl heptenone. 3
b) Give analytical evidence to prove that both the nitrogen atoms in nicotine are tertiary. 2

**B)** a) Give the reaction for Hofmann exhaustive methylation and degradation of pyrrole. 3
b) How will you prove that the side chain in nicotine is a pyrrolidine nucleus? 2

**C)** a) Give the Ott's synthesis of Adrenaline. 3
b) Give any one analytical evidence to prove that citral is an α, β-unsaturated aldehyde. 2

**D)** a) Give the synthesis of nicotine from nicotinic acid. 3
b) Give analytical evidence to prove that Citral has a carbonyl group. 2

**E)** a) Explain chromophore-chromophore interaction with a suitable example. 3
b) State the effect of solvent on λmax values with a suitable example. 2

**F)** a) Explain the fragmentation of the 2- methyl pentane. 3
b) What is molecular ion peak? Give its importance. 2

**Q.5** **A)** **Select the correct option and complete the following statements: (any five)** **5**

a) Cope elimination is observed in……
i) N-substituted amide ii) Aromatic ketoxime
iii) Tertiary amine oxide iv) N-substituted amine

b) All nucleophiles are……..
i) Lewis acids ii) Lewis bases
iii) Neutral iv) Electron pair acceptor

c) In NGP the stereochemistry of product is…….
i) Changed ii) Retained
iii) Inverted iv) None of the above

d) ……..is a thermodynamic term.
i) Electrophilicity ii) Nucleophilicity
iii) Basicity iv) Transition state

e) Which of the reaction is a thermal decomposition of xanthate esters?
i) Cope ii) Chugaev
iii) Pyrolysis of acetates iv) Favorski



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f) Benzophenone reacts with isopropyl alcohol in presence of light to form benzpinacol is an example of……..

i) Photoreduction ii) Photooxidation
iii) Photosensitization iv) Isomerization

g) In which of the following reaction carbon monoxide is eliminated as a by-product.

i) Norrish type-I at room temperature ii) Norrish type-I at elevated temperature
iii) Norrish type-II iv) Di-pi methane rearrangement

h) What does ISC stands for?

i) Internal System Crossing ii) Inter-System Crossing
iii) Intra-System Crossing iv) Internal Soft Crossing

**Q.5 B) State whether true or false: (Any five)** **5**

a) Cumulenes having odd number of double bonds shows geometrical isomerism.
b) Trans-1,3-Dimethyl cyclobutane is achiral.
c) DDT is an organic insecticide.
d) Active component of neem oil is Azadirachtin.
e) In quinoline electrophilic substitution takes place at 2- position.
f) Isoquinoline is also known as 2-azanaphthalene.
g) The dipole moment of pyridine N-Oxide is more than pyridine.

**Q.5 C) Fill in the blanks with correct alternatives given in the bracket: (Any five)** **5**

(linear, green catalyst, super critical$CO_2$, covalent bond, ultra sound, larger, smaller, Cumulene , dimethyl carbonate, convergent.)

a) Synthesis of benadryl is an example of ---------- synthesis.
b) Sonication is the term used for the reaction carried out using ----------
c) The green reagent used for the selective methylation of active methylene compounds is ----------
d) In biphenyl two phenyl rings are bonded by a single ----------
e) In 6-methoxy spiro [3.4] octane the substitution is on the ---------- ring
f) Butatriene is classified as ----------
g) Enzymes are examples of ----------
h) Dry cleaning of the clothes can be carried out using ----------

**Q.5 D) Match the columns: (Any five)** **5**

| | Column A | | Column B |
|---|---|---|---|
| a) | α-Pinene | i | -OH group |
| b) | Atropine | ii | 2-methyl butadiene |
| c) | Hormones | iii | Belladona alkaloid |
| d) | Citral-a | iv | Secretion of ductless glands |
| e) | Isoprene | v | Monoterpenoids |
| f) | Base peak | vi | Geranial |
| g) | Auxochrome | vii | Neral |
| | | viii | >C=O group |
| | | ix | Highest peak |

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**[Time: 3 Hours]** **[Total marks: 100]**

**N.B.: (1) All questions are compulsory.**
**(2) Figures to the right indicate full marks.**
**(3) Use of logarithmic table/non-programmable calculator is allowed.**

**1.** Attempt **any four** of the following**:**

**A.** What is symmetry element? Discuss the following symmetry elements with one example each **5**
i) Mirror plane
ii) Centre of symmetry

