Nuclear Fusion & Fission

TOPIC QUESTIONS

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

Time Allowed : 30min

1. The sodium isotope 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 Na from the aluminium isotope $^{27}_{13}Al$ and its subsequent decay?

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

2. 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 u

   1 u = 931.3 MeV

   A 1685 MeV

   B 1732 MeV

   C 1755 MeV

   D 1802 MeV

3. 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

4. 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.

5. 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.

6. The nuclear fuel, which provides the power output in a nuclear reactor, decreases in mass at a rateof 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

7. What is the mass difference of the $^{7}_{3}$Li nucleus?

Use the following data:
mass of a proton = 1.00728 u mass of a neutron = 1.00867 u mass of $^{7}_{3}$Li nucleus = 7.01436 u

A 0.93912 u

B 0.04051 u

C 0.04077 u

D 0.04216 u

8. The moderator in a nuclear reactor is sometimes made of graphite. What is the purpose of thegraphite?

   A to absorb all the heat produced

   B to decrease the neutron speeds

   C to absorb α and γ radiations

   D to prevent the reactor from going critical

9. An alpha particle moves at one-tenth the velocity of a beta particle. They both move through thesame uniform magnetic field at right angles to their motion.

   The magnitude of the ratio $\frac{\text{force on the alpha particle}}{\text{force on the beta particle}}$ is

   A $\frac{1}{4}$

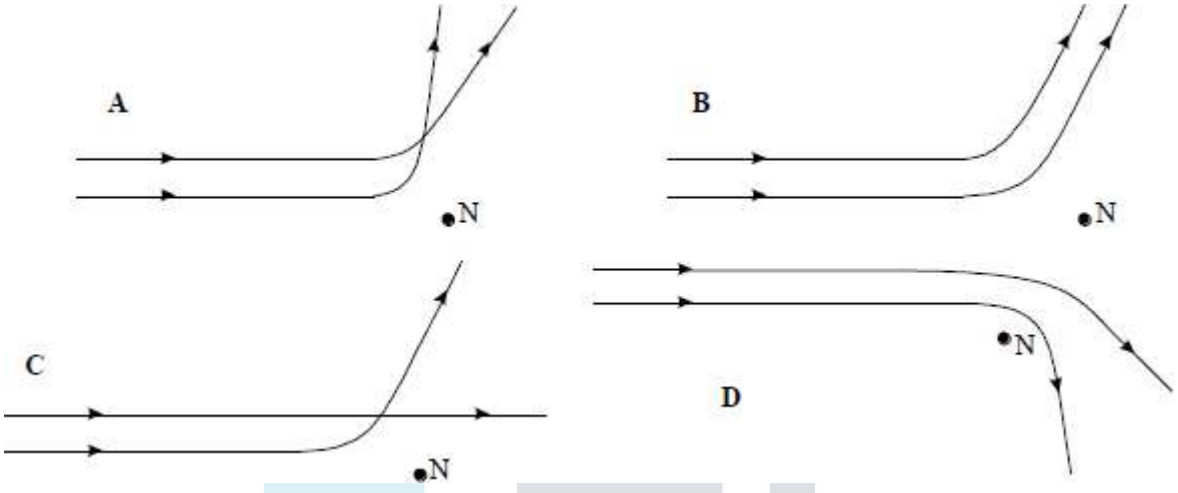
   B $\frac{1}{5}$

   C $\frac{1}{10}$

   D $\frac{1}{20}$

D	

10. In the Rutherford alpha particle scattering experiment, alpha particles having the same energy were fired at gold nuclei. The diagrams below are intended to represent encounters between twoalpha particles and a gold nucleus N, the alpha particles arriving at different times. Which one best represents the possible encounters?



11. Which of the following does **not** give a value in seconds?

A capacitance × resistance

B $\frac{1}{\text{frequency}}$

C half-life

D $\frac{\text{power}}{\text{work}}$

12. Which line, **A** to **D**, in the table gives a combination of materials that is commonly used formoderating, controlling and shielding respectively in a nuclear reactor?

	moderating	controlling	shielding
A	graphite	carbon	lead
B	cadmium	carbon	concrete
C	cadmium	boron	lead

13. Which one of the following statements is **not** true about the control rods used in a nuclear reactor?

A They must absorb neutrons.

B They must slow down neutrons to thermal speeds.

C They must retain their shape at high temperatures.

D The length of rod in the reactor must be variable.

14. The mass of the beryllium nucleus, $^{7}_{4}Be$, 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}

15. 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.

16. 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

17. 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

18. Nuclear binding energy is

A the energy required to overcome the electrostatic force between the protons in the nucleus

B energy equivalent of the mass of the protons in the nucleus

C the energy equivalent of the mass of all the nucleons in the nucleus

D the energy equivalent of the difference between the total mass of the individual nucleons and their mass when they are contained in the nucleus

19. The actinium series of radioactive decays starts with an isotope of uranium, nucleon (mass) number235, proton (atomic) number 92.

Which line in the table shows the nucleon number and proton number of the isotope after theemission of 5 α particles and 2 β particles?

	Nucleon number	proton number
A	213	82
B	215	80
C	215	84
D	227	87

20. A beam of α particles irradiates a metal foil. The paths of four α particles near the nucleus of ametal atom are shown in the diagram. Which one of the paths must be **incorrect**?