19 Cobalt-60 is a source of gamma radiation. Gamma radiation can be used to sterilise medical equipment.

(a) (i) Complete the nuclear equation for the decay of cobalt-60 to nickel.

$$^{60}_{27}\text{Co} \rightarrow \text{.....}\,\text{Ni} + \text{.....}\,\beta^- + {}^{0}_{0}\bar{\nu}_e$$

(2)

(ii) Suggest why the majority of the energy released is shared between the β^- particle and the antineutrino.

(1)

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(b) The activity of a cobalt-60 source is 4.07×10^{14} Bq initially.

When used for sterilising, the source is replaced when the activity drops below 1.85×10^{14} Bq.

Calculate the time in years until the source should be replaced.

half-life of cobalt-60 = 5.27 years
1 year = 3.16×10^7 s

(3)

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Time until source should be replaced = ... years

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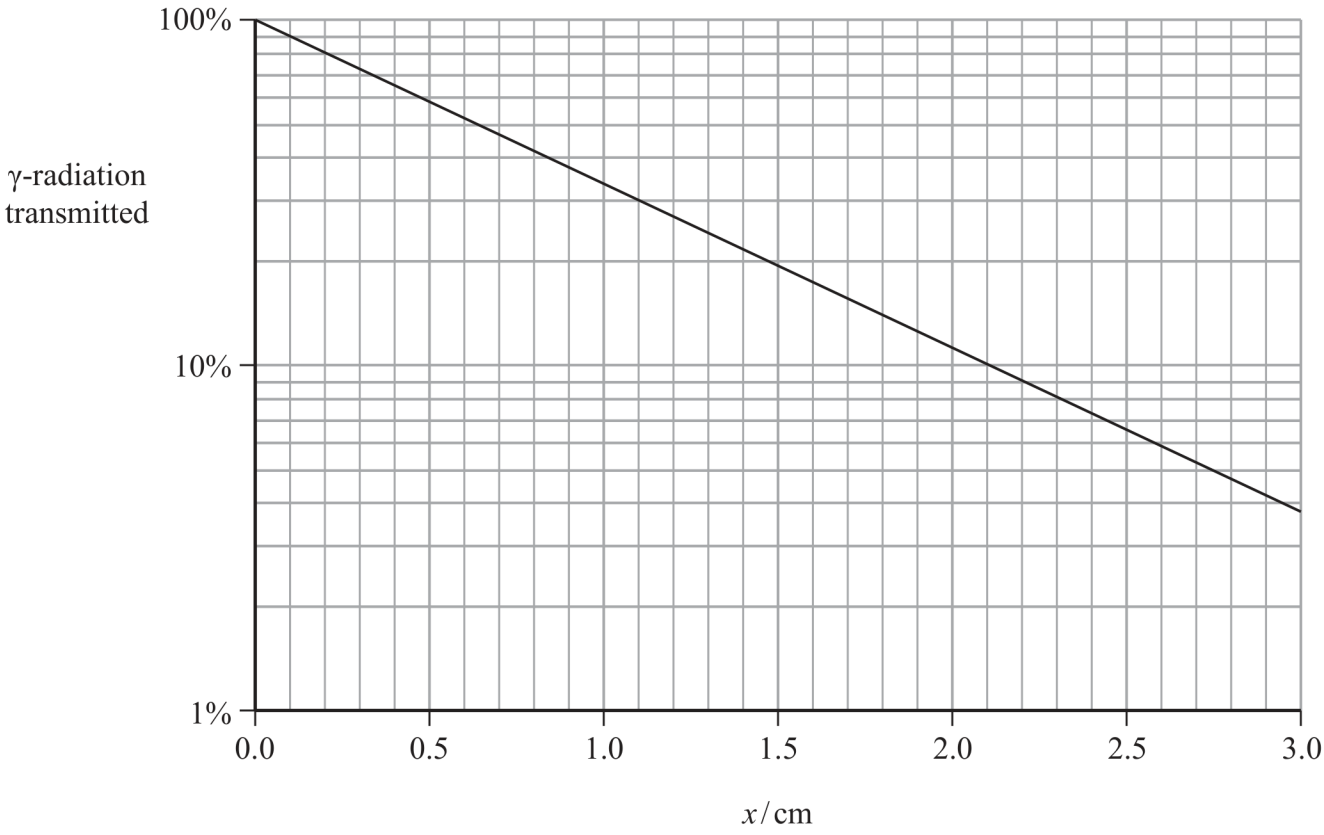
(c) When in use the cobalt-60 source is shielded with lead. The graph shows how the transmission of γ-radiation depends upon the thickness x of the lead shielding.



The count rate from a source must be reduced from 4.0×10^{14} Bq to 1.2×10^{14} Bq.

Deduce whether lead shielding of thickness 1.0 cm would be sufficient to achieve this.

(3)

(Total for Question 19 = 9 marks)