

Option B — Quantum Physics and Nuclear Physics

B1. (a) all particles/bodies have wave properties/an associated wavelength;
 the wavelength is given by $\lambda = \frac{h}{p}$ where p is momentum and h the Planck constant; [2]

(b) momentum = $80 \times 5.0 = 400 \text{ N s}$;
 $\lambda = \left(\frac{6.6 \times 10^{-34}}{400} \right) = 1.7 \times 10^{-36} \text{ m}$; [2]

B2. (a) (i) whenever a charged particle is accelerated it radiates e.m. radiation / *OWTTE*;
due to collision with target atoms accelerations of all different magnitudes
 result so many different wavelengths produced / *OWTTE*; [2]

(ii) characteristic spectra results from accelerated electrons ejecting electrons
 from deep energy levels in the molybdenum atoms / *OWTTE*;
 photons are emitted when electrons from higher levels move to the vacancies
 in these levels / *OWTTE*;
 20 kV acceleration does not give electrons enough energy to cause excitation
 from deep energy levels / *OWTTE*; [3]

(b) $\frac{hc}{\lambda} = Ve$;
 $\lambda = \left(\frac{hc}{Ve} \right) = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{15 \times 10^3 \times 1.6 \times 10^{-19}}$;
 to give $\lambda = 8.3 \times 10^{-11} \text{ m}$; [3]

B3. (a) (i) *proton number:* 55;
neutron number: 74; [2]

(ii) neutrino; [1]

(iii) weak (interaction); [1]

(iv) uud (group) changes to ddu (group); [1]

(b) $\lambda = \frac{0.69}{2.2} = 0.32 \text{ hr}^{-1}$;
 $\frac{N}{N_0} = e^{-\lambda t} = e^{-0.31 \times 6.0} = 0.15$;

therefore reduction in activity = 85% ;

[3]

Option H — Optics

H1.	<i>Name of associated region</i>	<i>Frequency / Hz</i>	<i>Possible source</i>	
	<i>gamma radiation</i>	10^{18}	<i>radioactive decay</i>	
	infra red;	10^{13}	hot objects / laser / remote control device;	
	radio waves;	10^6	(accelerated) motion of electrons in conductors/aerials/electric currents;	[4]

Do not apply ECF from region to possible source.

H2. (a) (i) when the (transmitted) ray/light in medium 2 is along the boundary/refracted at 90° ;
the angle of incidence in medium 1 is the critical angle; **[2]**

or

when a ray/light is incident on the boundary at an angle greater than the critical angle;
the ray is not transmitted / no light is transmitted but is totally reflected at the boundary / is totally internally reflected;

(ii) reflected ray with angle of reflection = angle of incidence;
transmitted ray with angle of refraction greater than angle of incidence; **[2]**
Judge both by eye.

(b) $n_1 \sin \theta_1 = n_2 \sin \theta_2$
 $\theta_1 = \phi_c$ and $\theta_2 = 90^\circ$;
 $n_1 \sin \phi_c = n_2$; **[2]**