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In the Rutherford scattering experiment most α particles passed through the foil undeflected.

What is a correct deduction from this result?

- A Most of the mass of an atom is within the nucleus.
- B The diameter of the nucleus is much less than the diameter of the atom.
- C The nucleus has a positive charge.
- D The charge of the atom is neutral.

(Total 1 mark)

11

The moderator of some nuclear reactors is made from graphite.

What is the principal purpose of the graphite?

- A to absorb all the heat produced
- B to decrease the speed of neutrons
- C to absorb α and β radiation
- D to prevent the reactor from going critical

(Total 1 mark)

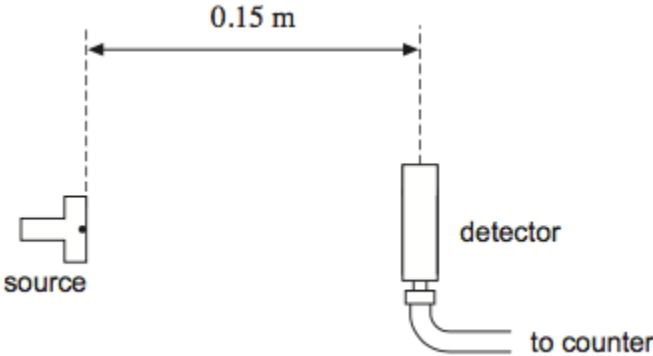
12

(a) The exposure of the general public to background radiation has changed substantially over the past 100 years.

State **one** source of radiation that has contributed to this change.

(1)

(b) A student measures background radiation using a detector and determines that background radiation has a mean count-rate of 40 counts per minute. She then places a γ ray source 0.15 m from the detector as shown below.



With this separation the average count per minute was 2050.

The student then moves the detector further from the γ ray source and records the count-rate again.

(i) Calculate the average count-rate she would expect to record when the source is placed 0.90 m from the detector.

count-rate = _____ min^{-1}

(3)

(ii) The average count per minute of 2050 was determined from a measurement over a period of 5 minutes. Explain why the student might choose to record for longer than 5 minutes when the separation is 0.90 m.

(1)

- (iii) When the detector was moved to 0.90 m the count-rate was lower than that calculated in part (b)(i). It is suggested that the source may also emit β particles.

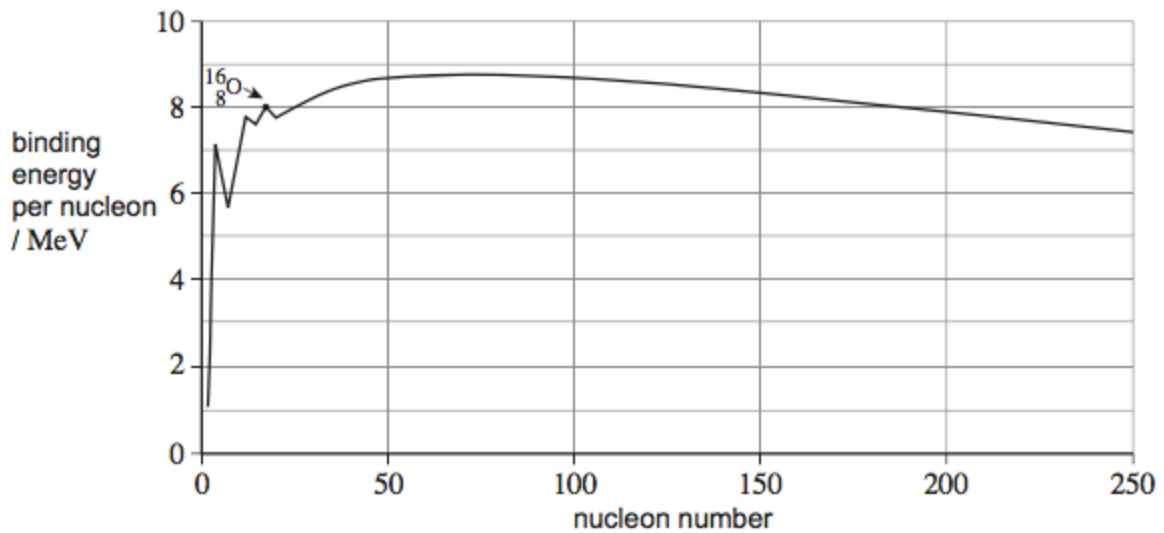
Explain how this can be checked.

(2)

(Total 7 marks)

13

The diagram shows how the binding energy per nucleon varies with nucleon number.



- (a) (i) Fission and fusion are two nuclear processes in which energy can be released. Explain why nuclei that undergo fission are restricted to a different part of the graph than those that undergo fusion.

(2)

- (ii) Explain, with reference to the diagram, why the energy released per nucleon from fusion is greater than that from fission.

(2)

- (b) (i) Calculate the mass difference, in kg, of the $^{16}_8\text{O}$ nucleus.

$$\text{mass of } ^{16}_8\text{O nucleus} = 15.991 \text{ u}$$

$$\text{mass difference} = \text{_____ kg}$$

(2)

- (ii) Using your answer to part **(b)(i)**, calculate the binding energy, in MeV, of an oxygen $^{16}_8\text{O}$ nucleus.

binding energy = _____ MeV

(1)

- (iii) Explain how the binding energy of an oxygen $^{16}_8\text{O}$ nucleus can be calculated with information obtained from the diagram.

(1)

(Total 8 marks)

14

- (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.

(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.

(2)

(Total 6 marks)

15

The carbon content of living trees includes a small proportion of carbon-14, which is a radioactive isotope. After a tree dies, the proportion of carbon-14 in it decreases due to radioactive decay.

- (a) (i) The half-life of carbon-14 is 5740 years.
Calculate the radioactive decay constant in yr^{-1} of carbon-14.

decay constant _____ yr^{-1}

(1)

- (ii) A piece of wood taken from an axe handle found on an archaeological site has 0.375 times as many carbon-14 atoms as an equal mass of living wood. Calculate the age of the axe handle in years.

age _____ yr

(3)

- (b) Suggest why the method of carbon dating is likely to be unreliable if a sample is:

- (i) less than 200 years old,

- (ii) more than 60 000 years old.

(2)

(Total 6 marks)

16

Which of the following is equal to $\frac{\text{radius of a nucleus of } {}_{51}^{125}\text{Sb}}{\text{radius of a nucleus of } {}_{20}^{64}\text{Zn}}$??

A 1.19

B 1.25

C 1.33

D 1.40

(Total 1 mark)