Homework 3: Nuclear Reactions

1. The equation below represents a nuclear reaction.

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

Identify which of the following nuclear reactions is represented by the equation.

A nuclear fusion
B alpha decay
C beta decay
D induced nuclear fission
E spontaneous nuclear fission

2. An element X emits an alpha particle to form a new element.
Identify which of the following statements is/are correct for the **new** element.

I The total number of protons and neutrons is four less than element X.
II The number of protons is the same as in element X.
III The new element is an isotope of element X.

A I only
B II only
C III only
D I and III only
E II and III only

3. The last two decays in a radioactive decay series are shown below.
A bismuth nucleus emits a beta particle and its product, a polonium nucleus, emits an alpha particle.

$$^{P}_{Q}Bi \xrightarrow{\beta} ^{R}_{S}Po \xrightarrow{\alpha} ^{208}_{82}Pb$$

Identify which numbers are represented by P, Q, R and S.

	P	Q	R	S
A	212	85	212	84
B	212	83	212	84
C	211	85	207	86
D	210	83	208	81
E	210	83	210	84

4. The following statement describes a fusion reaction.

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

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.
Calculate the energy released in this reaction.

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. Part of a radioactive decay series is shown below.

$$\begin{array}{ccccc} & & & {}^{208}_{\ y}Tl & & \\ & & \overset{\alpha}{\nearrow} & & \overset{\beta}{\searrow} & \\ {}^{212}_{82}Pb \xrightarrow{\beta} {}^{\ x}_{83}Bi & & & & & {}^{208}_{82}Pb \\ & & \underset{\beta}{\searrow} & & \underset{\alpha}{\nearrow} & \\ & & & {}^{212}_{84}Po & & \end{array}$$

The numbers x and y in the series have been omitted.
Identify the correct numbers for x and y.

	x	y
A	212	84
B	211	81
C	212	81
D	213	84
E	211	83

6. The process of nuclear fission occurs in the core of a nuclear reactor.
Identify which of the following statements is/are correct for this process.

I Two nuclei are produced when an unstable nucleus fissions.
II Two unstable nuclei combine during nuclear fission.
III Neutrons are released when an unstable nucleus fissions.

A I only
B II only
C III only
D I and III only
E I and III only

7. The symbols for two isotopes of carbon, carbon-14 and carbon-12, are as follows.

$${}^{14}_{6}C \qquad {}^{12}_{6}C$$

Identify the statement which correctly completes the following sentence:

"Carbon-14 and carbon-12 are said to be isotopes of carbon because…

A …carbon-14 and carbon-12 have different mass numbers but the same atomic number."
B …carbon-14 has the same mass number as carbon-12."
C …carbon-14 has a different atomic number from carbon-12."
D …carbon-14 is radioactive."
E …carbon-14 has the same number of neutrons as carbon-12."

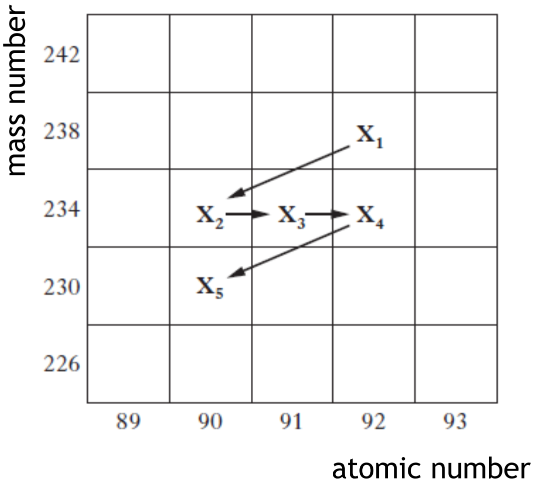
8. The three statements below refer to the process of nuclear fission.

I Fission may be spontaneous.
II Fission can be produced when neutrons bombard a nucleus, which has a large mass number.
III When fission occurs, a nucleus with a large mass number may split into nuclei with smaller mass numbers, along with several neutrons.

Identify which of the statements is/are true.

A III only
B I and II only
C I and III only
D II and III only
E I, II and III

9. Part of a radioactive decay series is shown in the diagram.
The symbols X_1 to X_5 represent nuclides in this series.



A student makes the following statements about the decay series.

I Nuclides X_2 and X_3 contain the same number of protons.
II Nuclides X_1 decays into X_2 by emitting an alpha particle.
III Nuclides X_3 decays into X_4 by emitting a beta particle.

Identify which of the statements is/are correct.

A I only
B II only
C III only
D II and III only
E I, II and III

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

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

Identify the row in the following table that correctly shows which radiations must be emitted at each stage.

