12.1 The Interaction of Matter with Radiation

Question Paper

Course	DP IB Physics
Section	12. Quantum & Nuclear Physics (HL only)
Topic	12.1 The Interaction of Matter with Radiation
Difficulty	Medium

Time allowed: 20

Score: /10

Percentage: /100

Question 1

A subatomic particle of mass m has an uncertainty in its position r, denoted by Δr. What is the uncertainty in its velocity, Δv?

A. $\frac{hm}{4\pi\Delta r}$

B. $\frac{h}{4\pi\Delta r}$

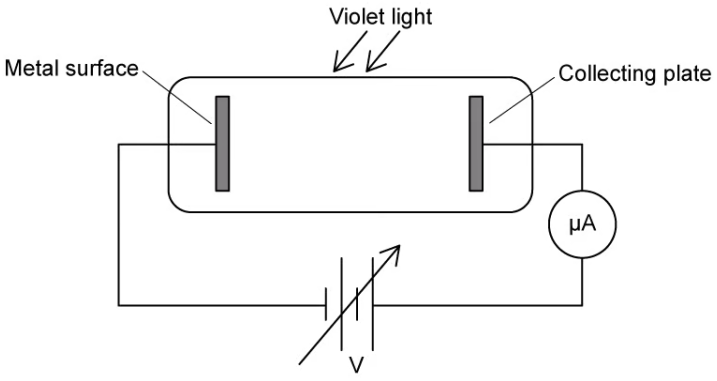
C. $\frac{h}{4\pi m\Delta r}$

D. $\frac{h}{4\pi}$

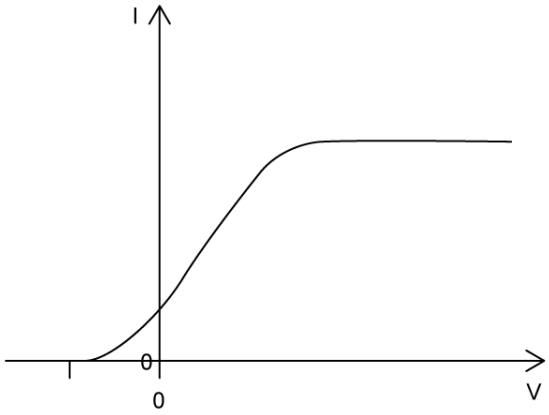
[1 mark]

Question 2

Violet light is incident on a metal surface, producing photoelectrons.

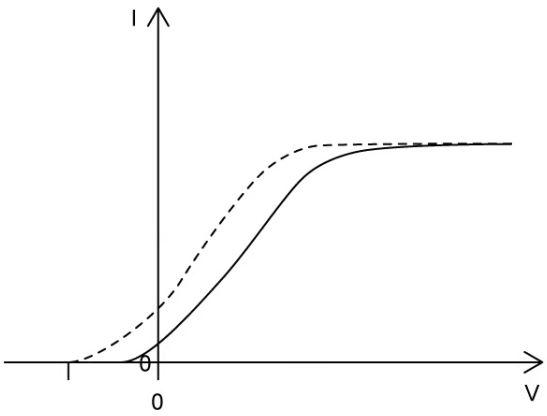


The variation of photocurrent *I* with potential difference *V* is shown.

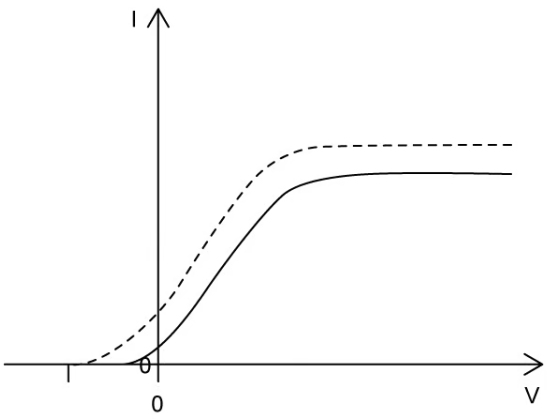


The light source is changed to red light of the same intensity as the violet light. Which graph shows the variation of photocurrent *I* with potential difference *V* for the red light? The results for the violet light are shown as a dashed line.

A.



B.