**B.** Discuss the point group assigned to following molecules **5**
i) $H_2$
ii) trans- dichloro ethylene

**C.** Draw molecular orbital diagram for CO molecule. Discuss its bond order and magnetic behaviour. **5**

**D.** Discuss triangular structure of tri-hydrogen ion on the basis of Molecular orbital theory. **5**

**E.** Explain formation of $H_2O$ molecule with the help of molecular orbital diagram. Discuss its magnetic behaviour. **5**

**F.** Discuss on the basis of Walsh diagram, correlation between bond angles and molecular orbitals with suitable example**.** **5**

**2.** Attempt **any four** of the following**:**

**A.** With the help of diagram, define and explain unit cell and lattice parameters. **5**

**B.** Define coordination number. Calculate number of atoms per unit cell (n) for, **5**
a) body centered cube (bcc),
b) Simple cube (sc).

**C.** What is atomic packing factor? Show that the packing factor for fcc lattice is 74%. **5**

**D.** With the help of diagram, explain the superconducting transition temperature (Tc). **5**

**E.** Differentiate between Schottky and Frenkel defect in ionic solid. **5**

**F.** Write a note on conventional superconductors. **5**

**3.** Attempt **any four** of the following**:**

**A.** What are f block elements? Give the ideal and observed electronic configuration of actinides. **5**

**B.** Write a short note on the ability of the lanthanide elements to form complexes. **5**

**C.** Explain the extraction process of lanthanides with respect to **5**
i) concentration ii) cracking of the minerals

**D.** On the basis of electronic configuration of lanthanides, explain the colour of lanthanide ions in solutions of their compounds. **5**

**E.** Give the commercial and nuclear applications for lanthanide. **5**



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**F.** i) Explain the similarities between zirconium and hafnium. **3**
ii) Explain any two minerals of lanthanides. **2**

**4.** Attempt **any four** of the following**:**

**A.** Explain protic and aprotic solvents with suitable examples. **5**

**B.** Write a note on non-aqueous solvents, give any two balance equations for each of the following reactions of liquid ammonia, **5**
a) Acid-base reactions
b) Redox reactions

**C.** Discuss allotropic forms of sulphur atom. **5**

**D.** Discuss the use of Platinised asbestos and vanadium pentoxide catalyst in the oxidation of sulphur dioxide to sulphur trioxide. **5**

**E.** Explain the bonding and structure of perchlorate ion ($ClO_4^-$) based on VSEPR theory. **5**

**F.** Discuss bonding and structure of $XY_3$ type interhalogen compound on the basis of VSEPR theory with suitable example. **5**

**5. Answer the following:**

**A.** **Select the correct option and complete the following statements: (any five)** **5**

**a.** Symmetry elements and _____are closely interrelated.
a) symmetry units b) symmetry operations c) symmetry components d) symmetry components

**b.** Improper rotational axis is denoted by symbol _____
a) Cn b) i c) Sn d) E

**c.** The axis with the _____order of symmetry operations is called subsidiary axis.
a)lowest b) highest c) big d) large

**d.** In _____molecule the electron distribution is symmetrical.
a) polyatomic b) monoatomic c) heteronuclear diatomic d) homonuclear diatomic

**e.** Atomic orbitals which overlap along the internuclear axis gives _____molecular orbitals.
a) σ b) dπ- p π c) dπ- dπ d) p π- p π

**f.** HCl molecule is _____
a) diamagnetic b) paramagnetic c) ferromagnetic d) nonmagnetic

**g.** In triangular $H_3^+$ ion, doubly degenerate orbitals are labelled as _____
a) a b) b c) e d) t

**h.** $BeH_2$ molecule show _____structure.
a)trigonal b) linear c) tetrahedral d) square planar

**B.** State whether true or false: (any five) **5**

**a.** Niobium tin ($Nb_3Sn$) is conventional superconductor.

**b.** Co-ordination number for body centered cube is 06.

**c.** Volume of unit cell in simple cube (sc) is $4/3\ \pi r^3$.



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**d.** AB AB ……types of arrangement is called hexagonal close packing (hcp).
**e.** When atom is missing from its lattice site and occupy interstitial sites, it results in Frenkel defect.
**f.** Fullerene is an allotrope of carbon.
**g.** In cubic crystal system a = b ≠ c and $\alpha=\beta=\gamma=90^0$.
h Magnetic permeability below Tc in Superconductor is zero.

