

Name of the Student: _____

Max. Marks : 20 Marks

Time : 20 Minutes

Q1.

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?

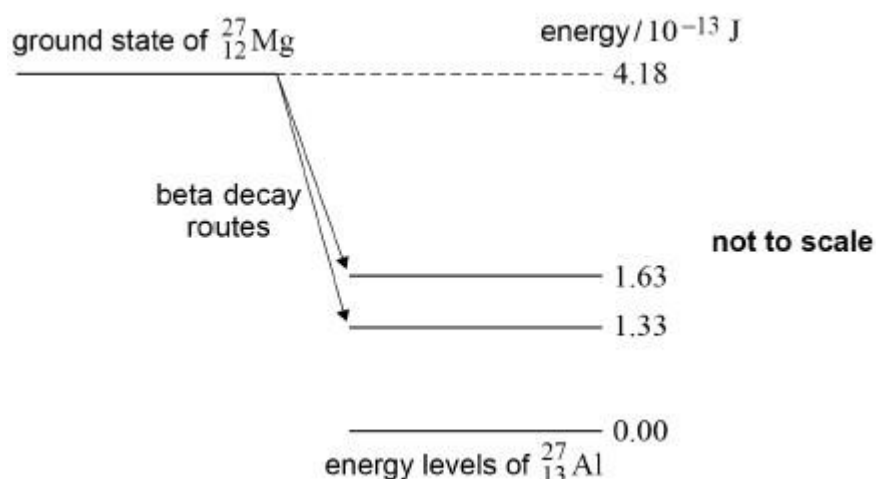
- A I plotted against d ☐
- B I plotted against d^2 ☐
- C I plotted against d^{-1} ☐
- D I plotted against d^{-2} ☐

(Total 1 mark)

Q2.

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

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)

Q3.

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

The rate of decay is proportional to

- A N ☐
- B t ☐
- C $\frac{1}{t}$ ☐
- D $\frac{t_{1/2}}{2}$ ☐

(Total 1 mark)

Q4.

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)

Q5.

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

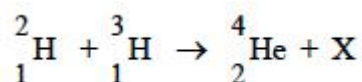
What is the maximum possible power output of the reactor?

- A 75 MW ☐
- B 150 MW ☐
- C 300 MW ☐
- D 9000 MW ☐

(Total 1 mark)

Q6.

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)

Q7.

