Option B — Quantum Physics and Nuclear Physics

B1. This question is about the de Broglie hypothesis.

(a) State the de Broglie hypothesis. *[2]*

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(b) Calculate the de Broglie wavelength associated with an adult of mass 80 kg running at a speed of $5.0\,\text{m}\,\text{s}^{-1}$. *[2]*

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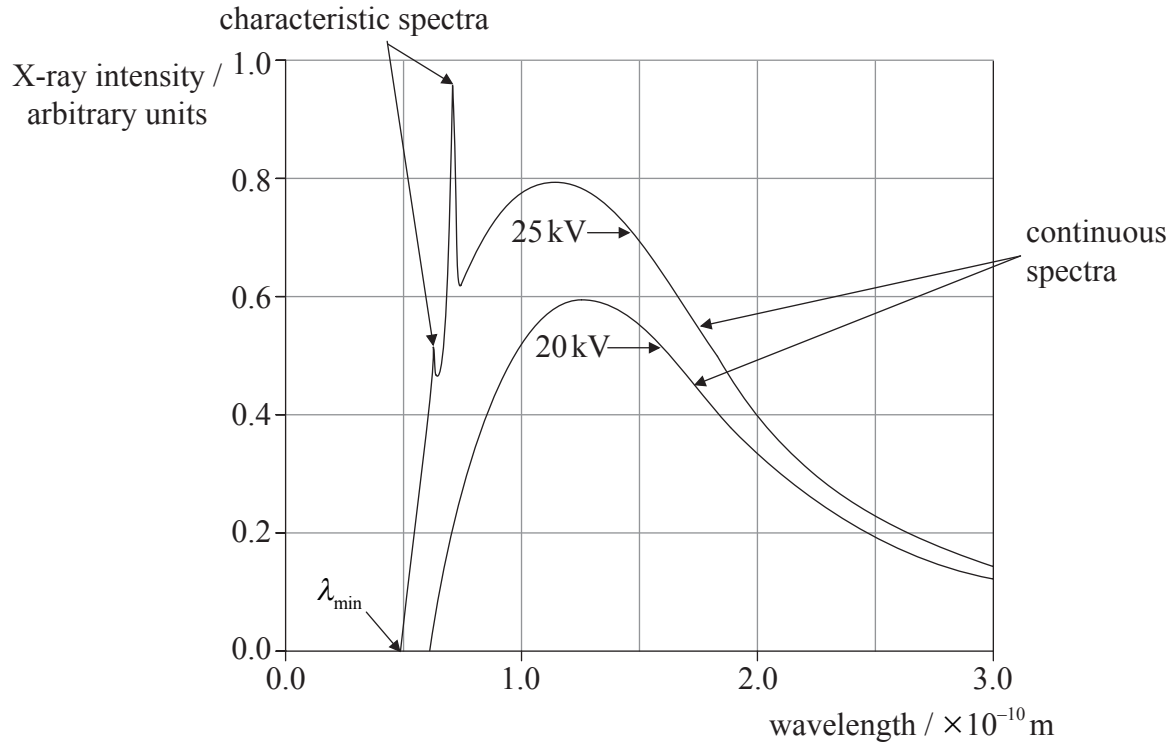
B2. This question is about X-ray spectra.

The diagram below shows the X-ray spectra produced by electrons striking a molybdenum target for two different accelerating potential differences of 25 kV and 20 kV.



(a) Explain

(i) the origin of the continuous spectrum. *[2]*

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(ii) why no characteristic spectra are produced for an accelerating potential of 20 kV. *[3]*

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(Question B2 continued)

(b) Determine the minimum wavelength λ_{min} of X-rays for an accelerating potential difference of **15 kV**. *[3]*

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B3. This question is about nuclear reactions.

(a) A nucleus of barium-129, atomic number (proton number) 56 undergoes β^+ decay to form a nucleus of caesium.

State, for this decay,

(i) the proton number and neutron number of a nucleus of caesium. *[2]*

proton number: . . . . . .

neutron number: . . . . . .

(ii) the name of the other particle produced. *[1]*

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(iii) the name of the interaction responsible. *[1]*

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(iv) the change in quark structure of a nucleus of caesium. *[1]*

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(b) The half-life of barium-129 is 2.2 hours. Determine the percentage decrease in the activity during a period of 6.0 hours of a sample of barium-129. *[3]*

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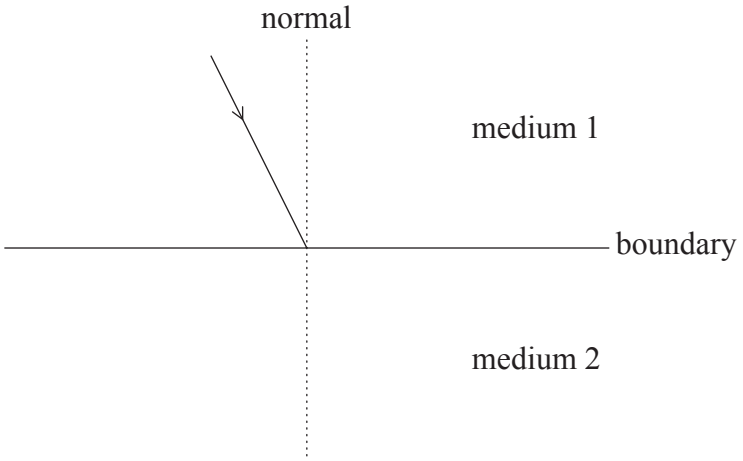
Option H — Optics

H1. The table below relates to the electromagnetic spectrum. Complete the table by stating the name of the region of the spectrum and the name of a possible source of the radiation associated with the given frequency. *[4]*

Name of associated region	Frequency / Hz	Possible source
gamma radiation	10^{18}	radioactive decay
	10^{13}	
	10^{6}	

H2. This question is about refraction.

(a) The diagram below shows a ray of monochromatic light incident on the boundary between two media. The dotted line is the normal to the boundary.



The refractive index of medium 1 is n_1 and that of medium 2 is n_2 and $n_1 > n_2$. The ray is incident at an angle to the normal that is less than the critical angle.

(i) Explain what is meant by critical angle. *[2]*

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(ii) On the diagram above, draw lines to show the paths of the ray after it is incident on the boundary. *[2]*

(b) Derive a relationship between n_1, n_2 and the critical angle ϕ_c. *[2]*

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