

**2021**  
**CHEMISTRY**  
**[HONOURS]**  
**Paper : IX**

Full Marks : 80

Time : 4 Hours

*The figures in the right-hand margin indicate marks.*

*Candidates are required to give their answers in  
 their own words as far as practicable.*

**GROUP-A**

**(Marks : 40)**

1. Answer any **two** questions: 1×2=2
- a) State the Grothus-Draper law.
  - b) Give one example of bioluminescence.
  - c) What is the dipole moment of benzene?
  - d) How many degrees of freedom (vibrational) does CO<sub>2</sub> have?
2. Answer any **two** questions: 2×2=4
- a) Write the Stern-Volmer equation, explaining all terms.
  - b) What is thermodynamic probability?

- c) Name two intermolecular forces, with examples.
  - d) What is the relation between fundamental frequency and force constant?
3. Answer any **four** questions: 6×4=24
- a) Explain why in some cases absorption and fluorescence spectra appear as mirror images of each other. Give one example each of phosphorescence and chemiluminescence. 4+2
  - b) If acetone is irradiated with light of wavelength 280 nm, methyl radical and CO are produced. If irradiation is at the rate of 100 erg mol sec<sup>-1</sup> for 10 minutes, how many Einsteins of radiation was involved? If the quantum yield is 0.25, how many moles of CO were produced? 3+3
  - c) What is photostationary equilibrium? Give an example. Name two quenchers of fluorescence. 3+1+2
  - d) Give one example each of diamagnetic, paramagnetic, ferromagnetic and anti-ferromagnetic substance. What is the unit

of electrical polarization? 4+2

e) Write an expression for energy of a rotational transition, explaining all terms. At a given temperature T, transition between which two levels show maximum intensity?

2+4

f) The fundamental vibrational frequency of N<sub>2</sub> is 2358 cm<sup>-1</sup>. What is the force constant associated with N≡N bond? Compare this value with force constant of 516 Nm<sup>-1</sup> for <sup>1</sup>H<sup>35</sup>Cl molecule.

6

4. Answer any **one** question: 10×1=10

a) Write an expression for rotational-vibrational energy of a rigid rotor with harmonic vibration. Indicate the terms that must be included for a non-rigid rotor with anharmonic vibration. What is the anharmonic term for Morse potential? What are the selection rules for a rigid rotor with harmonic vibration? How do they change for a non-rigid rotor with anharmonic vibrations?

2+2+2+2+2

b) Describe photodimerization of anthracene. Write the relevant reactions and reaction conditions. What is a typical quantum yield

for this reaction? Name a possible sensitizer and a possible quencher for this reaction.

5+2+1+2

c) Write the Debye equation. How does it differ from Clausius-Mosotti equation? Name an application of Debye equation. What factors contribute to a molecule's orientation polarization?

2+2+2+4

### GROUP-B

(Marks : 40)

5. Answer any **two** questions: 1×2=2

a) Give examples of two strong chemical bonds.

b) Give examples of two low-melting eutectics.

c) Name an experiment showing wave nature of electrons.

d) Write the time independent Schrodinger equation, explaining all terms.

6. Answer any **two** questions: 2×2=4

a) Give an example each of non-bonding and anti-bonding orbitals.

b) Give one example each of system with

congruent and incongruent melting points.

- c) State two postulates of quantum mechanics.
- d) What is the no. of nodes (besides at  $r=0$  and at  $r \rightarrow \infty$ ) for radial distribution of H atom wavefunction with quantum numbers  $n, l, m$ ?

7. Answer any **four** questions:  $6 \times 4 = 24$

- a) Give an example each of aromatic, non-aromatic and anti-aromatic electronic systems. Draw corresponding orbitals or  $\pi$  electron configurations when applicable.  $2 \times 3$
- b) Derive Nernst distribution law. Give an example where steam distillation is used.  $4+2$
- c) Draw the phase diagram of water-triethyl amine system, identifying its fixed points. How does the diagram differ from that of water-phenol system?  $4+2$
- d) State the limitations of the Bohr model. How can photo-electric effect be explained from quantum theory? Write the equation for observed frequency change in Compton effect.  $2+2+2$

e) Draw the wavefunctions for 2s, 2p electrons in H-atom.  $2 \times 3$

f) What are the differences between VB and MO wavefunctions? Briefly write why inclusion of VB terms is necessary to explain bonding in  $H_2$  molecule.  $3+3$

8. Answer any **one** question:  $10 \times 1 = 10$

- a) Name two models of spin-orbit coupling. Where are these applicable? Write an expression for charge transfer in terms of wavefunctions. Give an example where it can be realized.  $2+2+4+2$
- b) Deduce phase rule for non-reactive systems. State your assumptions clearly. Give an example of Lever rule. What is an azeotrope?  $6+2+2$
- c) Derive ground state energy of H atom from uncertainty principle. Can a particle (e.g. an electron) moving in a 2-D circular path have zero point energy? Explain. How can translational energy be quantized?  $5+3+2$