Higher Nuclear Reactions Questions

1. a) What **three conclusions** did **Rutherford** come to after carrying out the **scattering** experiment?

b) **Describe** how he carried out the experiment **with the aid of a diagram**.

2. State the number of **protons**, **neutrons** and the **element** for each of the following nuclei:

a) $^{210}_{83}Bi$

b) $^{235}_{92}U$

c) $^{226}_{88}Ra$

3. Part of a radioactive decay series is shown below.

State the **names** of the **particles emitted** at each stage.

$$^{210}_{83}Bi \rightarrow \ ^{210}_{84}Po \rightarrow \ ^{206}_{82}Pb$$

4. A radioactive source has a **half-life of 7 days**.

What **fraction** of its original activity is left **after 56 days**?

5. An experiment was set up by pupils to measure the half-life of a radioactive source.

The **background activity** was measured at **60Bq**, increased to **700Bq** when the radioactive source was brought out and put in position.

Calculate the **half-life of the source** if the activity measured **45 minutes later is 80Bq**.

6. a) What is meant by the term '**activity**'?

b) The activity of a radioactive source is **680MBq**.

Calculate how many atoms will decay in **4 minutes**.

7. State the definitions of the following terms:

a) Nuclear **Fission**.

b) Nuclear **Fusion.**

8. State whether the following reactions involve **nuclear fission or nuclear fusion**:

a)

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

b)

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

9.

$$ {}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{134}_{52}Te + {}^{98}_{40}Zr + 4\ {}^{1}_{0}n $$

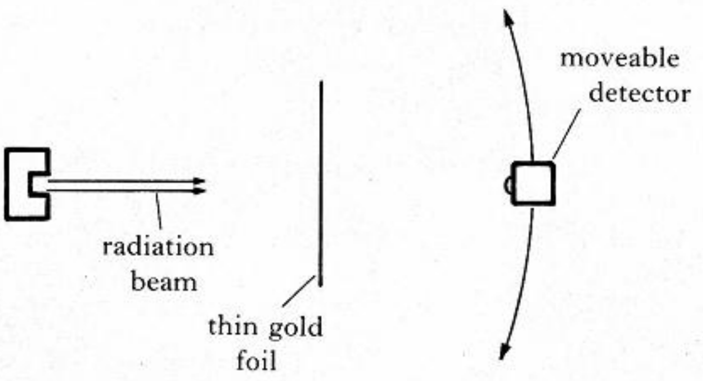
a) State the **type of nuclear reaction** taking place in the equation above.

b) **Calculate the energy released** in the nuclear reaction using the table of data below:

Nuclei	Mass (x 10^{-25} kg)
235 Uranium	3.901
134 Tellurium	2.221
98 Zirconium	1.626
Neutron	0.017

10.

In a famous experiment to investigate the structure of the atom, a beam of radiation is directed at a thin, gold foil target as shown in the diagram below.



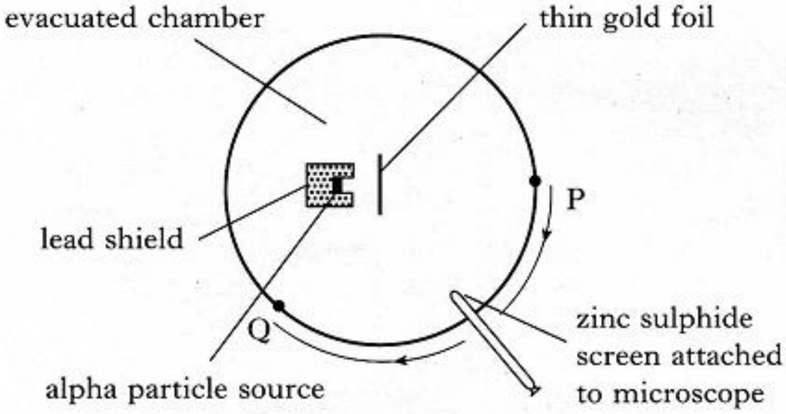
The experiment shows that most of the radiation passes through the gold foil but some "bounces back" without passing through the foil.

