Unit 21 · Photons

HARDER PRACTICE QUESTIONS

Full marks 32

Write your answers on separate paper. Show your working. Take h = 6.63×10^{-34} J s, c = 3.0×10^{8} m/s, e = 1.6×10^{-19} C and the mass of an electron 9.1×10^{-31} kg.

1 Spot the error [3]

Find the mistake in the working and correct it.

Light of frequency 7.5×10^{14} Hz falls on a metal of work function 2.0 eV. Sarita wrote: "$E_k = hf - \varphi = 6.63 \times 10^{-34} \times 7.5 \times 10^{14} - 2.0 = -2.0$ J, so no electrons come out."

2 Read the data [4]

Rabin measured the stopping potential for a metal at several frequencies.

f (10^{14} Hz)	5.5	6.0	7.0	8.0	9.0
V_s (V)	0.22	0.42	0.84	1.25	1.67

i. Find the slope of the graph of V_s against f.
ii. Find Planck's constant from it.
iii. Find the threshold frequency and the work function.
iv. What would light of 4.5×10^{14} Hz do?

3 Predict, then explain [3]

Write your prediction first, then explain it.

Light falls on a photocell and gives a current. Its frequency is raised, both frequencies above the threshold, while its power (energy each second) is kept the same. Predict what happens to i. the greatest kinetic energy of the photoelectrons, ii. the saturation current. Then explain.

4 Show that [3]

Show that a metal's threshold wavelength in nanometers is about 1240 divided by its work function in electron volts. Use it to find the threshold wavelength of a metal of work function 3.1 eV.

5 Estimate it [3]

Bright sunlight brings about 1000 W to each square meter. Taking an average photon energy of about 2 eV, estimate how many photons fall on a 1 m^2 solar panel each second. Why can't we see light arriving in packets?

6 Which explanation fits? [2]

Photoelectrons appear within a billionth of a second of the light being switched on, even in very dim light. Explanation A: the light is a wave whose energy builds up in the electrons until they can escape. Explanation B: the light comes as photons, each giving all its energy to one electron. Which fits? Why?

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Anup wrote: "Any light will free electrons if it is bright enough. The photoelectrons all leave with the same kinetic energy. The work function is the same for every metal."

8 Work backwards [3]

Light of wavelength 380 nm frees electrons from a metal, the fastest at 6.0×10^5 m/s. Find the metal's work function in eV.

9 Design it [4]

Kriti is making a door sensor that must respond to the beam of a blue LED (450 nm) but not to the red light (650 nm) of a lamp in the room. She can make the photocell's emitter of cesium ($\varphi = 1.9$ eV), lithium (2.5 eV) or copper (4.5 eV).

i. Find the photon energy of each light in eV.
ii. Which metal should she use? Why not the other two?
iii. What stopping potential would the blue beam give with her metal?

10 What if? [2]

What if the light on a photocell is made twice as bright and, at the same time, its frequency is lowered a little (still above the threshold)? Say what happens to the stopping potential and the saturation current.

11 Make your own [2]

Write a photoelectric problem whose answer is "the stopping potential is 1.5 V". Solve it to show it works.