# Quantum Physics – 2022 GCE Physics A Component 02

**1.** June/2022/Paper_H556/02/No.15

A gamma-ray photon of frequency $6.76 \times 10^{22}$ Hz creates a particle-antiparticle pair. The particle-antiparticle pair have zero kinetic energy.

What is the mass of the particle?

**A** $2.49 \times 10^{-28}$ kg

**B** $4.98 \times 10^{-28}$ kg

**C** $7.47 \times 10^{-20}$ kg

**D** $4.48 \times 10^{-11}$ kg

Your answer ☐ **[1]**

**2.** June/2022/Paper_H556/02/No.10

A proton of mass $1.67 \times 10^{-27}$ kg is travelling at a speed of $2.0 \times 10^{5}$ m s$^{-1}$.

The table below shows the mass and speed of four particles **A**, **B**, **C** and **D**.

| Particle | Mass / kg | Speed / $10^5$ m s$^{-1}$ |
|---|---|---|
| **A** | $9.11 \times 10^{-30}$ | 5.0 |
| **B** | $8.80 \times 10^{-28}$ | 3.0 |
| **C** | $2.49 \times 10^{-28}$ | 2.0 |
| **D** | $3.34 \times 10^{-27}$ | 1.0 |

Which particle has the same de Broglie wavelength as the proton?

Your answer ☐ **[1]**

**3.** June/2022/Paper_H556/02/No.17

A light-emitting diode (LED) can be used to determine the Planck constant $h$. When the LED just starts to emit light, the equation below is valid

$$eV = \frac{hc}{\lambda}$$

where $V$ is the potential difference (p.d.) across the LED, $\lambda$ is the wavelength of the light emitted, $c$ is the speed of light in vacuum and $e$ is the elementary charge.

**(a)** In the equation above, $\frac{hc}{\lambda}$ is the energy of a photon emitted from the LED.

Determine the S.I. base units for $h$.

base units = ..... **[2]**

**(b)*** Describe how an experiment can be carried out in the laboratory to determine $h$ from a graph. Your description must include how $V$ and $\lambda$ are accurately determined. Assume that the values of $e$ and $c$ are known. **[6]**

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**4.** June/2022/Paper_H556/02/No.19

The diagram below shows two parallel plates, **E** and **C**, in an evacuated glass tube.

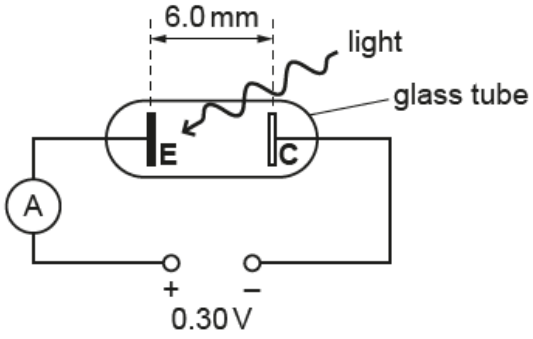



Plate **E** is made from potassium, which is sensitive to light. Plate **C** is not sensitive to light.

The separation between the plates is 6.0 mm and the potential difference between the plates is 0.30 V.

Light of frequency $6.3 \times 10^{14}$ Hz is incident on plate **E**. The photoelectrons emitted from this plate have **maximum** kinetic energy 0.30 eV ($4.8 \times 10^{-20}$ J). The photoelectrons are repelled by the negative plate **C**. The ammeter reading is zero because these photoelectrons reach plate **C** with zero kinetic energy.

**(a)** Calculate the work function of potassium in eV.

work function = ..... eV **[3]**

**(b)** This question is about a photoelectron emitted perpendicular to plate **E** and with an initial kinetic energy of $4.8 \times 10^{-20}$ J.

**(i)** Show that the magnitude of deceleration of this photoelectron is $8.8 \times 10^{12}$ m s$^{-2}$.

**[3]**

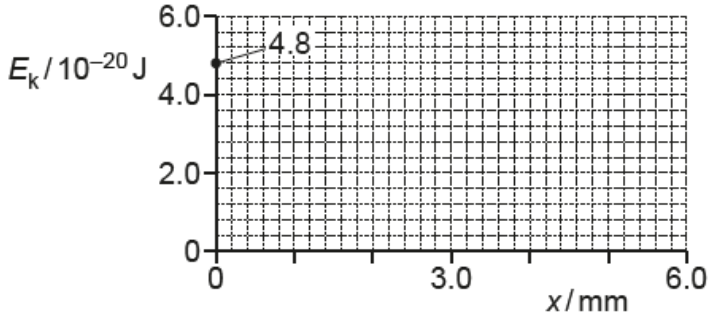
**(ii)** Show that the initial speed of the photoelectron is about $3 \times 10^5\,\text{m s}^{-1}$.

**[2]**

**(iii)** Calculate the time $t$ taken by the photoelectron to travel from plate **E** to plate **C**.

$t$ = ..... s **[2]**

**(iv)** Using the axes shown below, sketch a graph of kinetic energy $E_k$ against distance $x$ from plate **E**.




**[2]**

**(c)** Explain, in terms of photons, what happens to the ammeter reading when light of frequency greater than $6.3 \times 10^{14}$ Hz is now incident on plate **E**.

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