

Exercise walk-through

2.5

Photons, photoelectric effect and spectra (statements 57–63)

Pearson Edexcel · International A-Level · Physics

Intensity needs an area conversion

- 1 **Convert** $A = 25 \times 10^{-4} = 0.0025 \text{ m}^2$
- 2 **Incident** $P = IA = 800 \times 0.0025 = 2.0 \text{ W}$
- 3 **Useful** $P_{out} = \eta P = 0.20 \times 2.0 = 0.40 \text{ W}$

Decision

A 0.50 W device cannot run from this useful output.

Frequency and intensity change different things

Change	Photon energy	Maximum electron energy
Intensity rises; frequency fixed	Unchanged	Unchanged
Frequency rises	Increases	Increases above threshold

Exercises 2.1·2.2

2.1 A photon has frequency 6.0×10^{14} Hz. Calculate energy in joules and electronvolts. Use $h = 6.63 \times 10^{-34}$ J s, $e = 1.60 \times 10^{-19}$ C. [3]

photon



$$f = 6.0 \times 10^{14} \text{ Hz}$$

2.2 A surface has work function 2.4 eV. Calculate threshold frequency. Explain why increasing intensity below threshold does not cause ordinary single-photon emission. [3]

surface



$$\phi = 2.4 \text{ eV}$$

Exercises 2.1·2.2

2.1 A photon has frequency 6.0×10^{14} Hz. Calculate energy in joules and electronvolts. Use $h = 6.63 \times 10^{-34}$ J s, $e = 1.60 \times 10^{-19}$ C. [3]

photon



$$f = 6.0 \times 10^{14} \text{ Hz}$$

2.1 $E = hf$. $E = 6.63 \times 10^{-34} \times 6.0 \times 10^{14} = 3.98 \times 10^{-19}$ J. $E/(1.60 \times 10^{-19}) = 2.49$ eV.

2.2 A surface has work function 2.4 eV. Calculate threshold frequency. Explain why increasing intensity below threshold does not cause ordinary single-photon emission. [3]

surface



$$\phi = 2.4 \text{ eV}$$

2.2 $\phi = 2.4 \times 1.60 \times 10^{-19} = 3.84 \times 10^{-19}$ J. $f_0 = \phi/h = 5.79 \times 10^{14}$ Hz. Each photon

Exercises 2.3·3.1

2.3 An atom has allowed levels -6.0 , -3.0 and -1.0 eV. Electrons can start in the upper level and cascade. State the three possible emitted photon energies and identify the shortest-wavelength transition. [3]

_____	-1.0 eV	_____
_____	-3.0 eV	_____
_____	-6.0 eV	_____

3.1 For one surface above threshold, explain the effects of (a) doubling intensity at constant frequency; (b) increasing frequency at constant intensity. Discuss maximum kinetic energy and photon arrival rate. [4]

Exercises 2.3·3.1

2.3 An atom has allowed levels -6.0 , -3.0 and -1.0 eV. Electrons can start in the upper level and cascade. State the three possible emitted photon energies and identify the shortest-wavelength transition. [3]

_____ -1.0 eV

_____ -3.0 eV

_____ -6.0 eV

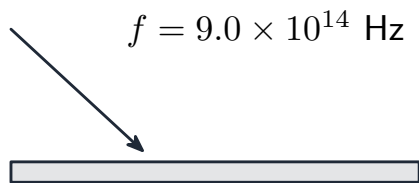
2.3 Allowed downward differences are 2.0 , 3.0 and 5.0 eV. The -1.0 to -6.0 eV transition has largest photon energy and thus shortest wavelength.

3.1 For one surface above threshold, explain the effects of (a) doubling intensity at constant frequency; (b) increasing frequency at constant intensity. Discuss maximum kinetic energy and photon arrival rate. [4]

3.1 (a) Photon energy is unchanged, so maximum electron kinetic energy is unchanged; photon arrival rate doubles, increasing available emissions per second. (b) $E_{k,max} = hf - \phi$ increases; at fixed incident power/intensity, each photon costs more energy, so photon arrival rate decreases. Photocurrent also depends on collection and material response; do not infer a fixed current ratio from frequency alone.

Exercise 3.2

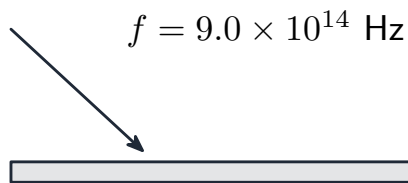
3.2 Light of frequency 9.0×10^{14} Hz reaches a surface of work function 2.0 eV. Calculate maximum kinetic energy and stopping potential. Explain how a kinetic-energy–frequency graph gives Planck’s constant and threshold frequency, and why the wave model was revised. [6]



$$\phi = 2.0 \text{ eV}$$

Exercise 3.2

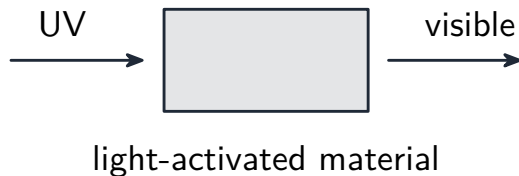
3.2 Light of frequency 9.0×10^{14} Hz reaches a surface of work function 2.0 eV. Calculate maximum kinetic energy and stopping potential. Explain how a kinetic-energy–frequency graph gives Planck’s constant and threshold frequency, and why the wave model was revised. [6]



3.2 Convert $\phi = 3.20 \times 10^{-19}$ J. $E_{k,max} = hf - \phi$, giving 2.77×10^{-19} J. $V_s = E_{k,max}/e =$

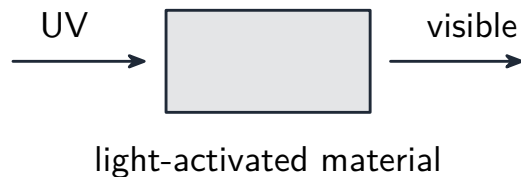
Exercise 3.3

3.3 A light-activated material absorbs ultraviolet photons and then emits visible light. Explain why this alone does not prove photoelectric emission. Name two observations that support a photon explanation of photoelectric emission, and one observation that supports the wave description of light. [4]



Exercise 3.3

3.3 A light-activated material absorbs ultraviolet photons and then emits visible light. Explain why this alone does not prove photoelectric emission. Name two observations that support a photon explanation of photoelectric emission, and one observation that supports the wave description of light. [4]



3.3 Absorption and re-emission can involve bound-electron energy-level transitions without an electron leaving the surface. A threshold frequency even at high intensity supports photons; prompt emission above threshold at low intensity or maximum electron energy increasing with frequency rather than intensity also supports photons. Interference, diffraction or polarisation supports the wave description.