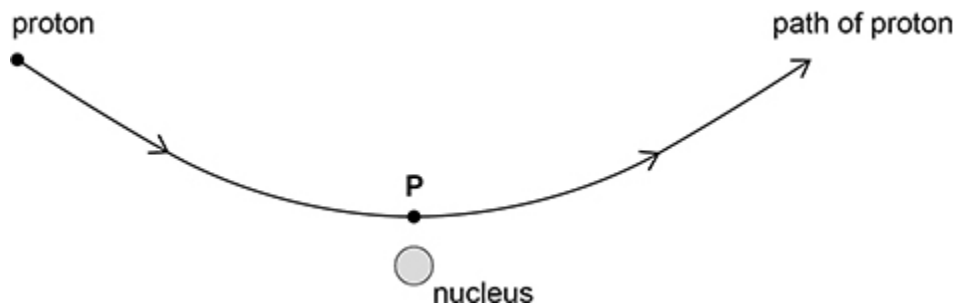


1.

The diagram shows the path of a proton being deflected by the nucleus of an atom. Point **P** is the position of the proton when it is closest to the nucleus.



What is **not** true about the proton along its path at **P**?

A Its rate of change of momentum is at a minimum.

☐

B Its kinetic energy is at a minimum.

☐

C Its potential energy is at a maximum.

☐

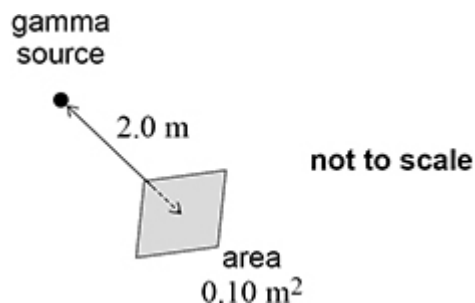
D Its acceleration is at a maximum.

☐

(Total 1 mark)

2.

The diagram shows an area of 0.10 m^2 normal to a line connecting it to a point source of gamma radiation. The source emits photons uniformly in all directions. The area and the source are separated by a distance of 2.0 m .



The source emits 5000 gamma photons per second.

Radioactivity MCQ

How many photons pass through the area every second?

- A 500 ☐
- B 250 ☐
- C 10 ☐
- D 2.5 ☐

(Total 1 mark)

3.

X and **Y** are two radioactive nuclides. **X** has a half-life of 3.0 minutes and **Y** has a half-life of 9.0 minutes.

Two freshly prepared samples of **X** and **Y** start decaying at the same time. After 18 minutes the number of radioactive nuclei in both samples is the same. The sample of **Y** initially contained N radioactive nuclei.

What was the initial number of radioactive nuclei in the sample of **X**?

- A $4N$ ☐
- B $16N$ ☐
- C $32N$ ☐
- D $64N$ ☐

(Total 1 mark)

4.

What is the main purpose of a moderator in a thermal nuclear reactor?

- A to shield the surroundings from ionising radiations ☐
- B to decrease the number of fission chain reactions ☐
- C to decrease neutron speeds ☐
- D to prevent the core from overheating ☐

(Total 1 mark)

5.

In the core of a nuclear reactor, the mass of fuel decreases at a rate of $9.0 \times 10^{-6} \text{ kg hour}^{-1}$ due to nuclear reactions.

What is the maximum power output of the reactor?