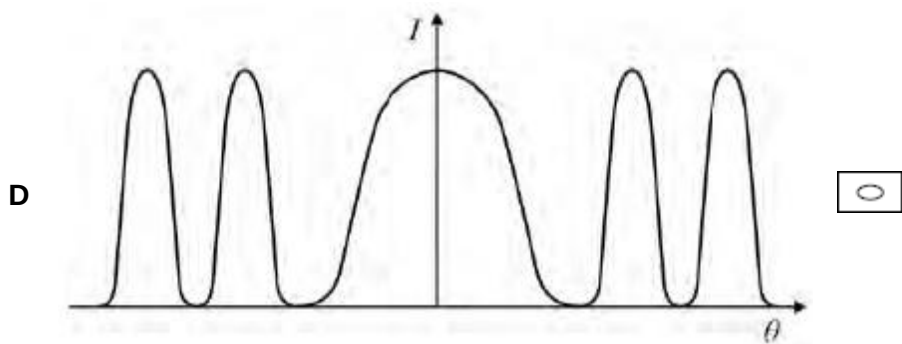
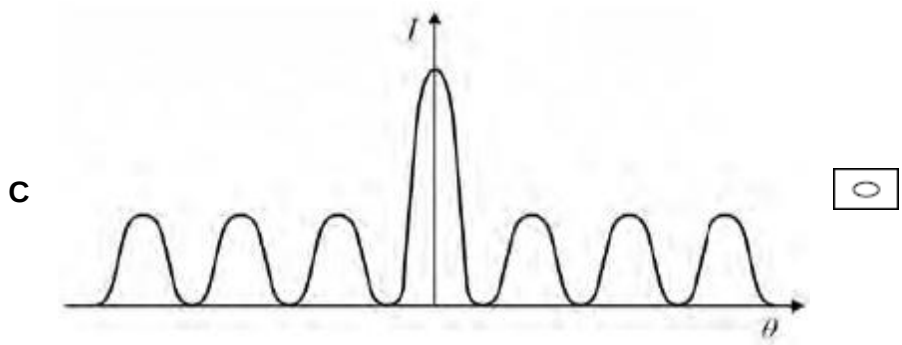
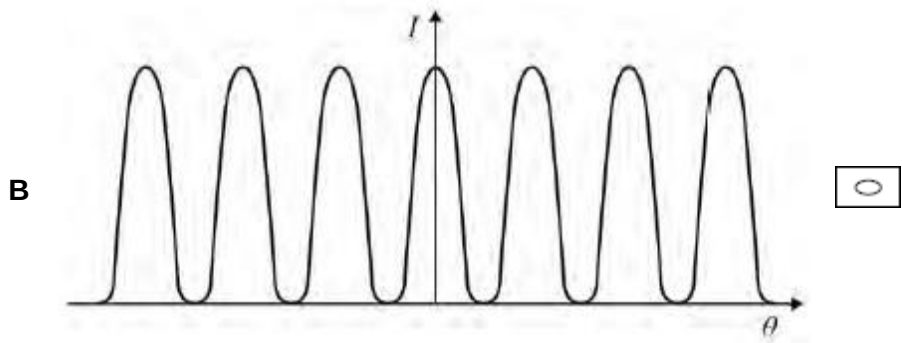
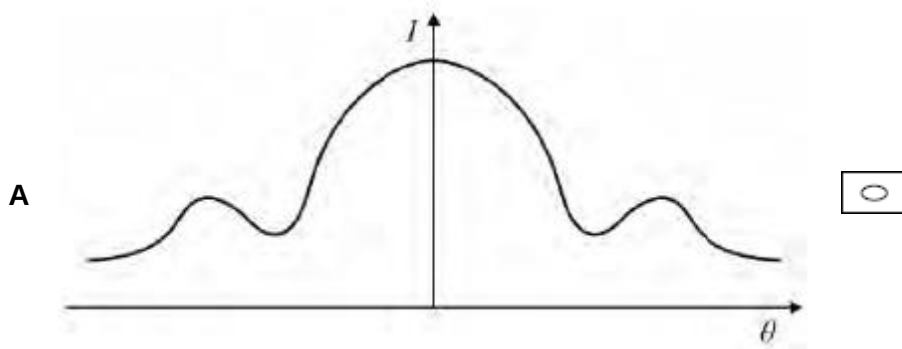
What effect are the control rods intended to have on the average kinetic energy and number of fission neutrons in a thermal nuclear reactor?

	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)

Q8.

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



(Total 1 mark)

Q9.

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 1.10×10^{-18} m ☐
- B 3.91×10^{-16} m ☐
- C 2.86×10^{-15} m ☐
- D 3.12×10^{-15} m ☐

(Total 1 mark)

Q10.

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)

Q11.

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)

Q12.

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)

Q13.

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)

Q14.

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)

Q15.

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)

Q16.

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)

Q17.

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

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

- A $2.69 \times 10^{-15} \text{ m}$ ☐
- B $2.89 \times 10^{-15} \text{ m}$ ☐
- C $6.55 \times 10^{-15} \text{ m}$ ☐
- D $7.05 \times 10^{-15} \text{ m}$ ☐

(Total 1 mark)

Q18.

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
$^{236}_{92}\text{U}$	7.5
$^{144}_{56}\text{Ba}$	8.3
$^{89}_{36}\text{Kr}$	8.6

- A 84 MeV ☐
- B 106 MeV ☐

C 191 MeV

☐

D 3730 MeV

☐

(Total 1 mark)

Q19.

β particles are emitted from a radioactive source in a school laboratory.

What is correct for these particles?

A A strong magnetic field will not deflect them.

☐

B They are absorbed by aluminium.

☐

C They do not damage human tissue.

☐

D Their range in air is shorter than that of α particles.

☐

(Total 1 mark)

Q20.

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)