Quantum Physics – 2021/20 GCE Physics A Component 02

1. Nov/2021/Paper_H556_02/No.17

(a) Define the **work function** of a metal.

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..... **[1]**

(b) The work function of potassium is 2.3 eV.

(i) Potassium emits electrons from its surface when blue light is incident on it. Extremely intense red light produces no electrons.

Explain these observations in terms of photons and their energy.

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..... **[4]**

(ii) Light from a laser is incident on some potassium in a vacuum. Electrons are emitted. The wavelength of the light is 320 nm.

Calculate the shortest de Broglie wavelength of the emitted electrons.

de Broglie wavelength = ... m **[4]**

2. Nov/2020/Paper_H556_02/No.3

Electromagnetic radiation is incident on a metal of work function 2.3 eV.
The maximum kinetic energy (KE) of the photoelectrons is 1.7 eV.

The frequency of this incident electromagnetic radiation is kept the same but its intensity is doubled.

What is the maximum KE of the photoelectrons now?

A 1.7 eV

B 2.9 eV

C 3.4 eV

D 4.0 eV

Your answer ☐ **[1]**

3. Nov/2020/Paper_H556_02/No.15

What can be deduced from the diffraction of electrons by a thin film of graphite?

A Electrons are leptons.

B Electrons are negatively charged.

C Electrons interact with atoms on a one-to-one basis.

D Electrons travel as waves.

Your answer ☐ **[1]**

4. Nov/2020/Paper_H556_02/No.17

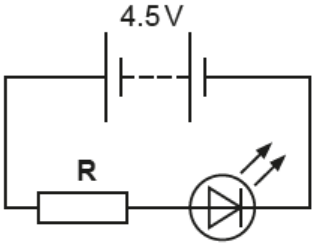
A light-emitting diode (LED) emits red light when it is positively biased and has a potential difference (p.d.) greater than about 1.8 V.

(a) The energy of a photon of red light is about 1.8 eV.

Calculate the wavelength λ of this red light.

λ = ... m **[3]**

(b) The LED is connected into a circuit, as shown below.

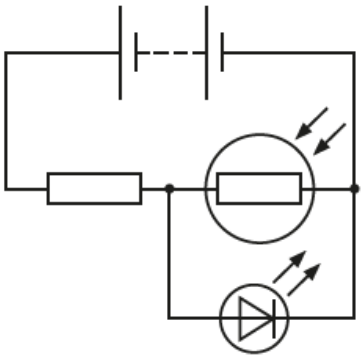


The battery has electromotive force (e.m.f.) 4.5 V and negligible internal resistance.
The resistor **R** has resistance 150 Ω.
Assume the p.d. across the LED is 1.8 V.

Calculate the ratio $\frac{\text{power dissipated by LED}}{\text{power dissipated by resistor}}$.

ratio = ... **[2]**

(c) The diagram below shows a circuit designed by a student.



The LED is very close to, and facing the light dependent resistor (LDR).
The circuit is taken into a dark room.

(i) The student thought that the LED would switch on.
Instead, the LED was found to repeatedly switch on and off.

Explain this behaviour of the LED in this potential divider circuit.

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..... **[2]**

(ii) Suggest a possible refinement so that the LED switches on permanently when taken into the dark room.

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..... **[1]**

5. Nov/2020/Paper_H556_02/No.19

(a) The Planck constant h is an important fundamental constant in quantum physics.

Determine the S.I. base units for h.

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

(b) A researcher is investigating the de Broglie wavelength of charged particles.

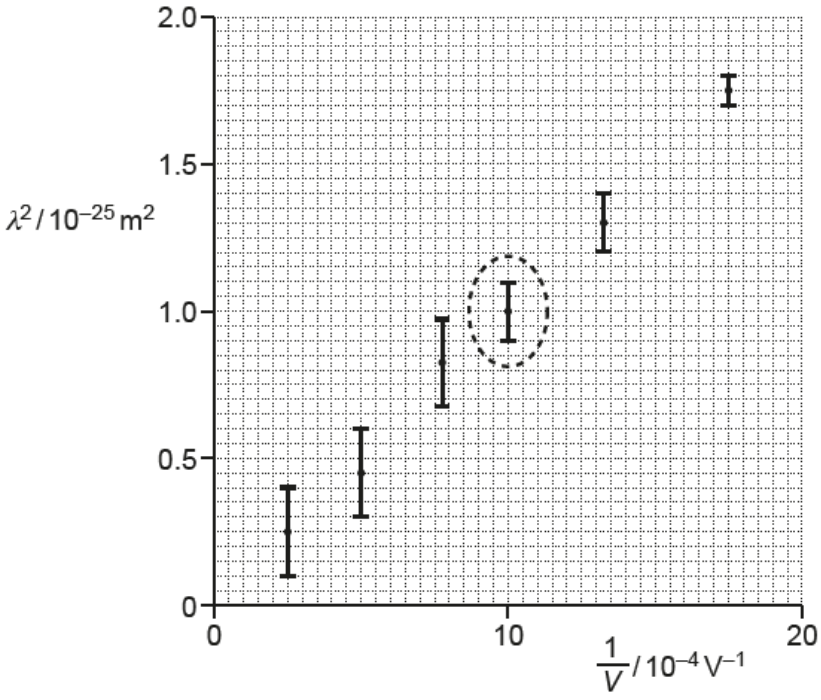
The charged particles are accelerated through a potential difference V. The de Broglie wavelength λ of these particles is then determined by the researcher.

Each particle has mass m and charge q.

(i) Show that the de Broglie wavelength λ is given by the expression $\lambda^2 = \frac{h^2}{2mq} \times \frac{1}{V}$.

[2]

(ii) The researcher plots data points on a λ^2 against $\frac{1}{V}$ grid, as shown below.



1 Calculate the percentage uncertainty in λ for the data point circled on the grid.

percentage uncertainty = ... % **[2]**

2 Draw a straight line of best fit through the data points. **[1]**

3 The charge q on the particle is $2e$, where e is the elementary charge.

Use your best fit straight line to show that the mass m of the particle is about 10^{-26} kg.

[4]