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3 (Sem-5/CBCS) CHE HC 1

2023

CHEMISTRY

(Honours Core)

Paper : CHE-HC-5016

(Organic Chemistry-IV)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : $1 \times 7 = 7$

(a) Nucleoside + Phosphate = ?

(b) A Nucleotide is represented as _____.

(c) Except _____ all α -amino acid are optically active.

(d) $\overset{+}{N}H_3 - CH_2 - CO - NH - CH_2 - COO^-$

It is a dipeptide. Name the component amino acid.

Contd.

- (e) What causes the disease sickle cell anaemia?
- (f) Give one example of oxidative enzymes.
- (g) Give an example of simple triglyceride.
2. Answer the following questions: $2 \times 4 = 8$

(a) Comment on the statement that ATP acts as a universal currency of free energy in biological synthesis.

(b) What products would be formed when a nucleotide from DNA - containing Thymine is hydrolysed?

(c) What happens when alanine is treated with nitrous acid? Give reaction.

(d) What do you mean by functional group interchange (FGI) and functional group addition?

3. Answer **any three** of the following:

$5 \times 3 = 15$

(a) What are the names of ribonucleosides of the five different bases, and also write the name of the bases?

(b) Draw a structure of nucleotide by showing phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar.

(c) Give the reaction of phthalimidomalonic ester synthesis for amino acid. - N

(d) Describe the following:

(i) Zwitterion structure of amino acid

(ii) Isoelectric point of amino acid

(e) What are enzymes and co-enzymes? Give example.

4. Answer **any three** of the following questions: $10 \times 3 = 30$

(i) (a) What is the difference between oils and fats? 5

(b) What do you mean by acid value and hardening of oils? 5

(ii) Write notes of the following:

$3 + 3 + 4 = 10$

(a) Oxidation of food stuffs and cellular energy

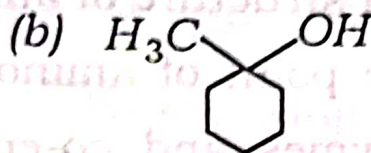
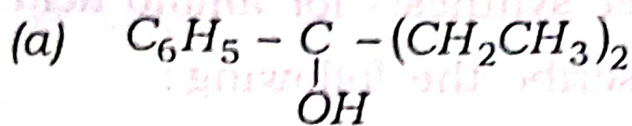
(b) Catabolism and anabolism

(c) Metabolic pathways of Carbohydrates

(iii) (a) How malaria is caused? Name some useful drugs which are employed as antimalarials. How pamaquine is synthesised? 5

(b) Describe the synthesis of Chloramphenicol. 5

(iv) Give the retrosynthesis of $5+5=10$



from Grignard reagent.

(v) (a) What is meant by nucleosides and nucleotides? Give one example of each. 3

(b) Write down the structure of nucleosides which is present only in RNA. 3

(c) What are the functions of nucleic acids in the human body? 4

✓ (vi) ✓ (a) Amino acids are weaker acids than carboxylic acids. Explain why? 2

✓ (b) What do you mean by N-terminal and C-terminal residue in proteins? How are these identified? 4

✓ (c) Explain the biological importance of proteins. 4

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3 (Sem-5/CBCS) CHE HC 2

2023

CHEMISTRY

(Honours Core)

Paper : CHE-HC-5026

(Physical Chemistry-V)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following as directed : $1 \times 7 = 7$

(a) State whether the following statement is True **or** False :

For the particle in the box, the maximum probability density for every stationary state wave-function is at the midpoint of the box.

Contd.

(b) Show that $\sin nx$. (n is an integer) is an eigenfunction of the operator $\frac{d^2}{dx^2}$ and find the eigenvalue.

(c) Derive the term symbol for the ground state configuration of Na .

(d) State which of the following are microwave active and why:
 CO_2 , OCS , HF , N_2

(e) The ionization energy of a molecule is 10 eV. Calculate the wavelength of the radiation that ionize the molecule.
(1 eV = 1.602×10^{-19} J)

(f) What do you mean by inter system crossing?

(g) What are photoinhibitors?

2. Answer the following questions: $2 \times 4 = 8$

(a) Show that the wave function for a particle in one-dimensional box of length a , where the potential energy is zero, is not an eigenfunction of the linear momentum operator in one dimension.