A $2.3 \times 10^8 \text{ W}$

☐

B $1.4 \times 10^{11} \text{ W}$

☐

C $8.1 \times 10^{11} \text{ W}$

☐

D $2.9 \times 10^{15} \text{ W}$

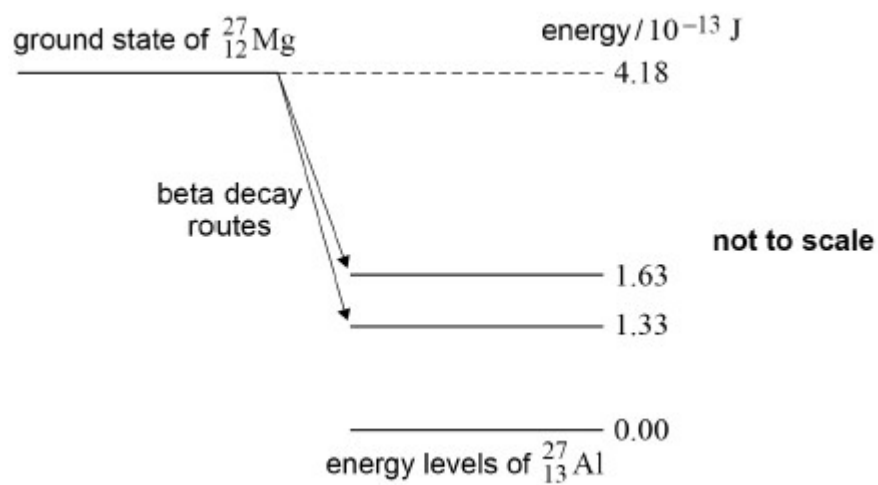
☐

(Total 1 mark)

6.

${}_{12}^{27}\text{Mg}$ can decay by beta minus emission to one of two possible excited states of ${}_{13}^{27}\text{Al}$.

Both excited states decay by the emission of a gamma photon directly to the ground state.



The diagram shows the energy levels and two routes for the beta decay.

One route results in the emission of a gamma photon with a higher frequency than the other photon.

What is the maximum possible kinetic energy for the beta particle emitted in this route?

A $1.33 \times 10^{-13} \text{ J}$

☐

B $1.63 \times 10^{-13} \text{ J}$

☐

C $2.55 \times 10^{-13} \text{ J}$

☐

D $2.85 \times 10^{-13} \text{ J}$

☐

(Total 1 mark)

7.

A point source emits gamma radiation. The intensity I of the radiation is measured at different distances d from the source.

Which graph will show a straight line through the origin?

A I plotted against d

☐

B I plotted against d^2

☐

C I plotted against d^{-1}

☐

D I plotted against d^{-2}

☐

(Total 1 mark)

8.

The mass of the fuel in a fission reactor decreases at a rate of $6.0 \times 10^{-6} \text{ kg hour}^{-1}$.

What is the maximum possible power output of the reactor?

A 75 MW

☐

B 150 MW

☐

C 300 MW

☐

D 9000 MW

☐

(Total 1 mark)

9.

The table shows the masses of three particles.

Particle	Mass / u
proton	1.00728
neutron	1.00867
nucleus of lithium ${}^7_3\text{Li}$	7.01436

What is the mass difference of a ${}^7_3\text{Li}$ nucleus?

A 4.99841 u

☐

B 0.04216 u

☐

C 0.04147 u

☐

D 0.04077 u

☐

(Total 1 mark)

10.

When a small radioactive source is placed in a cloud chamber, straight tracks about 4 cm long are observed. The same source is placed 10 cm from a Geiger tube and a count rate is detected. When a sheet of aluminium 5 mm thick is placed between the source and the Geiger tube the count rate falls to the background count rate.

Which types of radiation are emitted by the source?

A α , β and γ

☐

B β and γ

☐

C α and γ

☐

D α and β

☐

(Total 1 mark)

11.

The number of parent nuclei in a sample of a radioactive element is N at time t . The radioactive element has a half-life $t_{\frac{1}{2}}$

The rate of decay is proportional to

A N

☐

B t

☐

C $\frac{1}{t}$

☐

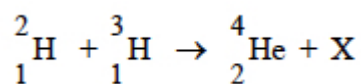
D $t_{\frac{1}{2}}$

☐

(Total 1 mark)

12.

A deuterium nucleus and a tritium nucleus fuse together to form a helium nucleus and a particle X. The equation for this process is:



What is X?

