



ANSWER BOOK

The photoelectric effect

Quantum phenomena · Year 12

AQA 3.2.2.1 · CIE 22.1, 22.2 · OCR A 4.5.1, 4.5.2

10 questions · 30 marks

NAVY EDITION

SECTION A · Warm-up

- A1** Any of: emission is instantaneous even in very dim light; there is a threshold frequency below which no electrons are emitted whatever the intensity; the maximum kinetic energy depends on frequency, not on intensity. [2]
- A2** $E = hf = 6.63 \times 10^{-34} \times 5.0 \times 10^{14} = 3.31 \times 10^{-19} \text{ J}$. [2]
- A3** The work function is the minimum energy needed to release an electron from the surface of the metal. [2]

SECTION B · Standard

- B1** At the threshold, $hf_0 = \phi$, so $f_0 = \phi/h = (3.2 \times 10^{-19})/(6.63 \times 10^{-34}) = 4.83 \times 10^{14} \text{ Hz}$. [3]
- B2** (a) $E_{k(\max)} = hf - \phi = 6.63 \times 10^{-34} \times 8.0 \times 10^{14} - 3.0 \times 10^{-19} = 2.30 \times 10^{-19} \text{ J}$. (b) $v = \sqrt{(2E_k/m)} = 7.11 \times 10^5 \text{ m s}^{-1}$. [4]
- B3** $E = (3.32 \times 10^{-19})/(1.60 \times 10^{-19}) = 2.07 \text{ eV}$. [3]
- B4** $eV_s = E_{k(\max)}$, so $V_s = E_{k(\max)}/e = (2.30 \times 10^{-19})/(1.60 \times 10^{-19}) = 1.44 \text{ V}$. [3]

SECTION C · Stretch

- C1** $\phi = 2.0 \times 1.60 \times 10^{-19} = 3.20 \times 10^{-19} \text{ J}$. $\lambda_0 = hc/\phi = (6.63 \times 10^{-34} \times 3.0 \times 10^8)/3.20 \times 10^{-19} = 622 \text{ nm}$. [4]
- C2** Photon energy $E = hc/\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8)/(400 \times 10^{-9}) = 4.97 \times 10^{-19} \text{ J}$. (a) $E_{k(\max)} = E - \phi = 4.97 \times 10^{-19} - 3.20 \times 10^{-19} = 1.77 \times 10^{-19} \text{ J}$. (b) $V_s = E_{k(\max)}/e = 1.11 \text{ V}$. [4]
- C3** Each electron is emitted by absorbing a single photon, and a photon's energy depends only on frequency ($E = hf$). Increasing intensity delivers more photons per second, so more electrons are emitted, but each still carries the same energy, so the maximum kinetic energy is unchanged. [3]