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

11. A smoke alarm contains a very small sample of the radioactive isotope Americium-241, represented by the symbol

$$^{241}_{95}\mathrm{Am}$$

(a) How many neutrons are there in a nucleus of this isotope?
(b) This isotope decays by emitting alpha particles as shown in the following statement.

$$^{241}_{95}Am \rightarrow {}^{s}_{r}T + \alpha$$

(i) Determine the numbers represented by the letters ***r*** and ***s***.
(ii) Use a Periodic Table to identify the element ***T***.

12. Some power stations use nuclear fission reactions to provide energy for generating electricity. The following statement represents a fission reaction.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{57}La + {}^{x}_{42}Mo + 2\,{}^{1}_{0}n + \boldsymbol{y}\,{}^{0}_{-1}e$$

(a) Determine the numbers represented by the letters x and y in the above statement.
(b) Explain why a nuclear fission reaction releases energy.
(c) The masses of the particles involved in the reaction are shown in the table.

Particle	*Mass (kg)*
$^{235}_{92}U$	$390{\cdot}173 \times 10^{-27}$
$^{139}_{57}La$	$230{\cdot}584 \times 10^{-27}$
$^{x}_{42}Mo$	$157{\cdot}544 \times 10^{-27}$
$^{1}_{0}n$	$1{\cdot}675 \times 10^{-27}$
$^{0}_{-1}e$	negligible

Calculate the energy released in this reaction.

13. A nuclear fission reaction is represented by the following statement.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{137}_{\boldsymbol{r}}Cs + ^{\boldsymbol{s}}_{37}\boldsymbol{T} + 4\,^{1}_{0}n$$

(a) Is this a spontaneous or induced reaction? You must justify your answer.
(b) Determine the numbers represented by the letters ***r*** and ***s*** in the above reaction.
(c) Use a Periodic Table to identify the element represented by ***T***.
(d) The masses of the nuclei and particles in the reaction are given below.

Particle	*Mass (kg)*
$^{235}_{92}U$	$390{\cdot}219 \times 10^{-27}$
$^{137}_{\boldsymbol{r}}Cs$	$227{\cdot}292 \times 10^{-27}$
$^{\boldsymbol{s}}_{37}\boldsymbol{T}$	$157{\cdot}562 \times 10^{-27}$
$^{1}_{0}n$	$1{\cdot}675 \times 10^{-27}$

Calculate the energy released in the reaction.

14. A ship is powered by a nuclear reactor.
One reaction that takes place in the core of the nuclear reactor is represented by the statement below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{58}Ce + ^{94}_{40}Zr + 2\,^{1}_{0}n + 6\,^{0}_{-1}e$$

(a) The symbol for the Uranium nucleus is $^{235}_{92}U$.
What information about the nucleus is provided by the following numbers?
(i) 92
(ii) 235

(b) Describe how neutrons produced during the reaction can cause further nuclear reaction.
(c) The masses of the particles involved in the reaction are shown in the table.

Particle	*Mass (kg)*
$^{235}_{92}U$	$390{\cdot}173 \times 10^{-27}$
$^{140}_{58}Ce$	$232{\cdot}242 \times 10^{-27}$
$^{94}_{40}Zr$	$155{\cdot}884 \times 10^{-27}$
$^{1}_{0}n$	$1{\cdot}675 \times 10^{-27}$
$^{0}_{-1}e$	negligible

Calculate the energy released in the reaction.

15. 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.

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

The masses of the nuclides involved are as follows.

Mass of $^{226}_{88}Ra$ = 3·75428 × 10^{-25} kg

Mass of $^{x}_{y}Rn$ = 3·68771 × 10^{-25} kg

Mass of $^{4}_{2}He$ = 6·64832 × 10^{-27} kg

(a) What are the values of x and y for the nuclide $^{x}_{y}Rn$?
(b) Calculate the energy released by one decay of this type.

16. Energy is released from stars as a result of nuclear reactions.
One of these reactions is represented by the statement given below.

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{18}_{9}F + \gamma$$

(a) What type of nuclear reaction is described by this statement?
(b) Explain why this reaction results in the release of energy.
You should make reference to an equation in your explanation.

17. The following statement represents a nuclear reaction which may form the basis of a nuclear power station of the future.

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

(a) What type of nuclear reaction is described by this statement?

(b) Using the information given below, and any other data required from the Data Sheet, calculate the energy released in the above nuclear reaction

Mass of $^{3}_{1}H$ = 5·00890 × 10^{-27} kg
Mass of $^{2}_{1}H$ = 3·34441 × 10^{-27} kg
Mass of $^{4}_{2}He$ = 6·64632 × 10^{-27} kg
Mass of $^{1}_{0}n$ = 1·67490 × 10^{-27} kg

(c) Calculate how many of the reactions of the type represented above would occur each second to produce a power of 25 MW.