A electron

☐

B neutron

☐

C positron

☐

D proton

☐

(Total 1 mark)

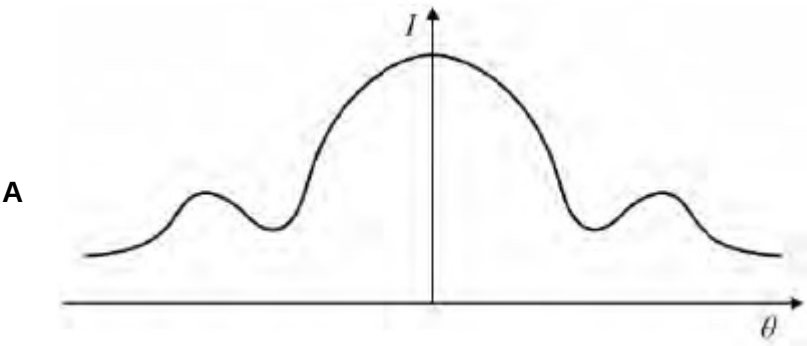
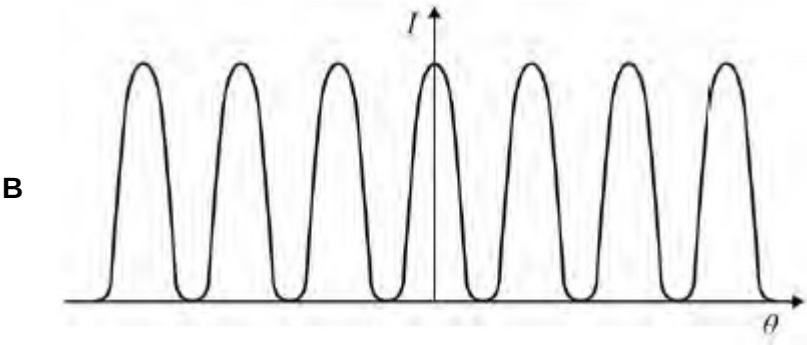
13. What effect are the control rods intended to have on the average kinetic energy and number of fission neutrons in a thermal nuclear reactor?

	Average kinetic energy of fission neutrons	Number of fission neutrons
A	unchanged	unchanged
B	reduced	unchanged
C	unchanged	reduced
D	increased	reduced

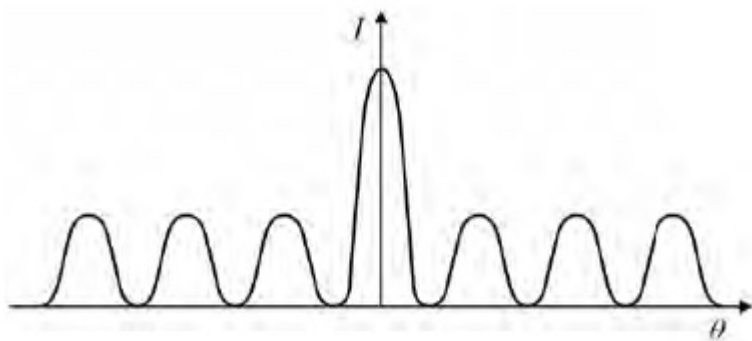
☐☐☐☐

(Total 1 mark)

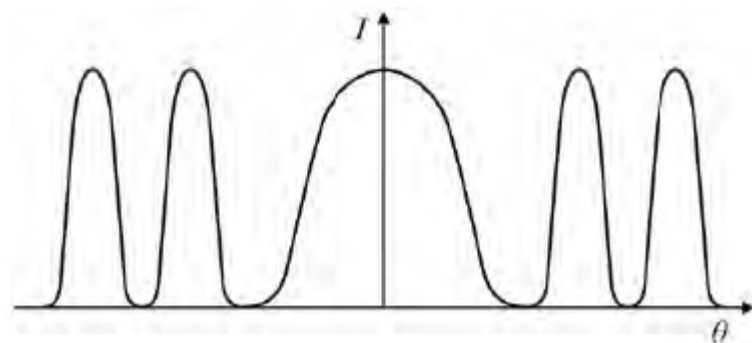
14. Which graph shows how intensity I varies with angle θ when electrons are diffracted by a nucleus?

