

## Questions in Quantum Physics — Assignment

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(Submit your solutions to all four questions to your tutor in Week 12)

1. The visible intensity threshold of a night-vision device is  $(4.0 \times 10^{-11} \text{ W/m}^2)$  at the wavelength of  $(600 \text{ nm})$ . If the light with this intensity and wavelength enters an eye and the pupil is open to its maximum diameter of  $8.5 \text{ mm}$ , how many photons per second enter the eye? (25 Marks)

$$I = 4 \times 10^{-11}$$

$$\begin{aligned} \text{Surface Area} &= \pi r^2 \\ &= \pi \times \left(\frac{8.5 \times 10^{-3}}{2}\right)^2 \\ &= 5.6745017 \times 10^{-6} \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Energy} &= \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}} \\ &= 3.98 \times 10^{-19} \text{ J} \end{aligned}$$

$$\text{Power} = \text{Intensity} \times \text{Surface Area} \quad (25 \text{ Marks})$$

$$= 5.6745017 \times 10^{-6} \times 4 \times 10^{-11}$$

$$= 2.2698 \times 10^{-16} \text{ W}$$

$$\text{number of photons (s}^{-1}\text{)}$$

$$\Rightarrow \frac{2.2698 \times 10^{-16}}{3.98 \times 10^{-19}} = 5705.73 \text{ s}^{-1}$$

~~2.2698~~ 5705 photons per second

2. A  $0.6 \text{ MeV}$  photon is scattered by a free electron initially at rest. After scattering, the scattering angle of the scattered photon is  $90^\circ$ .

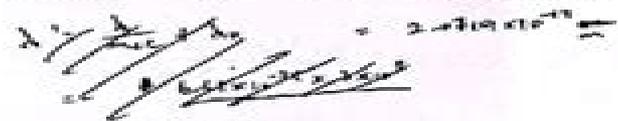
- (i) Determine the energy and the momentum of the scattered photon.  
 (ii) Determine the kinetic energy of the scattered electron.

(i) Compton Effect Equation:  $\rightarrow$  Scatter at  $90^\circ$  was normal

$$\lambda' - \lambda_0 = \frac{h}{mc} (1 - \cos \theta) \quad p = \frac{h}{\lambda}$$

$$\lambda' = \frac{h}{mc} (1 - \cos \theta) + \lambda_0$$

$$\theta = 90^\circ \quad \lambda_0 = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{0.6 \times 10^6 \times 1.6 \times 10^{19}} = 2.0719 \times 10^{-10} \text{ m}$$



$$\lambda' = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 3 \times 10^8} + 2.0719 \times 10^{-10}$$

$$= 4.4998 \times 10^{-10}$$

(25 marks)

$$p' = \frac{6.63 \times 10^{-34}}{4.4998 \times 10^{-10}}$$

$$= 1.472 \times 10^{-24} \text{ kg m s}^{-1}$$

$$E' = \frac{hc}{\lambda'}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.4998 \times 10^{-10}}$$

$$= 4.42 \times 10^{-16} \text{ J}$$

$$= 276385 \text{ eV} = 0.276 \text{ MeV}$$

(ii) Kinetic energy

$$= \text{Difference in energy} = 0.6 \text{ MeV} - 0.276 \text{ MeV}$$

$$= 0.324 \text{ MeV}$$

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**Hussin A.Rothana**



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### **Table of Contents Physics 12 Assignment Quantum Physics**

1. Understanding the eBook Physics 12 Assignment Quantum Physics
  - The Rise of Digital Reading Physics 12 Assignment Quantum Physics
  - Advantages of eBooks Over Traditional Books
2. Identifying Physics 12 Assignment Quantum Physics
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Physics 12 Assignment Quantum Physics
  - User-Friendly Interface
4. Exploring eBook Recommendations from Physics 12 Assignment Quantum Physics
  - Personalized Recommendations

- Physics 12 Assignment Quantum Physics User Reviews and Ratings
- Physics 12 Assignment Quantum Physics and Bestseller Lists
- 5. Accessing Physics 12 Assignment Quantum Physics Free and Paid eBooks
  - Physics 12 Assignment Quantum Physics Public Domain eBooks
  - Physics 12 Assignment Quantum Physics eBook Subscription Services
  - Physics 12 Assignment Quantum Physics Budget-Friendly Options
- 6. Navigating Physics 12 Assignment Quantum Physics eBook Formats
  - ePub, PDF, MOBI, and More
  - Physics 12 Assignment Quantum Physics Compatibility with Devices
  - Physics 12 Assignment Quantum Physics Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Physics 12 Assignment Quantum Physics
  - Highlighting and Note-Taking Physics 12 Assignment Quantum Physics
  - Interactive Elements Physics 12 Assignment Quantum Physics
- 8. Staying Engaged with Physics 12 Assignment Quantum Physics
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Physics 12 Assignment Quantum Physics
- 9. Balancing eBooks and Physical Books Physics 12 Assignment Quantum Physics
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Physics 12 Assignment Quantum Physics
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Physics 12 Assignment Quantum Physics
  - Setting Reading Goals Physics 12 Assignment Quantum Physics
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Physics 12 Assignment Quantum Physics
  - Fact-Checking eBook Content of Physics 12 Assignment Quantum Physics

- Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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