**C.** **Fill in the blanks with correct alternatives given in the bracket (any five)** **5**

**(**$Lu^{3+}$, spin and orbital moment, group 3 and 6 period, hydrolysis, 3+, Pt, Gadolinite, cracking)

**a.** Magnetic properties of lanthanides are due to the contribution of .....
**b.** Bis(2-ethylhexyl) phosphoric acid is less susceptible to ..... as compared to TBP.
**c.** ..... is a colourless lanthanide ions.
**d.** The process in which concentrated minerals are subjected to chemical treatment is known as ……..
**e.** ..... is less reactive because of lanthanide contraction.
**f.** . ..... is a silicate of lanthanides.
**g.** Position of lanthanide elements in the periodic table is .....
**h** The common oxidation state of lanthanides is ….

**D.** **Match the column: (Any five )** **5**

| Column A | | Column B |
|---|---|---|
| a. Ionizing solvents | i. | m + n |
| b. $ClO_2^-$ ion | ii. | Oxygen family |
| c. Contact process | iii. | $[Kr]4d^{10}5s^25p^5$ |
| d. Steric number of ABmEn molecule | iv. | $IF_7$ |
| e. Group 16 elements | v. | Angular Geometry |
| f. Electronic configuration of Iodine | vi. | Manufacturing of $H_2SO_4$ |
| g. $XY_7$ interhalogen | vii. | Nitrogen family |
| h. Rhombic sulphur | viii. | Polar |
| | ix. | Crown shape |
| | x. | $IF_5$ |

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**(Time: 3 Hours)** **Total Marks: 100**

**N.B.: (1) All questions are compulsory.**
**(2) Figures to the right indicate full marks.**
**(3) Use of log table/ non-programmable calculator is allowed.**

**Q.1** **Attempt any four of the following.** **20**

**A)** Define the term quality. Explain the term quality control and quality assurance.

**B)** What are the functions of a QC lab? What are the characteristics of LR, AR and GR grade reagents?

**C)** What is ppm? How many grams of KCl should be weighed to prepare 2.0 L of 25 ppm solution of $K^+$.

**D)** An aqueous solution of $H_2SO_4$ (mol.wt.=98) contains 10.78 g of acid per $dm^3$ of the solution. The density of acid solution is 1.123 g/ml Calculate i) molarity, ii) normality and iii) mole fraction of the acid in the solution.

**E)** What are the difficulties encountered in sampling of solid? Explain the term bulk ratio and size to weight ratio.

**F)** Write a note on –
i) sampling of Homogeneous liquids.
ii) Ambient sampling

**Q.2** **Attempt any four of the following.** **20**

**A)** Calculate the potential of 20 ml of 0.1M Fe(II) with 0.1M $KMnO_4$ at i) equivalence point ii) beyond the equivalence point of the titration.

**B)** Explain the conditions to be fulfilled by substance to be used as a metal ion indicator.

**C)** Justify the statement - EDTA is a good titrant for estimation of metal cations.

**D)** Explain back titration and alkalimetric titration with respect to EDTA titration.

**E)** Draw a titration curve of 20 ml of 0.1M Fe(II) with 0.1M Ce(IV) solution.

**F)** Discuss any two methods to increase the selectivity of EDTA.

**Q.3.** **Attempt any four of the following.** **20**

**A)** Discuss the principle of Atomic Absorption Spectroscopy. Explain the role of rotating chopper in AAS.

**B)** Name the burners used in FES. Discuss any one burner.

**C)** With the help of Jablonski diagram explain phosphorescence and fluorescence.

**D)** Explain the applications of fluorescence spectroscopy.

**E)** Discuss the working of turbidimeter with the help a labelled diagram.

**F)** Explain: - 1) Turbidimetric titrations 2) Phase titrations



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**Q.4** **Attempt any four of the following.** **20**

**A)** Explain the different steps involved in the process of solid phase extraction.

**B)** What is meant by sequestering? Discuss any one factors affecting solvent extraction.

**C)** Give the comparison between solvent extraction and solid phase extraction.

**D)** Give the applications of HPLC.

**E)** What is meant by HPLC? Discuss reciprocating pump.

**F)** Name the steps involved in HPTLC. Write a note on any one detector used in HPTLC.

**Q.5 A)** **Select the correct option and complete the following statements: (any five)** **05**

**a)** Quality control is primarily focused on _____ inspection and testing.
i) product ii) facilities iii) process

**b)** _____ grade reagents are suitable for general laboratory use and have acceptable purity for most applications.
i) AR ii) LR iii) GR