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(b) The functions $\psi_1 = \left(\frac{1}{\pi}\right)^{1/2} \cos x$ and

$\psi_2 = \left(\frac{1}{\pi}\right)^{1/2} \sin x$ are defined in the

interval $x=0$ to $x=2\pi$. Examine if the functions are orthogonal to each other.

(c) Write how the population of states affects the intensity of spectral line.

(d) Microwave causes molecules to rotate more energetically. A molecule absorbs microwave photon of wavelength 20 cm. Calculate the energy difference between the two rotational levels in joule.

3. Answer **any three** questions:

(a) Show that the energy levels of a harmonic oscillator are evenly spaced and it has an energy greater than zero even in its lowest state. 5

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(b) (i) Define complementary observable with one example. 1+1=2

(ii) Show that if two linear operators A and B have the same complete set of eigenfunctions, then $[\hat{A}, \hat{B}] = 0$. 3

(c) The first line in the pure rotational spectrum of $^{12}\text{C}^{16}\text{O}$ is observed at 3.8424 cm^{-1} . Calculate bond length considering the molecule as rigid rotator. Does the bond length of a real molecule change as rotational energy increases? If yes, how? 4+1=5

(d) (i) Discuss in brief what do you mean by hot bands: 2

(ii) Find the normal vibrational modes of CO_2 . Explain which are IR active and which are not. 3

(e) Write the mechanism of the $\text{H}_2\text{-Cl}_2$ photochemical reaction. Prove that the rate of formation of HCl is directly proportional to the intensity of the absorbed radiation. 2+3=5

4. Answer any three questions :

(a) (i) Write down the Hamiltonian operator for the hydrogen atom and show that the maximum radial probability density for the 1s state of H-atom occurs at a distance equal to Bohr radius. 2+3=5

(ii) Which of the following functions are eigenfunctions of $\frac{d^2}{dx^2}$?

(i) $\sin 2x$

(ii) $4 \cos 3x$

(iii) $5x^2$

(iv) $\frac{1}{x}$

(v) $5e^{-3x}$

Determine the eigenvalue of each function. 5

(b) (i) Derive expression for the total energy of a particle in a three-dimensional box. Explain the concept of degeneracy. 4+2=6

(ii) Taking the example of H_2^+ , explain how the potential energy diagram can be constructed. What information regarding characterization of a bond can be obtained from this diagram? 3+1=4

(c) (i) Considering the diatomic molecule to be a rigid rotator, deduce an expression in wave number unit for the energy required for rotational transition to take place. Explain how the spectrum will differ if the molecule is considered to be a non-rigid rotator. 3+2=5

(ii) The force constant of CO is 1840 Nm^{-1} . Calculate oscillation frequency and wave number in cm^{-1} . 3

(iii) Explain with examples the terms chromophore and auxochrome. 2

(d) (i) Show that the Raman lines in the pure rotational Raman spectrum of a diatomic molecule appear at wave number

$$\bar{\nu} = \bar{\nu}_0 \pm 2B(2J+3)$$

where $\bar{\nu}_0$ is the wave number of the Rayleigh line. Draw the schematic diagram to show the Stokes lines and the Anti-Stokes lines. 4+1=5

(ii) Show diagrammatically the relative frequencies of following electronic transitions :

(i) $\sigma \rightarrow \sigma^*$

(ii) $\pi \rightarrow \pi^*$

(iii) $n \rightarrow \pi^*$

(iv) $n \rightarrow \sigma^*$

Discuss the effect of polarity of the solvent on the above transitions. 3+2=5

(e) (i) Discuss briefly the molecular orbital treatment of BeH_2 and H_2O molecules. 5

(ii) HCl molecule has the fundamental frequency 2990 cm^{-1} . The anharmonicity constant is 0.019 . The depth of the potential well is 43000 cm^{-1} . Calculate the dissociation energy is kJ mol^{-1} .

3

(iii) Write short note on :

2

Rule of Mutual Exclusion

(f) (i) With the help of Jablonski diagram, explain all the photophysical processes that an electronically excited molecule may undergo. Give two major differences between fluorescence and phosphorescence.

