Q1.(a) Which ionizing radiation produces the greatest number of ion pairs per mm in air? Tick (✓) the correct answer.

α particles	
β particles	
γ rays	
X−rays	

(1)

(b) (i) Complete the table showing the typical maximum range in air for α and β particles.

Type of radiation	Typical range in air / m
α	
β	

(2)

(ii) γ rays have a range of at least 1 km in air.

However, a γ ray detector placed 0.5 m from a γ ray source detects a noticeably smaller count-rate as it is moved a few centimetres further away from the source.

Explain this observation.

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(1)

(c) Following an accident, a room is contaminated with dust containing americium which is an α−emitter.

Explain the most hazardous aspect of the presence of this dust to an unprotected human entering the room.

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(2)
(Total 6 marks)

Q2. (a) In a radioactivity experiment, background radiation is taken into account when taking corrected count rate readings in a laboratory. One source of background radiation is the rocks on which the laboratory is built. Give **two** other sources of background radiation.

source 1 .....

source 2 .....

(1)

(b) A γ ray detector with a cross-sectional area of 1.5×10^{-3} m^2 when facing the source is placed 0.18 m from the source.
A corrected count rate of 0.62 counts s^{-1} is recorded.

(i) Assume the source emits γ rays uniformly in all directions.
Show that the ratio

$$\frac{\text{number of } \gamma \text{ photons incident on detector}}{\text{number of } \gamma \text{ photons produced by source}}$$

is about 4×10^{-3}.

(2)

(ii) The γ ray detector detects 1 in 400 of the γ photons incident on the facing surface of the detector.
Calculate the activity of the source. State an appropriate unit.

answer = ... unit .....

(3)

(c) Calculate the corrected count rate when the detector is moved 0.10 m further from the source.

answer = ... counts s^{-1}

(3)
(Total 9 marks)

Q3. (a) $^{212}_{83}Bi$ can decay into $^{208}_{82}Pb$ by a β^- followed by an α decay, or by an α followed by a β^- decay. One or more of the following elements is involved in these decays:

$_{80}Hg$, $_{81}Tl$, $_{84}Po$, $_{85}At$.

Write out decay equations showing each stage in both of these decays.

First decay path	Second decay path

(6)

(b) (i) Describe how you would perform an experiment that demonstrates that gamma radiation obeys an inverse square law.

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(ii) Explain why gamma radiation obeys an inverse square law but alpha and beta radiation do not.

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(9)
(Total 15 marks)

Q4. (a) Calculate the radius of the $^{238}_{92}$U nucleus.

$r_0 = 1.3 \times 10^{-15}$ m

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(2)

(b) At a distance of 30 mm from a point source of γ rays the corrected count rate is *C*. Calculate the distance from the source at which the corrected count rate is 0.10 *C*, assuming that there is no absorption.

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(2)

(c) The activity of a source of β particles falls to 85% of its initial value in 52 s. Calculate the decay constant of the source.

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(3)

(d) Explain why the isotope of technetium, $^{99}Tc_{m}$, is often chosen as a suitable source of radiation for use in medical diagnosis.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3)
(Total 10 marks)