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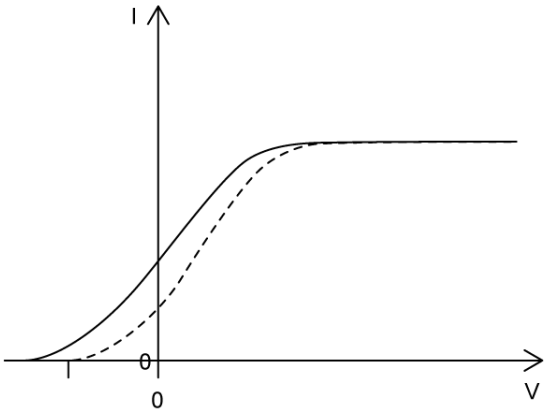
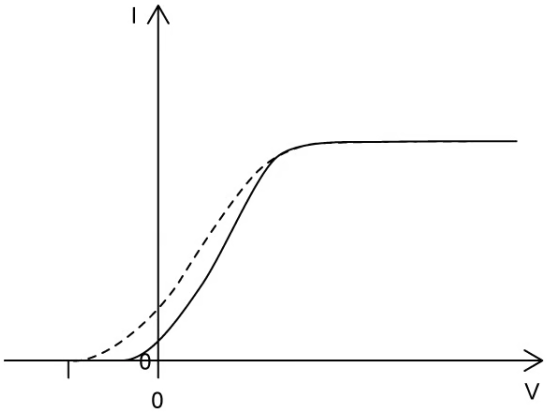


D.



[1 mark]

Question 3

Which expression is proportional to the probability of finding an electron in a particular region of space?

A. The magnitude of the wave function

B. The square of the magnitude of the wave function

C. $\frac{h}{4\pi \times uncertainty\ in\ momentum}$

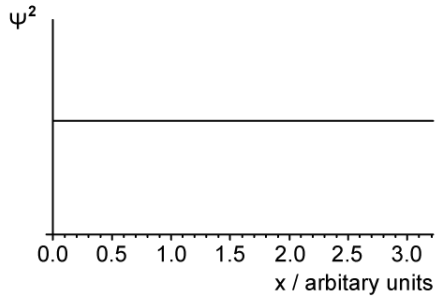
D. $\frac{h}{4\pi \times uncertainty\ in\ energy}$

[1 mark]

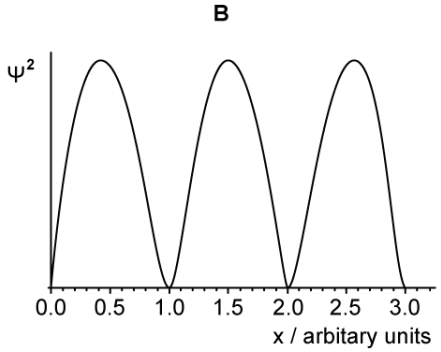
Question 4

The graphs show the variation with distance x of the square of the magnitude of the wave function, ψ^2, of a particle. Which graph corresponds to a particle with the largest uncertainty in momentum?

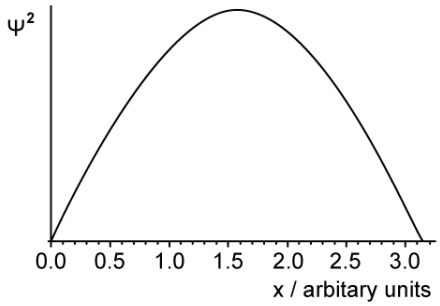
A



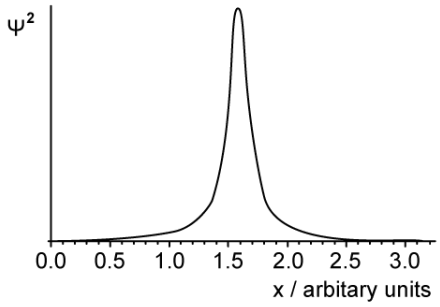
B



C



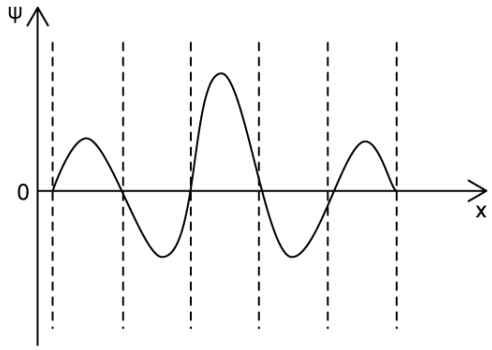
D



[1 mark]

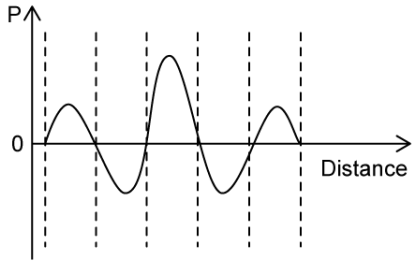
Question 5

The graph shows how the wave function Ψ of an electron varies with distance x.

