Questions

Einstein's photoelectric equation states

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

The term $\frac{1}{2}mv^2_{max}$ represents which of the following quantities?

- ☐ **A** energy of photoelectron
- ☐ **B** energy of photon
- ☐ **C** ionisation energy
- ☐ **D** work function

(Total for question = 1 mark)

* In a fluorescent lighting tube, electrons with a range of kinetic energies collide with atoms of mercury vapour. These atoms are initially in their ground state. As a result of these collisions, some of the atoms emit photons.

Explain what is meant by the ground state of an atom and why photons are emitted.

(6)

In the late 1880s it was discovered that a negatively-charged zinc plate loses its charge when exposed to ultraviolet radiation.

Explain why this happens, but only with ultraviolet radiation and not white light. You are expected to complete a calculation to support your answer.

work function of zinc = 6.9×10^{-19} J

(6)

(ii) Calculate the distance to a galaxy with a redshift $z = 0.12$

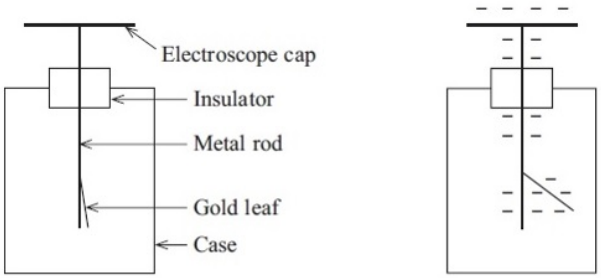
$H_0 = 2.1 \times 10^{-18}\ s^{-1}$

(2)

*(c) Discuss how astronomers were led to propose the existence of dark matter and the consequences of its existence for the ultimate fate of the universe.

(3)

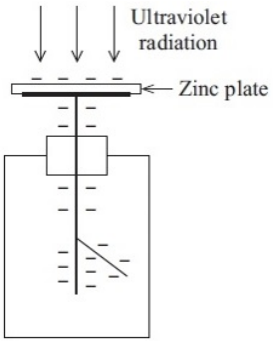
A gold leaf electroscope is used to detect very small amounts of charge. When the electroscope cap is negatively charged, electrons spread along the metal rod and the gold leaf so they both become negatively charged. The rod and leaf repel each other, so the gold leaf rises up.



Uncharged electroscope

Charged electroscope

A gold leaf electroscope can be used to demonstrate the photoelectric effect. A clean zinc plate is placed onto the cap of the electroscope and the plate and electroscope are charged negatively. Ultraviolet radiation is shone onto the zinc plate.



*(a) The gold leaf slowly falls.

Explain, with reference to the work function of zinc, why this happens.

(b) Why is the effect not observed if the ultraviolet radiation is replaced by visible light?

(1)

(c) Ultraviolet radiation of wavelength 2.00×10^{-7} m is shone onto the zinc plate.

Calculate the maximum speed of the electrons emitted from the plate.

work function of zinc = 6.88×10^{-19} J

(4)

(d) The source of ultraviolet radiation is moved further away from the zinc plate.

State what will happen to the maximum speed of the electrons emitted from the plate. Justify your answer.

(2)

*(b) Explain why the following observations may be understood by using a photon model of light, rather than a wave model.

- Light above a certain frequency causes the emission of electrons from the surface of a metal. This emission occurs instantaneously.
- Light below a certain frequency will not result in the emission of electrons however long it illuminates the surface.

(5)

Select one answer from A to D and put a cross in the box (☒)

The magnitude of the fractional change in frequency, $\Delta f/f$, produced in the Doppler effect depends upon

☒ **A** the relative velocity of the source and the observer.

☒ **B** the wavelength of the radiation being emitted by the source.

☒ **C** whether it is the source or the observer that is moving.

☒ **D** whether the source and observer are approaching or receding.

(Total for Question = 1 mark)

Select one answer from A to D and put a cross in the box (☒)

Current theories give a number of alternatives for the future evolution of our universe. According to current theory, an open universe

☒ **A** eventually reaches a maximum size.

☒ **B** expands forever.

☒ **C** has an unpredictable future.

☒ **D** is a steady state universe.

(Total for Question = 1 mark)

*(b) Radiation received at the Earth from a distant galaxy is redshifted. The distance to the galaxy can be determined from this redshift.

State what is meant by redshift, and explain how it allows the distance to the galaxy to be determined.

(4)