

Nuclear and particle physics

Question Paper 5

Level	A Level
Subject	Physics
Exam Board	OCR
Topic	Particles and medical physics
Sub-Topic	Nuclear and particle physics
Booklet	Question Paper 5

Time Allowed: 50 minutes

Score: / 41

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) (i) Complete Fig. 9.1 to show the quark composition and charge for neutrons and protons.

	quark composition	charge
neutron		
proton		

Fig. 9.1

[2]

(ii) Complete Fig. 9.2 to show the composition of quarks.

quark	charge	baryon number	strangeness
up		+ 1/3	
down			0

Fig. 9.2

[2]

(b) When a neutron decays it can produce particles that include an electron.

(i) Complete the decay equation below for a neutron.



[2]

(ii) Name the interaction responsible for the decay of the neutron.

..... [1]

(iii) Electrons and neutrons belong to different groups of particles. Name the group of particles to which each belongs.

electrons

neutrons

[1]

[Total: 8]

2 (a) Describe what is meant by the **spontaneous** and **random** nature of radioactive decay of unstable nuclei.

.....
.....
.....
..... [2]

(b) Define the *decay constant*.

.....
..... [2]

(c) Explain the technique of radioactive carbon-dating.

.....
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.....
.....
..... [4]

(d) The activity of a sample of living wood was measured over a period of time and averaged to give 0.249 Bq. The same mass of a sample of dead wood was measured in the same way and the activity was 0.194 Bq. The half-life of carbon-14 is 5570 years.

(i) Calculate

1 the decay constant in y^{-1} for the carbon-14 isotope

decay constant = y^{-1} [1]

2 the age of the sample of dead wood in years.

age = y [2]

(ii) Suggest why the activity was measured over a long time period and then averaged.

.....

..... [1]

(iii) Explain why the method of carbon-dating is not appropriate for samples that are greater than 10^5 years old.

.....

..... [1]

[Total: 13]

- 3 Technetium-99m is a common medical tracer injected into patients before they have a scan with a gamma camera. Technetium-99m is a gamma emitter with a half-life of about 6 hours. Each gamma ray photon has energy 2.2×10^{-14} J.

A patient is given a dose with an initial activity of 500 MBq.

- (a) Explain what is meant by *activity*.

.....
..... [1]

- (b) Calculate the initial rate of energy emission from the dose of technetium-99m.

rate of energy emission = Js^{-1} [2]

- 4 Fluorodeoxyglucose (FDG) is a radiopharmaceutical used for PET scans. It contains radioactive fluorine-18, which is a positron-emitter with a half-life of 6.6×10^3 s. A patient is injected with FDG which has an initial activity of 250 MBq.

(a) Calculate the decay constant of fluorine-18.

decay constant = s^{-1} [2]

(b) Show that the initial number of fluorine-18 nuclei in the FDG is about 2×10^{12} .

[1]

(c) About 9.9% of the mass of FDG is fluorine-18. Use your answer in (b) to determine the initial mass of FDG given to the patient. The molar mass of fluorine-18 is $0.018 \text{ kg mol}^{-1}$.

mass = kg [3]

