Radioactive Decay
TOPIC QUESTIONS

Level	A Level
Subject	Physics
Exam Board	AQA
Paper Type	Multiple Choice

Time Allowed : 30min

1. The mass of the beryllium nucleus, Be , is 7.01473 u. What is the binding energy **per nucleon** ofthis nucleus?

   Use the following data:

   mass of proton = 1.00728
   u mass of neutron =
   1.00867 u1u = 931.3 MeV

   A   1.6 MeV

   nucleon^{-1}

   B   5.4 MeV

   nucleon^{-1}

   C   9.4 MeV

   nucleon^{-1}

   D   12.5 MeV
   nucleon^{-1}

2. The fusion of two deuterium nuclei produces a nuclide of helium plus a neutron and liberates 3.27MeV of energy. How does the mass of the two deuterium nuclei compare with the combined mass of the helium nucleus and neutron?

   A It is 5.8×10^{-30} kg greater before fusion.

   B It is 5.8×10^{-30} kg greater after fusion.

   C It is 5.8×10^{-36} kg greater before fusion.

   D It is 5.8×10^{-36} kg greater after fusion.

3. The mass of the nuclear fuel in a nuclear reactor decreases at a rate of 1.2×10^{-5} kg per hour. Assuming 100% efficiency in the reactor what is the power output of the reactor?

   A 100 MW

   B 150 MW

   C 200 MW

   D 300 MW

4. Why is a moderator required in a thermal nuclear reactor?

   A to prevent overheating of the nuclear core

   B to absorb surplus uranium nuclei

   C to shield the surroundings from gamma radiation

   D to reduce the kinetic energy of fission neutrons

5. The sodium isotope $^{24}_{11}$Na is a radioactive isotope that can be produced by bombarding the aluminium isotope $^{27}_{13}$Al with neutrons. Which line, **A** to **D**, in the table correctly represents the production of ^{24}Na from the aluminium isotope $^{27}_{13}$Al and its subsequent decay?

	production	decay
A	$^{27}_{13}\text{Al} + ^{1}_{0}\text{n} \rightarrow ^{24}_{11}\text{Na} + ^{4}_{2}\alpha$	$^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} + ^{0}_{+1}\beta + \nu$
B	$^{27}_{13}\text{Al} + ^{1}_{0}\text{n} \rightarrow ^{24}_{11}\text{Na} + ^{4}_{2}\alpha$	$^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} + ^{0}_{-1}\beta + \overline{\nu}$
C	$^{27}_{13}\text{Al} + ^{1}_{0}\text{n} \rightarrow ^{24}_{11}\text{Na} + ^{3}_{2}\text{He}$	$^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} + ^{0}_{+1}\beta + \nu$
D	$^{27}_{13}\text{Al} + ^{1}_{0}\text{n} \rightarrow ^{24}_{11}\text{Na} + ^{3}_{2}\text{He}$	$^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} + ^{0}_{-1}\beta + \overline{\nu}$

6. What is the binding energy of the nucleus $^{238}_{92}$U?

Use the following data:

mass of a proton $=1.00728$ u

mass of a neutron $= 1.00867$ u

mass of a $^{238}_{92}$U nucleus =
238.05076 u1 u $= 931.3$ MeV

   A   1685 MeV

   B   1732 MeV

   C   1755 MeV

   D   1802 MeV

7. A thermal nuclear reactor is shut down by inserting the control rods fully into the core. Which line, **A** to **D**, shows correctly the effect of this action on the fission neutrons in the reactor?

	number of fission neutrons	average kinetic energy of fission neutrons
A	reduced	reduced
B	reduced	unchanged
C	unchanged	reduced
D	unchanged	unchanged

8. In a thermal reactor, induced fission is caused by the $^{235}_{92}U$ nucleus capturing a neutron, undergoing fission and producing more neutrons. Which one of the following statements is true?

   A   To sustain the reaction a large number of neutrons is required per fission.

   B   The purpose of the moderator is to absorb all the heat produced.

   C   The neutrons required for induced fission of $^{235}_{92}U$ should be slow neutrons.

   D   The purpose of the control rods is to slow down neutrons to thermal speeds.

9. Artificial radioactive nuclides are manufactured by placing naturally-occurring nuclides in a nuclear reactor. They are made radioactive in the reactor as a consequence of bombardment by

   A   α particles.

   B   β particles.

   C   protons.

   D   neutrons.