(*a*) State the type of radiation used.

(*b*) Explain how the results of the experiment suggest that the mass of the atom is concentrated at its centre (nucleus).

11.

The diagram shows the apparatus used by Rutherford to investigate the scattering of alpha particles by a gold foil.



From the observations made as the microscope and screen were moved from P to Q, Rutherford deduced that an atom has a nucleus which is:

(A) positively charged;

(B) massive;

(C) much smaller than the volume of the atom.

Explain how the observations from the scattering experiment led to these three deductions.

12.

(*a*) The first three stages in a radioactive decay series are shown below.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th \longrightarrow {}^{234}_{91}Pa \longrightarrow {}^{234}_{92}U$$

(i) What particle is emitted when Thorium (Th) decays to Palladium (Pa)?

(ii) How many neutrons are in the nuclide represented by $^{238}_{92}U$?

(iii) In the next stage of the above decay series, an alpha particle is emitted.

Copy and complete this stage of the radioactivity decay series shown below, giving values for a, b, c and d, and naming the element X.

$$^{234}_{92}U \longrightarrow {}^{a}_{b}X + {}^{c}_{d}\alpha$$

13.

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

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

(*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.

$$^{241}_{95}\text{Am} \longrightarrow \, ^{s}_{r}\boldsymbol{T} + \alpha$$

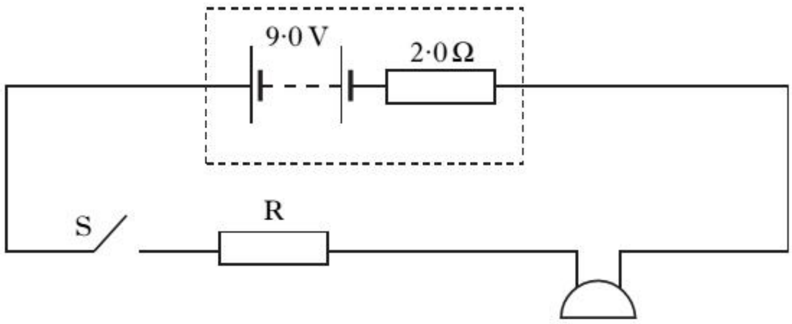
(i) Determine the numbers represented by the letters ***r*** and ***s***.

(ii) Use the data booklet to identify the element ***T***.

(*c*) The activity of the radioactive sample is 30 kBq. How many decays take place in one minute?

(*d*) The alarm circuit in the smoke detector contains a battery of e.m.f. 9·0 V and internal resistance 2·0 Ω.

This circuit is shown.



When smoke is detected, switch S closes and the buzzer operates. The buzzer has a resistance of 16 Ω and an operating voltage of 5·0 V.

Calculate the value of resistor R required in this circuit.

14.

(*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.

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

15.

(*a*) Two possible nuclear reactions involving uranium are represented by the statements shown below.

Statement **A** $\quad {}^{235}_{92}U + {}^{1}_{0}n = {}^{134}_{52}Te + {}^{98}_{40}Zr + 4\,{}^{1}_{0}n$

Statement **B** $\quad {}^{235}_{92}U + {}^{1}_{0}n = {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2\,{}^{1}_{0}n$

The masses of the nuclei and particles involved in the reactions are as follows.

	Mass
${}^{235}_{92}U$	$3{\cdot}901 \times 10^{-25}$ kg
${}^{134}_{52}Te$	$2{\cdot}221 \times 10^{-25}$ kg
${}^{98}_{40}Zr$	$1{\cdot}626 \times 10^{-25}$ kg
${}^{144}_{56}Ba$	$2{\cdot}388 \times 10^{-25}$ kg
${}^{90}_{36}Kr$	$1{\cdot}492 \times 10^{-25}$ kg
${}^{1}_{0}n$	$0{\cdot}017 \times 10^{-25}$ kg

(i) What type of nuclear reaction is described by statements **A** and **B**?

