7.2 Nuclear Reactions

Question Paper

Course	DP IB Physics
Section	7. Atomic, Nuclear & Particle Physics
Topic	7.2 Nuclear Reactions
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

A nucleus ${}^{A}_{Z}X$ has a mass M.

Which of the following expressions correctly represents the binding energy per nucleon of this nucleus in terms of the speed of light c, the mass of a proton m_p and the mass of a neutron m_n?

A. $\left(\frac{Zm_p + Am_n - M}{A}\right)c^2$

B. $\left(\frac{Zm_p + (A-Z)m_n - M}{Z}\right)c^2$

C. $\left(\frac{Zm_p + (Z-A)m_n - M}{A}\right)c^2$

D. $\left(\frac{Zm_p + (A-Z)m_n - M}{A}\right)c^2$

[1 mark]

Question 2

A nuclear reaction can be written in the form:

$$W + X = Y + Z$$

Energy is released during this reaction.

Which of the following is correct regarding the masses *m* and the binding energies *b* of the nuclides?

	Binding energy	Mass
A.	$b_W + b_X < b_Y + b_Z$	$m_W + m_X < m_Y + m_Z$
B.	$b_W + b_X > b_Y + b_Z$	$m_W + m_X < m_Y + m_Z$
C.	$b_W + b_X < b_Y + b_Z$	$m_W + m_X > m_Y + m_Z$
D.	$b_W + b_X > b_Y + b_Z$	$m_W + m_X > m_Y + m_Z$

[1 mark]

Question 3

One possible fission reaction for uranium–235 is:

$$^{235}_{92}\text{U} \rightarrow {}^{141}_{X}\text{Ba} + {}^{Y}_{Z}\text{Kr} + 3{}^{1}_{0}\text{n}$$

The proton number of barium is 20 more than the proton number of krypton. The measured mass of this nucleus is *M*.

Which expression gives the mass defect associated with the krypton nucleus?

A. $56m_p + 35m_n - M$

B. $36m_p + 55m_n - M$

C. $\frac{36m_p + 55m_n}{M}$

D. $56m_p + 55m_n + M$

[1 mark]

Question 4

The mass of a nucleus of rutherfordium–254 is 254.1001u.

Which of the following is not equal to the energy of this nucleus?

A. $254.1001 \times 931.5 \text{ MeV c}^{-2}$

B. $254.1001 \times 931.5 \times (1.6 \times 10^{-19}) \text{ J}$

C. $254.1001 \times (1.661 \times 10^{-27}) \times (3.00 \times 10^{8})^2 \text{ J}$

D. $254.1001 \times 931.5 \times (1.6 \times 10^{-13}) \text{ J}$

[1 mark]

Question 5

Fusion of Hydrogen can be simply modelled within the Sun by using the following reaction:

$$_{1}^{4}H \rightarrow {}_{2}^{4}He + 2{}_{1}^{0}e^{+} + 2\upsilon_{e} + {}_{0}^{0}\gamma$$

This reaction releases about 30 MeV of energy. If the Sun has a power output of 3.9×10^{26} W, approximately how many of these fusion reactions are occurring every second?

A. 3.67×10^{20} reactions per second

B. 5.12×10^{26} reactions per second

C. 8.88×10^{33} reactions per second

D. 9.13×10^{37} reactions per second

[1 mark]

Question 6

Following the development of the atomic bomb, scientists discovered that they could create elements heavier than uranium by bombarding nuclei with neutrons. These reactions, where smaller nuclei are combined to form a heavier nucleus are called fusion reactions.

Fusion reactions are balanced in exactly the same way as radioactive decay equations. Two incomplete examples are given below:

Reaction 1. $_{92}^{238}U + {}_{0}^{1}n \rightarrow \quad U$

Reaction 2. $_{94}^{239}Pu + 2\,{}_{0}^{1}n \rightarrow \quad Am + \; {}_{-1}^{0}e$

What are the missing products of these fusion reactions?

	Reaction 1	Reaction 2
A.	$_{92}^{239}\mathrm{U}$	$_{95}^{240}\mathrm{Am}$
B.	$_{92}^{239}\mathrm{U}$	$_{95}^{241}\mathrm{Am}$
C.	$_{92}^{237}\mathrm{U}$	$_{95}^{237}\mathrm{Am}$
D.	$_{92}^{237}\mathrm{U}$	$_{95}^{241}\mathrm{Am}$

[1 mark]

Question 7

Nuclear power stations use a fission reactor to create a nuclear reaction. A nucleus absorbs one neutron, leading to a reaction where more than one neutron is released. These neutrons in turn will set off more reactions in a process called a chain reaction.

Which one of these decay processes would be suitable to create a chain reaction?

A. ${}^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li + \_\_\_\_$

B. ${}^{27}_{13}Al + {}^{4}_{2}a \rightarrow {}^{30}_{15}P + \_\_\_\_$

C. ${}^{30}_{15}P \rightarrow {}^{30}_{14}Si + \_\_\_\_$

D. ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{138}_{55}Cs + {}^{95}_{37}Rb + \_\_\_\_$

[1 mark]

Question 8

A stationary uranium-238 nucleus decays by alpha-emission, as shown in the equation below:

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$$

This decay generates a total energy *E*.

Which of the following statements is correct regarding the kinetic energy of the alpha particle?

A. It is slightly less than 0.5*E*

B. It is equal to *E*

C. It is slightly greater than 0.5*E*

D. It is slightly less than *E*

[1 mark]

Question 9

Which of the following shows a possible reaction caused by bombardment by an alpha particle?

A. ${}^{14}_{7}\mathrm{N} + \mathrm{X} \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{0}\mathrm{n}$

B. ${}^{17}_{8}\mathrm{N} + \mathrm{X} \rightarrow {}^{20}_{9}\mathrm{F} + {}^{1}_{1}\mathrm{p}$

C. ${}^{17}_{8}\mathrm{O} + \mathrm{X} \rightarrow {}^{13}_{5}\mathrm{B} + {}^{4}_{2}\mathrm{He}$

D. ${}^{14}_{7}\mathrm{N} + \mathrm{X} \rightarrow {}^{11}_{6}\mathrm{C} + {}^{4}_{2}\mathrm{He}$

[1 mark]

Question 10

A certain reaction is:

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n} + (\text{energy})$$

Which process is demonstrated by this reaction?

A. Alpha decay

B. Beta decay

C. Nuclear fission

D. Nuclear fusion

[1 mark]