



Continuous Assessment Test (CAT - II), April 2024

Programme	: B.Tech.	Semester	: Winter 2023-2024
Course Title	: Engineering Physics	Course Code	: BPHY101L
School	: School of Advanced Sciences	Slot	: D1+TD1
Duration	: 90 mins	Max. Marks	: 50
Class No	: <PLEASE MENTION LAST FOUR DIGIT CLASS NO>		

Part – A (5 x 10 = 50)

Answer ALL Questions

Sl. No	Questions	Max Marks	CO	BL
1	For decades, the Cathode Ray Tube was used for video displays from televisions to computer screens where the electrons were regarded as a particle. Explain in detail, with neat diagrams, the particular experiment that provided the very first evidence of electron waves.	10	CO3	L1
2	(a) The flame of a candle has a yellowish colour and the flame of a Bunsen’s burner in the laboratory has a bluish colour. Find out which flame has a higher temperature? Describe how the intensity spectrum of radiation emitted from a colder object differs from the intensity spectrum of a hotter object. (b) X-rays with wavelength of 71-pm is incident on a calcite target. Find the wavelength of the X-rays scattered at the angle of 30°. What is the maximum shift that can be expected in this experiment?	5 5	CO3	L2
3	(c) Arrive at wave equation that describes the energy and position of the electron in space and time, taking into the account the wave nature of a moving electron. (d) Determine the minimum uncertainties in the positions of the following objects if their speeds are known with a precision of 1.0×10^{-3} m/s (a) an electron and (b) a bowling ball of mass 6.0 kg.	5 5	CO3	L2



4	A perfectly elastic ball is constrained to move along a straight line inside a tube of length L . Due to some block at $3/4^{\text{th}}$ L the ball could not move beyond that point. Derive the Eigen values and Eigen function for the ball.	10	CO3	L1
5	(a) Emission colors of CdSe quantum dots vary with size. Smaller particles emit blue light and increase in particle size leads towards red colour. Explain the physics behind it. Further comment on the consequences of size reduction. (b) An electron with kinetic energy 9.00 eV is incident on a square potential barrier with height of 10.00 eV and width of 5 nm. Find its transmission probability. If a proton is to have the same energy and transmission probability as an electron, what must the width of the barrier for proton be relative to the barrier width encountered by an electron?	5 5	CO3	L2

Moderator's Comment posted in VTOP

<Kindly paste the Moderator's comment here>

- After the moderation, the faculty members are requested to paste the feedback/comments posted by the moderators in VTOP in the box mentioned above. The final copy is required to be sent to the respective slot-wise coordinators.



- Question papers should be prepared by indicating cognitive levels as per Bloom's taxonomy as mentioned below,

BL	Description	Definition	Examples of action verbs to be used
L1	Remember / Knowledge	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers	Choose, Define, Identify, Describe, Tell, Explain, Memorise, Where, Name, Recall, Relate, What, When
L2	Understand	Demonstrate understanding of facts and ideas by organising, comparing, translating, interpreting, giving descriptions, and stating main ideas	Summarise, Explain, Demonstrate, Interpret, Classify, Compare, Contrast, Infer, Relate, Outline, Rephrase
L3	Apply	Solve problems to new situations by applying acquired knowledge, facts, techniques, and rules in a different way.	Apply, Build, Construct, Develop, Identify, Plan, Solve, Change, Relate, Complete, Use, Sketch
L4	Analyse	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalisations.	Analyse, Assume, Classify, Compare, Contrast, Distinguish, Examine, Infer, Inspect, Simplify
L5	Evaluate	Present and defend opinions by making judgements about information, validity of ideas, or quality of work based on a set of criteria.	Agree, Choose, Compare, Conclude, Decide, Determine, Disprove, Estimate, Evaluate, Interpret, Perceive, Prioritize
L6	Create	Compile information together in a different way by combining elements in a new pattern or proposing alternate solutions.	Change, Choose, Combine, Compile, Compose, Construct, Create, Design, Develop, Elaborate, Improve, Predict, Solve

1. Davison-Clermer exp.

Exp. setup, Diagram - (2 marks)

From De-Broglie hypothesis $\lambda = 1.66 \text{ \AA}$ (4 marks)

