

Solutions

These allocations are for the original questions on this sheet. B1 = one standalone point, M1 = one method point, A1 = one accuracy point.

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 $\phi = 2.4 \times 1.60 \times 10^{-19} = 3.84 \times 10^{-19}$ J. $f_0 = \phi/h = 5.79 \times 10^{14}$ Hz. Each photon still has too little energy; intensity increases photon number, not each photon's energy.

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 (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.

3.2 Convert $\phi = 3.20 \times 10^{-19}$ J. $E_{k,max} = hf - \phi$, giving 2.77×10^{-19} J. $V_s = E_{k,max}/e = 1.73$ V. The straight graph has gradient h and frequency intercept f_0 . Threshold and prompt emission at low intensity cannot be explained by the simple continuous-energy wave model but follow single-photon absorption.

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.