Exercise 15 - Nuclear Reactions

Past Paper Homework Questions

1. The statement below represents a nuclear reaction.

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

This is an example of

A nuclear fusion

B alpha particle emission

C beta particle emission

D spontaneous nuclear fission

E induced nuclear fission.

2. Which row of the table shows the correct values of x, y and z for the nuclear reaction described below?

$$^{214}_{x}\text{Pb} \rightarrow ^{y}_{83}\text{Bi} + ^{0}_{z}\text{e}$$

	x	y	z
A	84	214	1
B	83	210	4
C	85	214	2
D	82	214	–1
E	82	210	–1

3. Under certain conditions, a nucleus of nitrogen absorbs an alpha particle to form the nucleus of another element and releases a single particle.

Which one of the following statements correctly describes this process?

A $^{14}_{7}\text{N} + ^{3}_{2}\text{He} \rightarrow ^{16}_{9}\text{F} + ^{1}_{0}\text{n}$

B $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{17}_{10}\text{Ne} + ^{0}_{-1}\text{e}$

C $^{14}_{7}\text{N} + ^{3}_{2}\text{He} \rightarrow ^{16}_{8}\text{O} + ^{1}_{1}\text{p}$

D $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{18}_{9}\text{F} + 2\,^{0}_{-1}\text{e}$

E $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{17}_{8}\text{O} + ^{1}_{1}\text{p}$

4. The following statement describes a fusion reaction.

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \longrightarrow ^{3}_{2}\text{He} + ^{1}_{0}\text{n} + \text{energy}$$

The total mass of the particles before the reaction is $6{\cdot}684 \times 10^{-27}$ kg.

The total mass of the particles after the reaction is $6{\cdot}680 \times 10^{-27}$ kg.

The energy released in this reaction is

A $6{\cdot}012 \times 10^{-10}$ J

B $6{\cdot}016 \times 10^{-10}$ J

C $1{\cdot}800 \times 10^{-13}$ J

D $3{\cdot}600 \times 10^{-13}$ J

E $1{\cdot}200 \times 10^{-21}$ J.

5. A series of radioactive decays starts from the isotope Uranium 238.

Two alpha particles and two beta particles are emitted during the decays.

Which row in the table gives the mass number and the atomic number of the resulting nucleus?

	Mass number	*Atomic number*
A	232	88
B	230	86
C	230	90
D	246	94
E	246	98

6. An isotope of uranium decays into an isotope of protactinium in two stages as shown.

$$^{238}_{92}\mathrm{U} \xrightarrow[\text{stage 1}]{} {}^{234}_{90}\mathrm{Th} \xrightarrow[\text{stage 2}]{} {}^{234}_{91}\mathrm{Pa}$$

Which row in the table identifies the radiations which must be emitted at each stage?

	stage 1	*stage 2*
A	alpha	gamma
B	beta	gamma
C	gamma	beta
D	beta	alpha
E	alpha	beta

7. Which of the following statements describes nuclear fission?

A A nucleus of large mass number splits into two nuclei, releasing several neutrons.

B A nucleus of large mass number splits into two nuclei, releasing several electrons.

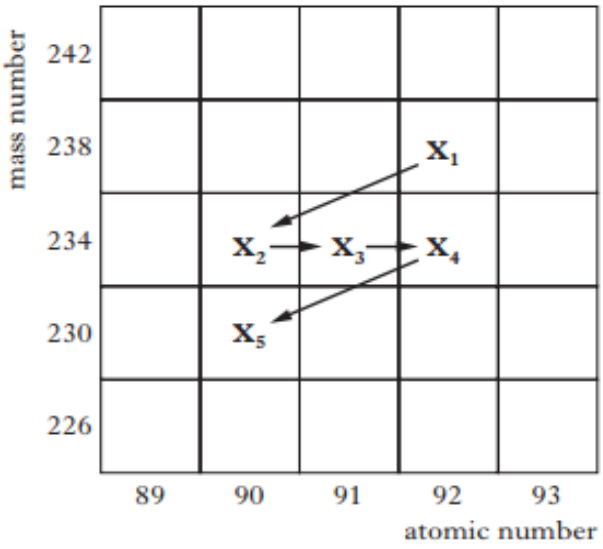
C A nucleus of large mass number splits into two nuclei, releasing several protons.