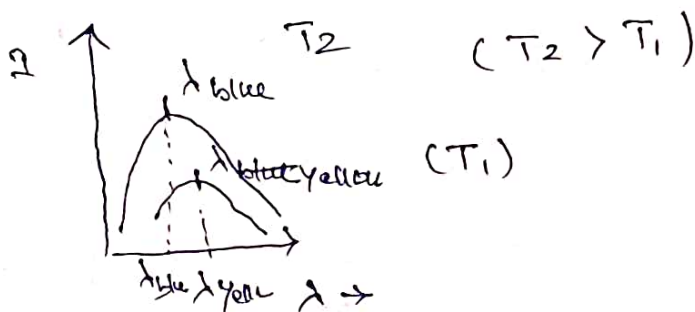
from Bragg's diffraction $\lambda = 1.65 \text{ \AA}$ (4 marks).

2 (a) Wien's displacement law $\lambda_{max} = \frac{b}{T}$; $T = \frac{b}{\lambda}$
lower the 'b' higher the T

$$\lambda_{yellow} > \lambda_{blue}$$

\therefore Bunsen's burner will have high Temperature. (3 marks)

Diagram (2 marks)



(b) Compton's scattering $(\lambda' - \lambda) = \frac{h}{m_0 c} (1 - \cos \theta)$ (1-mark)

Given, $\lambda = 71 \text{ pm}$

$\theta = 30^\circ$

$\lambda' = 71.325 \text{ pm}$ (2-marks).

The max. shift can be observed @ $\theta = 180^\circ$

$$\Delta \lambda = 4.86 \text{ pm}$$

3. Schrodinger's time-dependent wave equation

$$\boxed{i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial x^2} + U\psi} \quad (5 \text{ marks}).$$

3 (b) Given

$$\Delta v = 1 \times 10^{-3} \text{ m/s}$$

$$\Delta p = m \cdot \Delta v$$

$$\Delta x \cdot \Delta p = \frac{h}{2} \rightarrow \Delta x = \frac{h}{2} \Delta p$$

(1 mark)

for electron

$$\Delta x = 5.8 \text{ cm}$$

(2 marks)

for ball

$$\Delta x = 8.8 \times 10^{-33} \text{ m}$$

(2 marks)

4. Particle in 1D box

Assumptions, Boundary condition & Diagram (2 marks)

Derivation $E_n = \frac{2n^2 h^2}{9 m L^2}$

(4 marks)

$$\psi_n = \sqrt{\frac{8}{3L}} \sin\left(\frac{4n\pi}{3L} \cdot x\right)$$

(4 marks).

5. (b) Given,

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

$$E = 9 \text{ eV}, V = 10 \text{ eV}, L = 5 \text{ nm}$$

$$T = \frac{16E(V-E)}{V^2} e^{-2kL}$$

where $k = \sqrt{\frac{2m_e(V-E)}{h^2}}$

$$k = 5.824 \times 10^9$$

$$T = \frac{16 \times 9 \times (10-9)}{100} \times e^{-2 \times 5.824 \times 10^9 \times 5 \times 10^{-9}}$$

$$= 1.44 \times e^{-52.5}$$

$$[e^y = 10^{y/2.303}]$$

$$T = 2.27 \times 10^{-23}$$

(3 marks)

if $T_p = T_e$ then, $E_p = E_e$

$$T_e = T_p \Rightarrow \sqrt{\frac{2m_e}{h^2}} L e = \sqrt{\frac{2m_p}{h^2}} L p$$

$$\sqrt{\frac{m_e}{m_p}} L e = L p$$

(2 marks)

51 5(9)

Quantum confinement effect

- Quantum confinement effect (QCE) is change in the electronic and optical properties of a material when its size is very small typically $< \text{nm}$.
- QCE happens when the particle size approaches de Broglie wavelength of electron wavefunction.
- This is a typical case of particle in a box.
- When the size of the bulk material is reduced, the energy band splits into discrete energy states.
- The band gap between valence band and conduction band increases as the size of the particle decreases.
- When the size of the particle is smaller, its band gap is larger, consequently its optical absorption is blue shifted towards higher energy. Hence, smaller particles appear blue while larger particles appear red.
- Also this increase in the energy band gap turns metals to semiconductors and semiconductors to insulators at nanoscale.