Exercise walk-through

The Photoelectric Effect ▪ 15.5

eXercise

You must be able to

- describe the **photoelectric effect 光电效应**: light ejecting electrons from a metal
- apply the photoelectric equation $E = hf = \phi + KE_{max}$ with the **work function 功函数** ϕ
- explain why a **threshold frequency 截止频率** exists

Method — The photoelectric effect

Light shining on a metal can eject electrons, but only if each **photon** carries enough energy.

Method — The photoelectric equation

$hf = \phi + KE_{max}$, where ϕ (the work function) is the minimum energy to free an electron, and KE_{max} is the most kinetic energy an ejected electron can have.

Method — Threshold frequency

Below a threshold frequency f_0 (where $hf_0 = \phi$), **no** electrons are emitted, however bright the light — direct evidence that light is quantized.

Practice 2.1 ▪ 1 mark

State what the photoelectric effect is.

Solution 2.1

Method: The photoelectric effect

Worked steps

light ejecting electrons from the surface of a metal B1.

Practice 2.2 ▪ 1 mark

Define the work function of a metal.

Solution 2.2

Method: The photoelectric equation

Worked steps

the minimum energy needed to free an electron from the metal B1.

Practice 2.3 ▪ 2 marks

A metal has a work function of 2.0 eV. A photon of 5.0 eV strikes it. Find the maximum kinetic energy of the ejected electron.

Solution 2.3

Method: The photoelectric equation

Worked steps

$KE_{max} = hf - \phi = 5.0 - 2.0 = 3.0$ eV **M1** **A1**.

Exam-style 3.1 ▪ 1 mark

The photoelectric equation is

A $hf = \phi + KE_{max}$

B $E = mc^2$

C $E = \frac{1}{2}mv^2$

D $\lambda = h/p$

Solution 3.1

Method: The photoelectric equation

A $hf = \phi + KE_{max}$ ✓

B $E = mc^2$

C $E = \frac{1}{2}mv^2$

D $\lambda = h/p$

Worked steps

A.

Exam-style 3.2 ▪ 1 mark

Below the threshold frequency, the number of electrons emitted is

A at its maximum

B zero

C half the usual

D steadily increasing

Solution 3.2

Method: Threshold frequency

A at its maximum

B zero ✓

C half the usual

D steadily increasing

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

Light of photon energy 4.0 eV strikes a metal of work function 2.5 eV.
(a) Find the maximum kinetic energy of an ejected electron.
(b) Explain why even very dim light of this frequency still ejects electrons.

Solution 3.3

Method: The photoelectric equation

Worked steps

(a) $KE_{max} = 4.0 - 2.5 = 1.5$ eV M1 A1. (b) each photon has enough energy on its own to free an electron, so even a few photons (dim light) eject some — brightness only changes how many B1 B1.