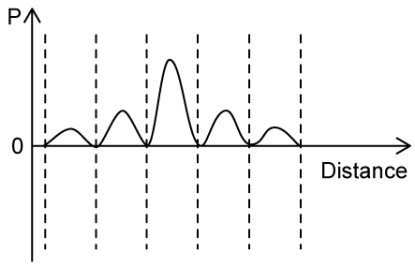


Which of the following graphs shows the probability $\mathbb{P}$ of finding the electron at each position along the distance x?

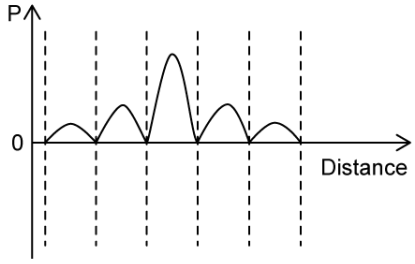
A



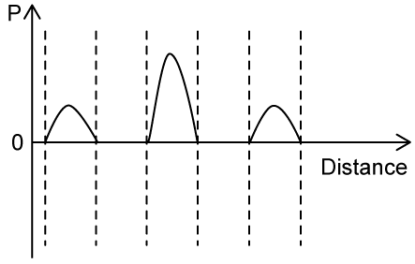
B



C



D



[1 mark]

Question 6

According to Heisenberg's uncertainty principle, conjugate quantities are pairs of quantities that cannot be known simultaneously with unlimited precision. What unit represents the product of two conjugate quantities?

A. $kg^2\,m\,s^{-1}$

B. $kg\,m^2\,s$

C. $kg\,m^2\,s^{-1}$

D. $kg\,m^2\,s^{-2}$

[1 mark]

Question 7

Alpha particles of mass *m* are accelerated from rest through a potential difference ΔV. Which of the following gives the de Broglie wavelength of the alpha particles as a result of the acceleration?

Use the following data:

- Planck's constant is *h*
- The magnitude of charge on an electron is e

A. $hm\Delta V$

B. $\sqrt{2hm\Delta Ve}$

C. $\sqrt{\dfrac{h}{m\Delta V}}$

D. $\dfrac{h}{\sqrt{4m\Delta Ve}}$

[1 mark]

Question 8

Which expression evaluates the de Broglie wavelength of an electron of mass *m* and charge e in the *n* = 2 state of hydrogen?

A. $\frac{h}{\sqrt{2me}}$

B. $\frac{h}{\sqrt{3.4me}}$

C. $\frac{h}{\sqrt{6.8me}}$

D. $\frac{h}{\sqrt{13.6me}}$

[1 mark]

Question 9

The electron wave function Ψ is a function of position and time. Which expression evaluates the probability of discovering the electron in some volume ΔV?

A. ψ

B. ψ^2

C. $|\psi|^2$

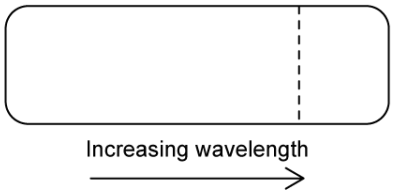
D. $|\psi|^2 \Delta V$

[1 mark]

Question 10

According to the Bohr model for hydrogen, visible light is emitted when electrons make transitions from excited states down to the state with $n = 2$.

The dotted line in the diagram represents such a transition, from $n = 3$ to $n = 2$, in the spectrum of hydrogen.

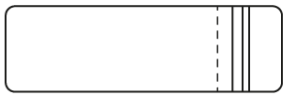


Which of the following diagrams could represent the visible light emission spectrum of hydrogen?

A

B

C



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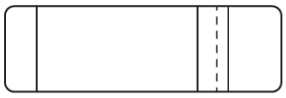

[1 mark]