10. The nuclear fuel, which provides the power output in a nuclear reactor, decreases in mass at a rate of 6.0×10^{-6} kg per hour. What is the maximum possible power output of the reactor?
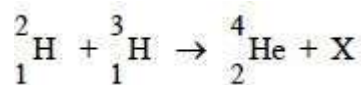
    A   42 kW

    B   75 MW

    C   150 MW

    D   300 MW

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 $\dfrac{1}{t}$

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

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:

$$_{1}^{2}\text{H} + {}_{1}^{3}\text{H} \rightarrow {}_{2}^{4}\text{He} + \text{X}$$

    What is **X**?

    A   electron

    B   neutron

C positron

**D** proton

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

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

A

B

C

D
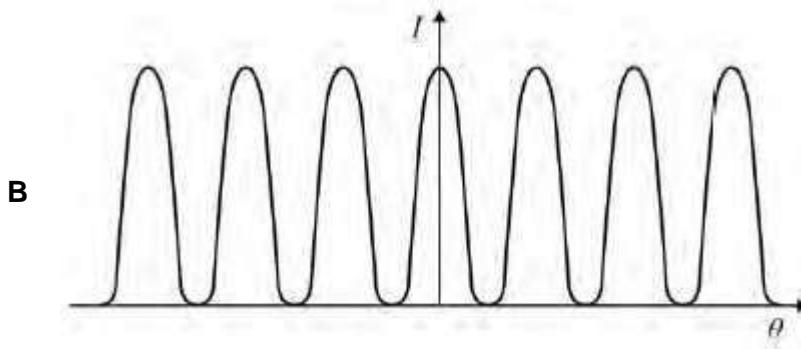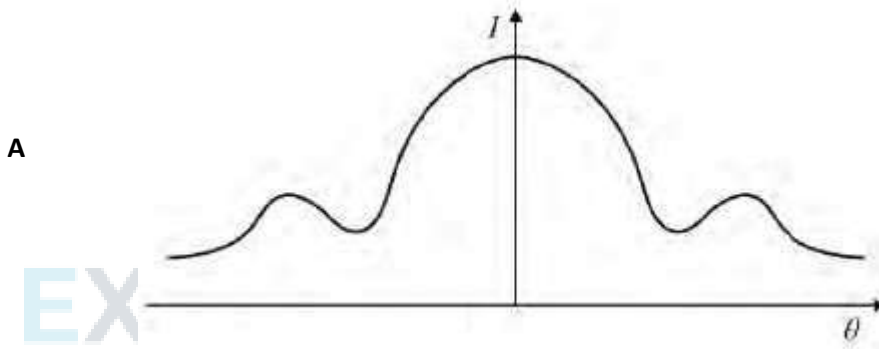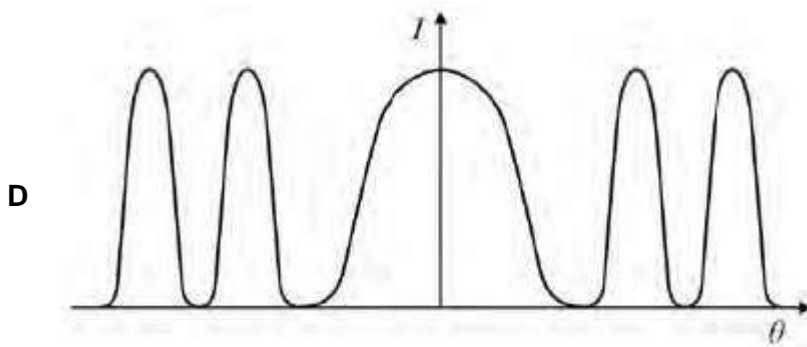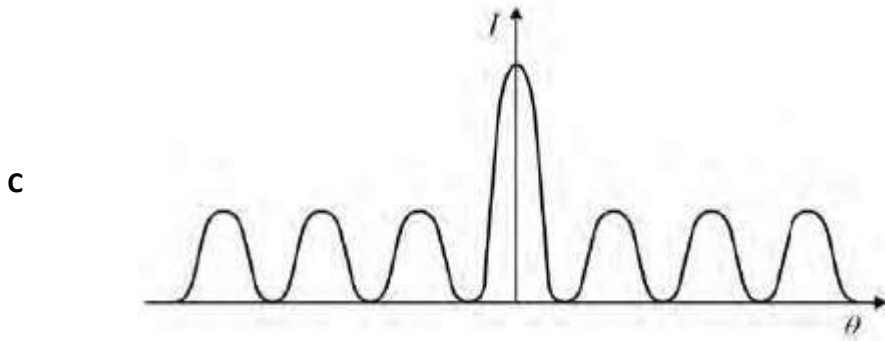
15. The radius of a uranium $^{238}_{92}\text{U}$ nucleus is 7.75×10^{-15} mWhat is

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

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}

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

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.

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

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