Subject: Chemistry (Hons.)
Semester: 4
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Topic: Foundation of Quantum Mechanics

[Based on the class-lectures, here is the 1st installment of home-assignments. The students must go through all the assignments. The students are advised to remain in contact for any type of academic discussion.]

1. Point out the characteristics of wave and particle. Give two examples where particle nature of light is exhibited. Give examples of two experiments that show wave nature of electron.

2. The longest wavelength of light that will induce emission of electrons from potassium is 552 nm. Calculate the work function of potassium in units of Joules and eV.

3. Write down the generalized form of uncertainty principle defining the terms used. Hence, deduce the same for position-momentum uncertainty.
Hints: $\Delta A . \Delta B \geq \frac{1}{2}\left|\langle [A, B] \rangle\right| \quad \Rightarrow \Delta x . \Delta p_x \geq \frac{1}{2}\hbar$

4. The de Broglie wavelength of the electron moving in the first orbit of hydrogen atom (Bohr model) is equal to the circumference of the orbit – Justify.

5. Write down Schrödinger's time-independent equation and find out the operator corresponding to kinetic energy.

6. Curvature of the corresponding wavefunction with respect to the trajectory is a measure of the kinetic energy of the particle – Explain.
Hints: Double differentiation is a measure of curvature.

7. Mention the conditions of acceptability of wavefunctions with justification.

8. Check whether the following are acceptable wavefunctions within the range $-\infty \leq x \leq \infty$ (if not mentioned):
i) $y = m.x$
ii) $y = m.x^2$
iii) $y = e^{ax^2}$
iv) $y = A.\sin x \quad (0 \leq x \leq \pi)$
v) $y = 1/x$
vi) $y = e^{-ax^2}$
where m, a and A are constants.

9. Explain Born's interpretation of wavefunction. Write down the SI unit of $\Psi^*\Psi$ for a particle moving in 1-dimensional box.

10. Rewrite the expression $\int \Psi_i^* \Psi_j \, d\tau$ in terms of bra-ket vector representation. If orthonormality is satisfied, mention the cases when the integral vanishes and becomes unity.