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UG 5th Semester Examination – 2025 (Under NCCF)
Award: B. Sc.
Discipline: Chemistry
Course Type: MJC - 9
Course Code: BSCCEMMJ503
Course Name: Physical Chemistry - III

Full Marks: 35 **Time – 2 Hours**

1. Answer any five questions. **1×5 = 5**

(a) What does an operator in quantum mechanics represent?
(b) Write the dimension of $\hbar^2(\partial^2/\partial x^2)$.
(c) Mention microwave and infrared regions in Hz.
(d) Write the unit and dimension of 'action' in quantum mechanics.
(e) What are the term symbols for a $3d^1$ electron?
(f) Iodine sublimes usually. Explain the situation under which it can be made to melt.
(g) What is the physical significance of a normalized wavefunction?
(h) Evaluate: $[\int_0^x dx, \frac{d}{dx}]$.

2. Answer any five questions. **2×5 = 10**

(a) Find a relation between de Broglie wavelength of a particle in 1-dimensional box in its lowest energy level and the length of the box and hence find the energy of the particle in this level.
(b) If there is +2% error in the determination of rotational constant, B of a diatomic molecule, calculate the % of error in its bond length determination.
(c) Write down the difference between *Normal Zeeman effect* and *Anomalous Zeeman effect.*
(d) Show that e^{ikx} is an eigenfunction of the momentum operator, and find the corresponding eigenvalue.
(e) What is meant by triple point of water? Why it is different from the normal melting point of ice?
(f) The force constant for NO is $1550 nm^{-1}$. Calculate the natural frequency of the molecule.
(g) Calculate the wavelength of a tennis ball of mass 65g travelling at the velocity of $45 ms^{-1}$.
(h) Mention any two difference between classical and quantum mechanics.

3. Answer any two questions. **5×2 = 10**

(a) Using the Wilson-Sommerfeld quantization rule find the quantized energy values for a harmonic oscillator (1-dimension). 5
(b) i) State Heisenberg's Uncertainty Principle and write its mathematical form.
ii) With the help of above principle, prove that an electron cannot exist inside nucleus. (2+3)
(c) Derive the expression of J_{max}, where J_{max} is the rotational level with maximum population for diatomic molecule.
(d) Draw a phase diagram for the water system. Locate positions on the diagram where the degree of freedom (F) is 0, 1 and 2. Can you find any position where F is greater than 2? (2+2+1)

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

(a) i) Write the essential condition for a molecule to be infra-red active. Show, using a harmonic oscillator model, that the frequency of photon absorbed by a diatomic molecule is equal to that of its vibration. Compare the stretching vibrational frequencies of $C = C$ and $C \equiv C$.
ii) Explain and draw how many spectral lines are possible when an electronic transition occurs from 3p to 3s level of Na?
iii) What is the uncertainty in the velocity of an electron if the uncertainty in its position is 100 pm? 4+4+2

(b) i) State with example what kind of nuclei are n.m.r. active?
ii) What is coupling constant (J)?
iii) Draw qualitatively the n.m.r. spectra of ethanol showing the relative peak positions and peak intensity.
iv) All magnetically equivalent protons are chemically equivalent but all chemically equivalent protons are not magnetically equivalent − comment. 2+2+4+2

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