$3+2=5$

(ii) A substance was exposed to a radiation of wavelength 420 nm for a definite period of time when an amount of 10.5 J of energy was absorbed. During this time $1.8 \times 10^{-5}\text{ mol}$ of the substance was found to decompose. Calculate quantum efficiency.

3

(iii) What is a photostationary state? Explain with example.

2

OPTION-E

(Polymer Chemistry)

Paper : CHE-HE-5056

1. Answer the following questions : $1 \times 7 = 7$
- (a) Which of the following is not a polymer ?
- (i) Sucrose
 - (ii) Enzyme
 - (iii) Cellulose
 - (iv) Nucleic acid
- (b) Functionality of phenol is
- (i) one
 - (ii) two
 - (iii) three
 - (iv) four
- (c) Tubeless tyres are co-polymers of isoprene and
- (i) neoprene
 - (ii) isobutylene
 - (iii) PAN
 - (iv) silicones
- (d) Which of the following polymers can have strong intermolecular forces ?
- (i) Nylon
 - (ii) Polystyrene
 - (iii) Rubber
 - (iv) Polyesters

- (e) The WLF Equation is :
- a combination of Voigt and Maxwell models that describes creep
 - a four-parameter model for stress relaxation
 - an expression for the shift factor that is used in the time-temperature superposition principle
 - the relationship between intrinsic viscosity and molecular weight
- (f) Polypropylene produced commercially using a Ziegler-Natta catalyst is predominantly
- atactic
 - isotactic
 - syndiotactic
 - None of the three
- (g) For a polymer to be completely miscible with a solvent at a given temperature (i.e. form a single-phase mixture at all compositions)
- the free energy change ΔG_m must be negative and the second derivative of the free energy (with respect to composition) must be positive
 - ΔG_m must be positive and the second derivative negative
 - ΔG_m must be negative and the second derivative must also be negative
 - they must both be positive

2. Answer the following questions : $2 \times 4 = 8$

- Why do polymers do not have sharp melting point ?
- Differentiate between rubbers and plastics on the basis of intermolecular forces.
- Can nucleic acids, proteins and starch be considered as step growth polymers ?
- A particular sample of polymer has 100 chains with molecular weight 1000, 200 chains with molecular weight 10000, and 200 chains with molecular weight 100000. Calculate the polydispersity of the sample.

3. Answer **any three** of the following questions : $5 \times 3 = 15$

- Explain Flory-Huggins theory and enlist the assumptions.
- Bring out the differences between chain growth and step growth polymerization.
- Discuss the various factors which affect the crystallinity of polymers with suitable examples.
- Write short notes on :
 - Living radical polymerization
 - Biodegradable polymer

(e) Explain the mechanism of anionic polymerization with suitable examples.

4. Answer **any three** of the following questions :
10×3=30

(a) What is number average molecular weight and weight-average molecular weight of polymer? Derive an expression for it. Define degree of polymerisation and polydispersity index of a polymer sample. Draw the molecular weight distribution curves of three hypothetical polymer samples having same number-average molecular weight, but different polydispersities. 2+3+2+3=10

(b) Define glass transition temperature (T_g) and melting temperature (T_m) for polymers. What is the interrelationship between these two parameters? Explain with suitable diagram the dilatometric method for the determination of T_g in polymers. 2+2+6=10

(c) Describe the structure of Ziegler-Natta catalyst used in co-ordination polymerization of olefins. Write the mechanism of polymerization of olefins when Ziegler-Natta catalyst is used. How is it different from polymerization of olefins using free radical initiators? 2+5+3=10

(d) What do you mean by chain transfer in polymerization process? Derive an expression for kinetics of chain polymerization. Write a note on kinetic chain length in free radical polymerization. 2+5+3=10

(e) What are the different kinds of polymerization techniques? Citing advantages and limitations, describe the bulk and solution polymerization technique. 2+4+4=10

(f) Write the differences between thermosetting and thermoplastics. Discuss preparation, properties and uses of following polymer molecules (**any two**)

(i) Polyethylene

(ii) Synthetic rubber

(iii) Polycarbonates 2+4+4=10

OPTION-B

(Analytical Method in Chemistry)

Paper : CHE-HE-5026

1. Answer the following questions : $1 \times 7 = 7$

(a) What is the applicability of Q-test in data analysis ?