**c)** 1 $\mu g\ L^{-1}\ is$ _____.
i) 1 ppm ii) 1 ppb iii) 1 ppt

**d)** Molarity and mole fraction are concentration units which are temperature _____.
i) dependent ii) sensitive iii) independent

**e)** Coning and quartering is method of _____.
i) reduction of sample size ii) increase of sample size iii) reduction of particle size

**f)** In sampling of solid bulk ratio should be as _____ as possible
i) small ii) minimum iii) large

**g)** For sampling of flowing liquid, a _____ sampler is used
i) auger ii) multiple tube iii) sample thief

**h)** The long form of CRM is _____
i) certificate reference material ii) certified reference material iii) certified reference matrix

**Q.5 B)** **State whether true or false: (any five)** **05**

**a)** $Ca^{2+}$ ions are titrated by replacement EDTA titrations.

**b)** Metal ion indicators are also ligands.

**c)** In complexometric titration, at the end point precipitate is observed.

**d)** The M-EDTA complexes are water insoluble.

**e)** In EDTA titrations, complexation occurs in single step.

**f)** EDTA titrations are carried out at low pH.

**g)** Titration of Fe (II) with $KMNO_4$ number of electrons involved are 5.



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**Q.5 C) Fill in the blanks with correct alternatives given in the bracket: (any five)** **05**

(alkali & alkali earth metals, UV, phosphorescence, turbidimeter, toxic metals, hollow cathode lamp, low, conjugated double, AAS, fluorescence)

**a)** _____ studies are done at low temperature (-196$^0$C).
**b)** Flame photometry is extensively used for the estimation of ____.
**c)** In AAS the source of radiation is _____.
**d)** Instant emission of absorbed radiation is called _____.
**e)** Absorption of radiation is independent of flame temperature in _____.
**f)** The instrument used to measure the intensity of transmitted light is known as _____.
**g)** Molecules having _____ bond are suitable for fluorescence and phosphorescence.
**h)** The function of secondary filter in fluorimetry is to absorb _____ light radiation.

**Q.5 D) Match the columns: (any five)** **05**

| Column A | | Column B |
|---|---|---|
| **a)** Counter current extraction | **(i)** | Double beam densitometer |
| **b)** UV detector | **(ii)** | Solid phase extraction |
| **c)** HPTLC | **(iii)** | Extraction in organic solvent |
| **d)** Silica powder | **(iv)** | Uranium |
| **e)** Fluorometric detector | **(v)** | Aluminium |
| **f)** Neutral chelate | **(vi)** | Craig |
| **g)** 8-Hydroxyquinoline | **(vii)** | Gradient elution |
| | **(viii)** | Mercury vapour lamp |
| | **(ix)** | HPLC |

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Duration:[2½Hours] **[Total Marks: 75]**

N.B. 1) All questions are compulsory.
2) Figures to the right indicate full marks.

1. (a) Attempt any **ONE** question:
   i. Define a self complementary graph. If $G$ is self complementary graph of order $p$, show that $G$ is connected and $p \equiv 0$ or $1(\mod 4)$. (8)
   ii. Prove that a non-increasing sequence $S : d_1, d_2, \cdots, d_n$ $(n \geqslant 2)$ of non-negative integers where $d_1 \geqslant 1$ is graphical if and only if the sequence $S_1 : d_2 - 1, d_3 - 1, \cdots, d_{d_1+1} - 1, d_{d_1+2}, \cdots, d_n$ is graphical. (8)

   (b) Attempt any **TWO** questions:
   i. Show that in a party of 6 or more people, either there are 3 persons who know one another or there are three persons who do not know one another. (6)
   ii. Show that a graph $G$ is disconnected if and only if its vertex set $V$ can be partitioned into two subsets $V_1$ and $V_2$ such that there exists no edge in $G$ whose one end vertex is in the subset $V_1$ and the other in the subset $V_2$. (6)
   iii. Find three nonisomorphic graphs with degree sequence 3,3,2,2,2,2. (6)

2. (a) Attempt any **ONE** question:
   i. State and prove Cayley's formula for spanning trees. (8)
   ii. Define Cut Vertex in a simple graph $G$. Show that vertex $v$ is a cut vertex if and only if there exists two vertices $x$ and $y$ such that $v$ is on every $x - y$ path in $G$. (8)