(ii) Show by calculation how much mass is "lost" in each of reactions **A** and **B**.

(iii) Explain which of the reactions **A** and **B** releases the greater amount of energy.

(*b*) A third possible nuclear reaction involving ${}^{235}_{92}U$ is represented by the following statement.

$${}^{235}_{92}U + {}^{1}_{0}n = {}^{98}_{42}Mo + {}^{136}_{y}Xe + 2\,{}^{1}_{0}n + 4\,{}^{0}_{-1}e$$

(i) The symbol for the uranium nucleus is ${}^{235}_{92}U$. What information about the particles in the nucleus is provided by the numbers 92 and 235?

(ii) Determine the number represented by y.

16.

Energy is released from stars as a result of nuclear reactions.

One of these reactions is represented by the statement given below.

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

(*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.

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

$$^{A}_{Z}\mathbf{X} \quad + \quad ^{2}_{1}\mathrm{H} \quad \longrightarrow \quad 2\ ^{4}_{2}\mathrm{He} \quad + \quad ^{1}_{0}\mathrm{n} \quad + \quad \text{energy}$$

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

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

(i) Use the data booklet to identify the element **X**.

(ii) The energy released in this reaction is $2{\cdot}97 \times 10^{-12}$ J.

Calculate the mass of the nucleus $^{A}_{Z}\mathbf{X}$.

18.

(*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.

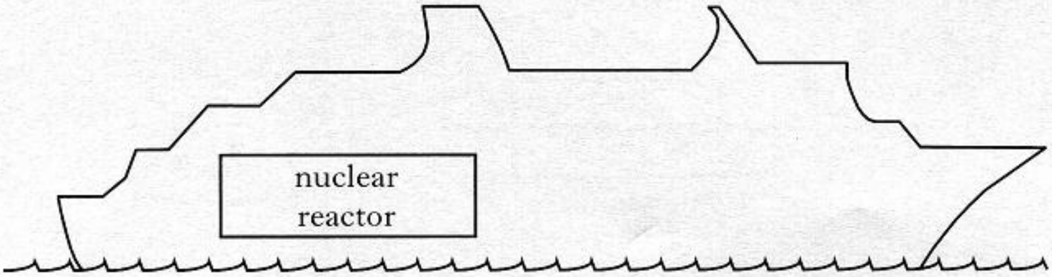
Particle	*Mass*/kg
$^{3}_{1}\mathrm{H}$	$5{\cdot}005 \times 10^{-27}$
$^{2}_{1}\mathrm{H}$	$3{\cdot}342 \times 10^{-27}$
$^{4}_{2}\mathrm{He}$	$6{\cdot}642 \times 10^{-27}$
$^{1}_{0}\mathrm{n}$	$1{\cdot}675 \times 10^{-27}$

(i) Name this type of nuclear reaction.

(ii) Calculate the energy released in this reaction.

19.

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.

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

(*a*) The symbol for the Uranium nucleus is $^{235}_{92}\text{U}$.

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 reactions.

(*c*) The masses of particles involved in the reaction are shown in the table.

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

Calculate the energy released in the reaction.

20.

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*) State the name given to the above type of nuclear reaction.

(*b*) Explain, using $E = mc^2$, how this nuclear reaction results in the production of energy.

(*c*) 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 $^{3}_{1}H$ $= 5\cdot00890 \times 10^{-27}$ kg

mass of $^{2}_{1}H$ $= 3\cdot34441 \times 10^{-27}$ kg

mass of $^{4}_{2}He = 6\cdot64632 \times 10^{-27}$ kg

mass of $^{1}_{0}n$ $= 1\cdot67490 \times 10^{-27}$ kg

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