D Two nuclei combine to form one nucleus, releasing several electrons.

E Two nuclei combine to form one nucleus, releasing several neutrons.

8. Part of a radioactive decay series is shown in the diagram.

The symbols $\mathbf{X_1}$ to $\mathbf{X_5}$ represent nuclides in this series.



A student makes the following statements about the decay series.

I Nuclides $\mathbf{X_2}$ and $\mathbf{X_3}$ contain the same number of protons.

II Nuclide $\mathbf{X_1}$ decays into nuclide $\mathbf{X_2}$ by emitting an alpha particle.

III Nuclide $\mathbf{X_3}$ decays into nuclide $\mathbf{X_4}$ by emitting a beta particle.

Which of these statements is/are correct?

A I only

B II only

C III only

D II and III only

E I, II and III

9. (*a*) The following statement represents a nuclear reaction.

$$^{239}_{94}\text{Pu} + ^{1}_{0}\text{n} \longrightarrow ^{137}_{52}\text{Te} + ^{100}_{42}\text{Mo} + 3\,^{1}_{0}\text{n} + \text{energy}$$

The total mass of the particles before the reaction is $3{\cdot}9842 \times 10^{-27}$ kg and the total mass of the particles after the reaction is $3{\cdot}9825 \times 10^{-27}$ kg.

(i) State and explain whether this reaction is spontaneous or induced. 1

(ii) Calculate the energy, in joules, released by this reaction. 4

10. Radium (Ra) decays to radon (Rn) by the emission of an alpha particle.
Some energy is also released by this decay.
The decay is represented by the statement shown below.

$$^{226}_{88}\text{Ra} \longrightarrow ^{x}_{y}\text{Rn} + ^{4}_{2}\text{He}$$

The masses of the nuclides involved are as follows.

Mass of $^{226}_{88}\text{Ra} = 3{\cdot}75428 \times 10^{-25}$ kg

Mass of $^{x}_{y}\text{Rn} = 3{\cdot}68771 \times 10^{-25}$ kg

Mass of $^{4}_{2}\text{He} = 6{\cdot}64832 \times 10^{-27}$ kg

(*a*) (i) What are the values of x and y for the nuclide $^{x}_{y}\text{Rn}$? 2

(ii) Why is energy released by this decay? 2

(iii) Calculate the energy released by one decay of this type. **5**

(*b*) The alpha particle leaves the radium nucleus with a speed of $1{\cdot}5 \times 10^{7}\,\text{m s}^{-1}$.

The alpha particle is now accelerated through a potential difference of 25 kV.

Calculate the **final** kinetic energy, in joules, of the alpha particle. 6

11. (*a*) The Sun is the source of most of the energy on Earth. This energy is produced by nuclear reactions which take place in the interior of the Sun.

One such reaction can be described by the following statement.

$$^{3}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

The masses of the particles involved in this reaction are shown in the table.

Particle	*Mass*/kg
$^{3}_{1}\mathrm{H}$	$5{\cdot}005 \times 10^{-27}$
$^{2}_{1}\mathrm{H}$	$3{\cdot}342 \times 10^{-27}$
$^{4}_{2}\mathrm{He}$	$6{\cdot}642 \times 10^{-27}$
$^{1}_{0}\mathrm{n}$	$1{\cdot}675 \times 10^{-27}$

(i) Name this type of nuclear reaction. 1

(ii) Calculate the energy released in this reaction. 6

12. (*a*) In a certain star, one of the fusion reactions taking place is represented by the following statement.

$$^{1}_{1}\mathrm{H} + {}^{15}_{7}\mathrm{N} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{4}_{2}\mathrm{He}$$

The energy released by this reaction is $7{\cdot}96662 \times 10^{-13}$ J.

The table shows the masses of three of the particles.

Particle	*Mass*/kg
$^{1}_{1}\mathrm{H}$	$1{\cdot}68706 \times 10^{-27}$
$^{12}_{6}\mathrm{C}$	$20{\cdot}1031 \times 10^{-27}$
$^{4}_{2}\mathrm{He}$	$6{\cdot}69944 \times 10^{-27}$

Calculate the mass of the nitrogen nucleus. 5

Total 40