   (b) Attempt any **TWO** questions:
   i. Show that every two vertices of a tree are connected by a unique path. (6)
   ii. Let $\tau(G)$ denote the number of spanning trees of a graph $G$. (6)
   Use this $\tau(G) = \tau(G - e) + \tau(G.e)$ recurrence formula to find $\tau(K_4 - e)$.
   iii. Describe Breath First Search (BFS) algorithm. Use BFS to find spanning tree for the wheel graph $W_n$ starting at the vertex of degree $n$ where $n$ is integer with $n \geq 3$. (6)

3. (a) Attempt any **ONE** question:
   i. If $G$ is graph on $p$ vertices with $p \geq 3$ and $\delta(G) \geq \frac{P}{2}$ where $\delta(G)$ denotes the minimum degree of $G$ then show that $G$ contains a Hamiltonian cycle. (8)
   ii. Prove that a connected graph G contains Eulerian trail if and only if exactly two vertices of G have odd degree. (8)

   (b) Attempt any **TWO** questions:
   i. Define closure of a graph $C(G)$ and show that a simple graph is Hamiltonian if and only if its closure is Hamiltonian. (6)
   ii. Prove that the cube graph $Q_k$ is bipartite $k-$regular graph with $2^k$ vertices. (6)



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iii. If $G$ is Hamiltonian graph then for every nonempty proper subset $S$ of $V(G)$, prove that $\omega(G-S) \leq |S|$. Is converse true? Justify. (6)

4. Attempt any **THREE** questions:

(a) If a graph $G$ contains a $u-v$ walk of length $l$, then show that $G$ contains a $u-v$ path of length at most $l$. (5)

(b) Let $G$ be a simple graph and $\delta(G) \geq 2$, then show that there exists a cycle of length at least $\delta(G)+1$ in $G$. (5)

(c) Define a binary tree. Show that the number of leaves in a full binary tree with n vertices is $\frac{n+1}{2}$. (5)

(d) Describe Kruskal's algorithm for finding minmum spanning tree in a connected weighted graph using an example. (5)

(e) A mouse eats his way through a $3 \times 3 \times 3$ cube of cheese by tunnelling through all of the $27 \times 1 \times 1$ sub-cubes. If he starts at one corner and always move on to an uneaten sub-cube, can he finish at the center of the cube? (5)

(f) Define a line graph of a graph $G$. Show that the line graph a simple graph $G$ is a path if and only if $G$ is a path. (5)

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Duration 2 $\frac{1}{2}$Hrs Marks: 75

N.B. : (1) All questions are compulsory.
(2) Figures to the right indicate marks.

1. (a) Attempt **any One** of the following: (8)
   (i) Show that in a metric space $(X, d)$
      (I) arbitrary union of open sets is open set.
      (II) finite intersection of open sets is open set.
   (ii) Define an open ball $B(x, r)$ in a metric space $(X, d)$ and show that every open ball is an open set. Also give an example to show that the converse need not be true.

   (b) Attempt **any Two** of the following: (12)
   (i) Show that $S = \{x \in \mathbb{Q} : 3 < x^2 < 5\}$ is both open and closed in the subspace $\mathbb{Q}$ of $\mathbb{R}$ with usual metric.
   (ii) (I) Consider the subspace $Y = [0, \infty)$ of $\mathbb{R}$ where distance $d$ in $\mathbb{R}$ is usual. Find $B_Y(0, 5)$ an open ball in the subspace $(Y, d)$.
      (II) In $(\mathbb{R}, \text{usual})$, show that $\mathbb{Q}$ is neither a closed set nor an open set.
   (iii) Consider the norms $\| \ \|_1$, $\| \ \|_2$ and $\| \ \|_\infty$ on $\mathbb{R}^2$ defined as $\|x\|_1 = |x_1| + |x_2|$, $\|x\|_2 = \sqrt{x_1^2 + x_2^2}$ and $\|x\|_\infty = \max\{|x_1|, |x_2|\}$, for any $x = (x_1, x_2) \in \mathbb{R}^2$. Show that for $x \in \mathbb{R}^2$,
   I) $\|x\|_2 \leq \|x\|_1$ II) $\|x\|_1 \leq \sqrt{2}\, \|x\|_2$ III) $\|x\|_\infty \leq \|x\|_2$

2. (a) Attempt **any One** of the following: (8)
   (i) Let $(X, d)$ be a metric space and $Y$ be a non-empty subset of $X$. Prove that a subset $G$ of $Y$ is open in the subspace $(Y, d)$ if and only if $G = V \cap Y$ where $V$ is an open set in $(X, d)$ .
   (ii) State and prove Nested interval theorem in $\mathbb{R}$.

