Haldia Government College
PG Semester 2 Examination 2020
Semester: **2**   Stream: **M.Sc.**

Subject: **Physical Chemistry**

Paper: **CEM -201**

Full Marks:**20**

Time:**1 hr.**

E-mail id for answer script submission: **hgcchemistry2020@gmail.com**

Answer any **one** of the following questions.

1. Construct ladder operators $\hat{A}_+$, $\hat{A}_-$ for simple harmonic oscillator. Show that $\hat{A}_+\hat{A}_- \neq \hat{H}$ Evaluate $[\hat{H},\hat{A}_-]$. Why $\hat{A}_-$ is called lowering operator. Using ladder operators, find the ground state energy and wave function (normalized) of a simple harmonic oscillator. Evaluate $\langle x \rangle$ of the oscillator in quantum state n.
(2+2+3+2+4+4+3)

2. Write down the expression of the operators for the components of angular momentum. Evaluate the commutators formed by any two of them. Justify whether $\hat{L}^2$ and $\hat{L}_z$ have simultaneous eigen functions. Express $\hat{L}^2$ of a rigid rotor in spherical polar coordinate. Evaluate the ϕ dependent normalized part of the total wave function for rigid rotor. Show that the quantum number appears in the ϕ dependent part is restricted to integers.
(3+4+3+2+4+4)

3. For H-atom $\psi_{100} = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} e^{-r/a_0}$. Find the radial distribution function for 1s orbital. Compute the average distance at which the probability of finding the electron in 1s orbital is maximum, and hence give a definition of orbital. Calculate average distance from the nucleus for the electron present in 1s orbital of H-atom. Find the ground state energy of H-atom. Show that degree of degeneracy of the *n-th* energy level is n^2.
(3+(3+2)+4+4+4)

4. What do you understand by Raman Scattering? Explain classically the appearance of stokes and anti-stokes Raman lines of a molecule. Write short notes on: (i) Fluorescence (ii) Phosphorescence. Consider an enzyme catalyzed reaction undergoing uncompetitive inhibition. Find an expression that relates the velocity of the reaction with the concentration of the substrate, hence draw the Lineweaver-Burk plot to show the effect of concentration of the inhibitor.
((2+4)+(4+4)+6)

5. State the rule of mutual exclusion in vibrational spectroscopy with a suitable example. Write short note on Flash Photolysis. Describe in detail the different processes involved in the dissipation of energy from the excited electronic state. What do you mean by relaxation time? Derive the expression of relaxation time for second order reaction of the type

$$A+B \underset{K_2}{\overset{K_1}{\rightleftharpoons}} P$$
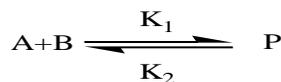
Where, K_1 and K_2 are the forward and backward rate constants. Low temperature is generally required to observe phosphorescence—Explain.
(4+4+4+(2+4)+2)

6. Mention the assumption of the activated complex theory. How can you say that the activated complex theory is much better than the collision theory for a chemical reaction? What is autocatalysis? Find out the rate constant of autocatalytic reaction A→P. Show that pure rotational Raman shift is twice as that of rotational frequency. Define oscillatory reaction with suitable example.
(2+3+2+6+4+3)