(b) Why quartz cuvettes are used for UV-visible spectroscopy ?

(c) What is the mid-IR wavelength range ?

(d) Why is atomic absorption spectroscopy (AAS) more sensitive than atomic emission spectroscopy ?

(e) State true or false :

Thermal analysis gives information about changes in material properties as function of temperature.

(f) How does the change in temperature affect the end-point of conductometric titration ?

(g) Give an example of chelating agent used in solvent extraction process.

2. Answer the following questions : $2 \times 4 = 8$

(a) The mean of four determinations of the copper content of a sample of an alloy was 8.27% with a standard deviation 0.17%. Calculate the 95% confidence limit for the true value. Given, from the t -tables, the value of t for the 95% confidence level with three degrees of freedom is 3.18.

(b) What are the limitations of Beer-Lambert's law?

(c) What is Potentiometry? Mention one application of potentiometry.

(d) Mention two advantages of thin layer chromatography (TLC) over paper and column chromatography.

3. Answer **any three** of the following questions :

$5 \times 3 = 15$

(a) Discuss with an example how the strength of an acid can be determined by pH metric titration against a standard base.

(b) A mixture of CaO and CaCO_3 is analysed by TGA. The result indicates that mass of the sample decreases from 250.6 mg to 190.8 mg only between 600°C and 900°C . Calculate the percentage of calcium carbonate in the mixture.

(c) Discuss how Job's method of continuous variation can be used to determine the composition of the Ferric-thiocyanate complex.

(d) ✓ Analyses of a sample of iron ore gave the following percentage values for the iron content :

7.08, 7.21, 7.12, 7.09, 7.16, 7.14, 7.07, 7.14, 7.18, 7.11

Calculate the mean, standard deviation and coefficient of variation for the values.

$$1+2+2=5$$

(e) ✓ What are the different techniques used in solvent extraction ? Elaborate *any one* of the techniques.

$$1+4=5$$

4. Answer **any three** of the following questions :

$$10 \times 3 = 30$$

(a) (i) Discuss how thermogravimetric analysis (TGA) can be utilized for the quantitative estimation of calcium (Ca) and magnesium (Mg) from a mixture of CaCO_3 and MgCO_3 .

5

(ii) Discuss the principle of colorimetric estimation of metal ions from aqueous solution.

5

(b) (i) ✓ Discuss the effect of temperature, nature of ions, concentration of ions and size of the electrodes on the conductance of a solution.

5

(ii) ✓ Discuss with an example how pK_a of an acid can be determined by electroanalytical methods.

5

(c) (i) What are the advantages of Fourier-Transform Infrared spectrometer over dispersive Infrared spectrometer ?

2

(ii) Vibrational frequency of HCl molecule is found at 2885 cm^{-1} . If the hydrogen atom of this molecule is substituted with deuterium, what will be the vibrational frequency of the molecule ?

2

(iii) How can we differentiate primary, secondary and tertiary amines using IR spectroscopy ?

2

(iv) What is the effect and importance of isotopic substitution in IR spectroscopy? 2

(v) What is the fingerprint region in IR spectroscopy? Why it is called so? 1+1=2

(d) (i) What is the basic principle of Atomic absorption spectroscopy? What are the different atomization processes commonly employed in the atomic absorption spectroscopy (AAS)? 3+2=5

(ii) What is the purpose of monochromator and nebulizer in Inductively coupled plasma atomic emission spectroscopy (ICP-AES)? What are the advantages of ICP-AES over AAS? 3+2=5

(e) (i) What is meant by development of a chromatogram? Discuss the different methods used for development of a chromatogram. 1+6=7

(ii) A sample of S-(+) enantiomer of a compound has an observed rotation of $+19.2^\circ$. If the specific rotation of the pure enantiomer is $+24^\circ$ then what is the optical purity of the sample? What is the composition of the mixture? 3

(f) (i) Discuss the principle of conductometric titration for the determination of equivalence points of acid-base reaction. 5

(ii) What is a chiral shift reagent? Discuss its role in NMR spectroscopy with a suitable example. 1+4=5