   (b) Attempt **any Two** of the following: (12)
   (i) Show that in a metric space $(X, d)$ every Convergent sequence is Cauchy. Is the converse true? Justify
   (ii) Show that a sequence $(x_n)$ in $(\mathbb{R}^2, d)$ (where $d$ is Euclidean distance) converges to a point $p = (p_1, p_2) \in \mathbb{R}^2$ if and only if $(x_n^i) \longrightarrow p_i$ for $1 \leq i \leq 2$, in $\mathbb{R}$ with respect to the usual distance, where $x_n = (x_n^1, x_n^2)$.
   (iii) Show that $\mathbb{R}$ is a complete metric space w.r.t. the usual distance.

3. (a) Attempt any One from the following: (8)
   (i) Show that a compact subset of a metric space is closed and bounded. Give an example to show that a closed and bounded subset of a metric space need not be compact.
   (ii) Consider the metric space $(\mathbb{R}, d)$ where $d$ is usual metric, $\emptyset \neq A \subset \mathbb{R}$. Prove that $A$ is sequentially compact if and only if $A$ satisfies Bolzano-Weierstrass property.



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(b) Attempt **any Two** of the following: (12)

(i) Check whether the following sets are compact in the given metric spaces:
(I) $S^1 = \{(x, y) \in \mathbb{R}^2 : x^2 + y^2 = 1\}$ in $(\mathbb{R}^2, d)$ where $d$ is usual distance.
(II) $E = \{n + \frac{1}{n} : n \in \mathbb{N}\}$ in $(\mathbb{N}, d)$ where $d$ is usual distance from $\mathbb{R}$.

(ii) Prove or disprove: Interior and closure of a compact set is compact.

(iii) Prove that a subset $K$ in a discrete metric space $(X, d)$ is compact if and only if $K$ is a finite set.

4. Attempt **any Three** of the following: (15)

(a) Let $d_1, d_2$ be metrics on $X$. Define $d : X \times X \longrightarrow \mathbb{R}$ as $d(x, y) = \max\{d_1(x, y), d_2(x, y)\}$. Show that $d$ is a metric on $X$.

(b) Let $d_1$ and $d_2$ be metrics on a non-empty set $X$ such that there exist $k_1, k_2 > 0$ such that $k_1 d_1(x, y) \leq d_2(x, y) \leq k_2 d_1(x, y)$, $\forall x, y \in X$. Show that a sequence $(x_n)$ is Cauchy in $(X, d_1)$ if and only if sequence $(x_n)$ is Cauchy in $(X, d_2)$.

(c) Check whether Cantor's theorem is applicable in each of the following examples and find $\cap_{n\in\mathbb{N}} F_n$ in each case, where $(F_n)$ is a sequence of subsets of $\mathbb{R}$ and the distance $d$ is usual distance from $\mathbb{R}$.

(i) $X = [-1, 1]$, $F_n = [-\frac{1}{n}, \frac{1}{n}]$, $n \in \mathbb{N}$
(ii) $X = (0, 1)$, $F_n = \left(0, \frac{1}{n+1}\right]$, $n \in \mathbb{N}$

(d) Prove that in a discrete metric space every Cauchy sequence is eventually constant. Hence deduce that a discrete metric space is complete.

(e) If $(X, d)$ be a metric space and $(x_n)$ be any convergent sequence in $X$ such that $(x_n)$ converges to $p$ then show that $K = \{x_n : n \in \mathbb{N}\} \cup \{p\}$ is compact subset of $(X, d)$.

(f) If $A$, $B$ are compact subsets of any metric space, prove that $A \cup B$ is also compact.

