



ANSWER BOOK

Collisions of electrons with atoms

Quantum phenomena · Year 12

AQA 3.2.2.2 · CIE 22.4 · OCR A 5.5.2

10 questions · 30 marks

NAVY EDITION

SECTION A · Warm-up

- A1** Excitation lifts an electron to a higher energy level within the atom; ionisation gives the electron enough energy to be removed from the atom completely. [2]
- A2** $3.4 \text{ eV} = 3.4 \times 1.60 \times 10^{-19} = 5.44 \times 10^{-19} \text{ J}$. [2]
- A3** $(8.0 \times 10^{-19}) / (1.60 \times 10^{-19}) = 5.0 \text{ eV}$. [2]

SECTION B · Standard

- B1** One electronvolt is the energy gained by an electron accelerated through a potential difference of one volt. $12.1 \text{ eV} = 12.1 \times 1.60 \times 10^{-19} = 1.94 \times 10^{-18} \text{ J}$. [3]
- B2** $E_k = eV = 1.60 \times 10^{-19} \times 5.0 = 8.00 \times 10^{-19} \text{ J}$. $v = \sqrt{(2E_k/m)} = 1.33 \times 10^6 \text{ m s}^{-1}$. [3]
- B3** Yes: 6.0 eV exceeds 4.9 eV, so excitation occurs. The electron loses 4.9 eV, keeping 6.0 - 4.9 = 1.1 eV = $1.76 \times 10^{-19} \text{ J}$. [4]
- B4** $E_k = 13.6 \text{ eV} = 2.18 \times 10^{-18} \text{ J}$. $v = \sqrt{(2E_k/m)} = 2.19 \times 10^6 \text{ m s}^{-1}$. [3]

SECTION C · Stretch

- C1** Accelerated electrons collide with mercury atoms, exciting or ionising them. As the excited atoms de-excite they emit ultraviolet photons. These strike the phosphor coating on the tube, which absorbs them and re-emits the energy as visible light. [4]
- C2** The electron carries 12 eV, so both excitations (4.9 eV and 6.7 eV) are possible. For the 4.9 eV transition: $f = E/h = (4.9 \times 1.60 \times 10^{-19}) / (6.63 \times 10^{-34}) = 1.18 \times 10^{15} \text{ Hz}$, so $\lambda = c/f = 254 \text{ nm}$. [4]
- C3** The atom can only accept energy in the exact amounts that lift an electron between its energy levels. An electron with less than the first excitation energy cannot supply a whole step, so no energy is absorbed and the collision is elastic: the electron continues with its kinetic energy essentially unchanged. [3]