☐☐

C


☐

D


☐

(Total 1 mark)

15.

The radius of a uranium $^{238}_{92}\text{U}$ nucleus is $7.75 \times 10^{-15} \text{ m}$

What is the radius of a $^{12}_6\text{C}$ nucleus?

A $1.10 \times 10^{-18} \text{ m}$

☐

B $3.91 \times 10^{-16} \text{ m}$

☐

C $2.86 \times 10^{-15} \text{ m}$

☐

D $3.12 \times 10^{-15} \text{ m}$

☐

(Total 1 mark)

- 16.** During a single fission event of uranium-235 in a nuclear reactor the total mass lost is 0.23 u. The reactor is 25% efficient.

How many events per second are required to generate 900 MW of power?

- A 1.1×10^{14} ☐
- B 6.6×10^{18} ☐
- C 1.1×10^{20} ☐
- D 4.4×10^{20} ☐

(Total 1 mark)

- 17.** Which of the following substances can be used as a moderator in a nuclear reactor?

- A Boron ☐
- B Concrete ☐
- C Uranium-238 ☐
- D Water ☐

(Total 1 mark)

- 18.** The Rutherford scattering experiment led to

- A the discovery of the electron. ☐
- B the quark model of hadrons. ☐
- C the discovery of the nucleus. ☐
- D evidence for wave-particle duality. ☐

(Total 1 mark)

19.

A Geiger counter is placed near a radioactive source and different materials are placed between the source and the Geiger counter.

The results of the tests are shown in the table.

Material	Count rate of Geiger counter / s^{-1}
None	1000
Paper	1000
Aluminium foil	250
Thick steel	50

What is the radiation emitted by the source?

A α only

☐

B α and γ

☐

C α and β

☐

D β and γ

☐

(Total 1 mark)

20.

Nobelium-259 has a half-life of 3500 s.

What is the decay constant of nobelium-259?

A $8.7 \times 10^{-5} \text{ s}^{-1}$

☐

B $2.0 \times 10^{-4} \text{ s}^{-1}$

☐

C $1.7 \times 10^{-2} \text{ s}^{-1}$

☐

D $1.2 \times 10^{-2} \text{ s}^{-1}$

☐

(Total 1 mark)

21.

A pure sample of nuclide **X** containing N nuclei has an activity A .
The half-life of **X** is 6000 years.

A pure sample of nuclide **Y** containing $3N$ nuclei has an activity $6A$.

What is the half-life of nuclide **Y**?

A 1000 years

☐

B 3000 years

☐

C 12 000 years

☐

D 18 000 years

☐

(Total 1 mark)

22.

Cobalt-60 has a half-life of 5.27 years.

What is the total activity of 1.0 g of cobalt-60?

A 4.2×10^{13} Bq

☐

B 2.2×10^{14} Bq

☐

C 2.5×10^{15} Bq

☐

D 1.3×10^{21} Bq

☐

(Total 1 mark)

23.

The radius of a nucleus of the iron nuclide $^{56}_{27}\text{Fe}$ is 4.35×10^{-15} m.

What is the radius of a nucleus of the uranium nuclide $^{238}_{92}\text{U}$?

A 2.69×10^{-15} m

☐

B 2.89×10^{-15} m

☐

C 6.55×10^{-15} m

☐

D 7.05×10^{-15} m

☐

(Total 1 mark)

24.

Uranium-236 undergoes nuclear fission to produce barium-144, krypton-89 and three free neutrons.

What is the energy released in this process?

Nuclide	Binding energy per nucleon / MeV
${}_{92}^{236}\text{U}$	7.5
${}_{56}^{144}\text{Ba}$	8.3
${}_{36}^{89}\text{Kr}$	8.6

A 84 MeV

☐

B 106 MeV

☐

C 191 MeV

☐

D 3730 MeV

☐

(Total 1 mark)