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**Time: $2\frac{1}{2}$ hours** **Total Marks:75**

**Instructions:1) All questions are compulsory.**

**2) Figures to right indicate marks for respective sub questions**

Q.1 A Answer any **ONE**

i) Let G be an abelian group of order $n$. Let $m$ be an integer which is relatively prime to $n$. Prove that $f: G \to G$ defined by $f(x) = x^m$ is an automorphism of $G$. Hence determine whether $f: V_4 \to V_4$ defined as $f(x) = x^3$ is an automorphism, where $V_4$ is Klein 4 −group. 08

ii) Let $H$ and $K$ be subgroups of a group G. Prove that $H \cup K$ is a subgroup of G if and only if $H \subseteq K$ or $K \subseteq H$. Give an example of a group $G$ and its subgroups $H$ and $K$ such that $H \cup K$ is not a subgroup of $G$. 08

B Answer any **TWO**

i) If $H, K$ are subgroups of a group $G$ then show that $HK$ is a subgroup of $G$ if and only if $HK = KH$. 06

ii) Let $G$ be a group and $a \in G$ be any element. Prove that order of $a$ is equal to the order of $a^{-1}$ in $G$. Hence deduce that if $a$ is an element of $G$ of order $n$ then for each integer $k$ such that $1 \leq k \leq n$, order of $a^k$ is equal to the order of $a^{n-k}$. 06

iii) Let $G$ be a group and $H$ be non-empty subset of $G$. Prove that $H$ is a subgroup of $G$ if and only if $ab^{-1} \in H$ for all $a, b \in H$. 06

Q.2 A Answer any **ONE**

i) Let $G$ be a group. If $G$ is the internal direct product of two of its subgroups $H, K$ then prove that $G$ is isomorphic to the external direct product $H \times K$ of $H$ and $K$. 08

ii) Let $G$ and $G'$ be groups and $f: G \to G'$ be onto group homomorphism. Prove that, 08

p) ker $f = \{x \in G: f(x) = e'\}$ is a normal subgroup of $G$.

q) If $H'$ is a subgroup of $G'$ then $f^{-1}(H') = \{g \in G : f(g) \in H'\}$ is a subgroup of $G$. If $H'$ is normal in $G'$, prove that $f^{-1}(H')$ is normal in $G$.

B Answer any **TWO**

i) Let $H, K$ be normal subgroups of $G$ and $K$ be a subgroup of $H$. Then prove that $\frac{G/K}{H/K}$ is isomorphic to $G/H$. 06

ii) Prove that $A_n$ is normal subgroup of $S_n$. 06



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iii) If $H_1, H_2$ are normal subgroups of groups $G_1$, $G_2$ respectively, then prove that $H_1 \times H_2$ is a normal subgroup of $G_1 \times G_2$. 06

Q.3 A Answer any **ONE**

i) p) Let G be a finite group and $a \in G$. Show that $G =< a >$ if and only if the order of $a$ equals the order of the group G. 08
q) Let G be an infinite group and let $a \in G$. If $G =< a >$, then show that order of $a$ is also infinite.

ii) Prove that any infinite cyclic group is isomorphic to $\mathbb{Z}$. Hence, show that any two infinite cyclic groups are isomorphic. 08

B Answer any **TWO**

i) Prove or disprove: If G is a group such that every proper subgroup of G is cyclic, then G has to be cyclic 06

ii) Show that an infinite cyclic group generated by $a$ has exactly two generators $a$ and $a^{-1}$. 06

iii) Prove that the group of non-zero real numbers under multiplication is not cyclic. 06

Q.4 Answer any **THREE**

i) Let G be a group. 05

p) Suppose that for all $a, b \in G$, $ab = ca$ implies $b = c$. Prove that $G$ is abelian.

q) Suppose that $(ab)^2 = a^2b^2$; for all $a, b \in G$. Prove that G is abelian.

ii) Construct the composition table of the group $U(12)$ of units in $\mathbb{Z}_{12}$ under multiplication modulo 12. Is there a subgroup of order 2 in $U(12)$? If yes, determine it. 05

iii) List all left cosets of the subgroup $H = \{\overline{1}, \overline{17}\}$ of $U(32)$, the group of residue classes under multiplication modulo 32. 05

iv) Let $H$ be a normal subgroup of a group $G$. If $G/H$ has an element of order $n$ then show that $G$ has an element of order $n$. 05

v) List all the generators and subgroups of a cyclic group $\mathbb{Z}_{20}$. 05

vi) Let $G =< a >$ be a cyclic group of order 24. Let $H$ be a subgroup of $G$ generated by $a^{12}$ and $K$ be the subgroup generated by $a^6$. Determine 05
p) The order of $a^2H$ in $G/H$
q) The order of $a^4K$ in $G/K$

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