The Photoelectric Effect

1.

(a) In an experiment, an electrically insulated zinc plate is negatively charged. When exposed to a weak ultra-violet source, the plate starts to lose its negative charge.

Explain this phenomenon in terms of the photoelectric effect. Suggest how increasing the intensity of the ultra-violet source would affect the experiment.

(You will be awarded marks for the quality of written communication in your answer to this question.)

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.... [7]

(b) A 1.0 mW laser produces red light of wavelength 6.3×10^{-7} m.

(i) Calculate

1. the frequency of the radiation,

frequency = ... unit .... [3]

2. the energy of a photon of red light.

energy = ... J [2]

(ii) Calculate the number of photons emitted per second by the laser.

number = ... s^{-1} [2]

(iii) State how, and explain why, the number of photons emitted per second would change if the 1.0 mW laser produced blue light.

....

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.... **[2]**

2.

(a) Einstein's photoelectric equation may be written as

$$hf = \phi + \tfrac{1}{2}mv_{max}^2$$

Identify the terms

hf ....

ϕ ....

$\tfrac{1}{2}mv_{max}^2$ .... **[3]**

(b) The surface of sodium metal is exposed to electromagnetic radiation of wavelength 6.5×10^{-7} m. This wavelength is the maximum for which photoelectrons are released.

(i) Calculate the threshold frequency.

frequency = ... unit: .... **[3]**

(ii) Show that the work function energy of the metal is 1.9 eV.

[3]

(c) For a particular wavelength of incident light, sodium releases photoelectrons. State how the rate of release of photoelectrons changes when the intensity of light is doubled. Explain your answer.

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.... [2]

3.

(a) The concept of the photon was important in the development of physics throughout the last century. Explain what is meant by a photon.

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....[1]

(b) Fig. 7.1 shows a photocell.

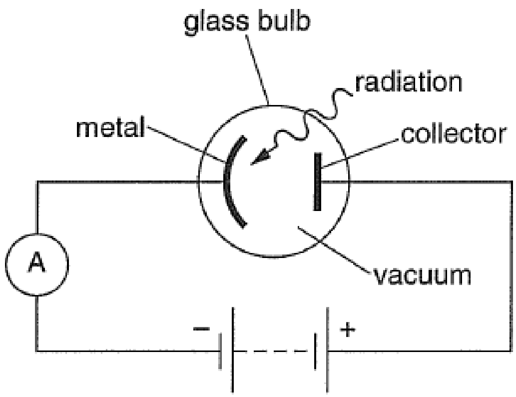

Fig. 7.1

When the metal surface is exposed to electromagnetic radiation, photoelectrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current.

(i) For a certain frequency and intensity of radiation, the ammeter shows a current of 1.2×10^{-7} A. Calculate

1. the charge reaching the collector in 5.0 s

charge = ... C

2. the number of photoelectrons reaching the collector in 5.0 s.

number of electrons = ...
[3]

(ii) The work function energy of the metal is 3.5×10^{-19} J and the incident radiation has frequency 7.0×10^{14} Hz. Calculate the maximum kinetic energy of an ejected photoelectron.

energy = ... J [3]

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State the effect this has on each of the following

1. the energy of each photon

....

....

2. the maximum kinetic energy of each photoelectron

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3. the current in the photocell.

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....
[3]

4.

(a) In atomic and nuclear physics, the electronvolt (eV) is a convenient unit of energy. Define one electronvolt and state its value in joules.

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....[2]

(b) Insert the missing words in the following passage describing some important aspects of the photoelectric effect.

In the photoelectric effect, a single photon interacts with a single electron at the surface of the metal. In this interaction, ... is conserved. Albert Einstein summarised this interaction in terms of his famous Nobel prize-winning equation

$$hf = \phi + \tfrac{1}{2} m v_{max}^2$$

where hf is the energy of the .... , ϕ is the work function energy of the metal and $\tfrac{1}{2} m v_{max}^2$ is the maximum kinetic energy of the ....

[3]

(c) When the surface of a particular metal is exposed to a weak source of electromagnetic radiation of wavelength 3.2×10^{-7} m, electrons of **negligible** kinetic energy are released from the metal.

(i) Calculate the work function energy of the metal in joules and in electronvolts (eV).

work function energy = ... J

work function energy = ... eV [4]

(ii) Describe the effect on the electrons when the incident radiation is of longer wavelength.

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....[2]