Extended Homework Task
Physics P7 Radioactivity
Aiming for Grade 6

Name ……

Please hand in a completed printed version at the end of the topic

P7 Radioactivity – Aiming for Grade 6

Task

Part 1: Radiation and atoms

Design a cartoon book that explains the principles of radioactive decay. Each of the particles involved (alpha, beta, gamma, protons, neutrons) should be a character, and the book should make clear:

- the symbols for alpha, beta, and gamma radiation, and the neutron
- what stops alpha, beta, and gamma radiation
- what alpha, beta, and gamma radiation actually are
- the charge on alpha, beta, and gamma radiation, and the neutron
- the ionising power of alpha, beta, and gamma radiation
- the range in air for alpha, beta, and gamma radiation.

You should include an example of each of alpha, beta, and gamma decay in terms of what happens to the nucleus, and an explanation of the term 'isotope'.

Nuclear fusion:

The Sun shines because of nuclear fusion. You are going to estimate how long the Sun will shine based on the fact that that the Sun's energy source is nuclear fusion. Complete the calculation below.

First, you calculate the number of protons (hydrogen nuclei) in the Sun that can undergo fusion.

A The mass of the Sun is 2×10^{30} kg, but only 75% of the Sun is hydrogen, so

the mass of hydrogen $= 2 \times 10^{30}$ kg $\times 0.75 =$ _____ kg

B The mass of a proton is 1.667×10^{-27} kg. So, the number of protons

$$= \frac{\text{Your answer to A}}{\text{mass of a proton}} = \frac{\text{Your answer to A}}{1.667 \times 10^{-27}} =$$

$$\frac{\text{_____}}{1.667 \times 10^{-27}} = \text{_____ protons}$$

C You need 4 protons to make one helium nucleus in a fusion reaction. So the

number of fusion reactions that you can have with this number of protons $=$

$$\frac{\text{Your answer to B}}{4} = \frac{\text{_____}}{4} = \text{_____ reactions}$$

Next you work out the energy produced in one fusion reaction.

D The mass of 4 protons (hydrogen nuclei) is 6.693×10^{-27} kg

The mass of one helium nucleus is 6.645×10^{-27}kg

The difference in mass between the helium nucleus and the 4 protons

$= 6.693 \times 10^{-27}$ kg – 6.645×10^{-27} kg = _____ kg.

E energy = mass × (speed of light)^2. So, the energy released when this mass is converted to energy in one fusion reaction

= [your answer to D] × (speed of light)^2 = _____

= _____ × $(3 \times 10^8)^2$ = _____ J.

Finally, you work out the energy released by all the hydrogen nuclei, and the lifetime of the Sun.

F Total energy released in fusion = energy per reaction × number of reactions

= [your answer to E] × [your answer to C] = _____ J.

G The luminosity of the Sun is about 4×10^{26} W which means that it radiates 4×10^{26} joules per second. So the lifetime of the Sun

$$\frac{\text{Your answer to F}}{4 \times 10^{26}\ \text{J/s}} = \frac{\qquad}{4 \times 10^{26}\ \text{J/s}} = \text{\_\_\_\_\_}\ \text{s.}$$

H. Convert your answer to G to years.

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Part 3: Half-life, using radioactivity and risk

Using radioactivity and risk

You are in charge of a section of a hospital that deals with using radioactivity to explore internal organs and control or destroy cancer cells. You need to write a leaflet for the public explaining the risks and benefits of using radioactive materials in this way.

Include an FAQ (Frequently Asked Questions) section in your leaflet. You should include the answers to questions that people might have because they have heard the word ‘radioactive’ in situations that are negative, such as in relation to an accident at a nuclear power station. Here are some concerns or misconceptions that people have about radioactive materials:

- all radioactive material is dangerous
- you don’t normally come into contact with radioactive material
- all radioactive materials cause cancer.

Questions

Part 1: Radiation and atoms

1 **a** Compare alpha and beta radiation.

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..... (*4 marks*)

b Compare alpha and gamma radiation.

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..... (*4 marks*)

2 The atomic number of thorium is 90. Use the periodic table to write a balanced decay equation for each of the following:

a the decay of thorium-229 by alpha decay.

..... (*3 marks*)

b the decay of thorium-231 by beta decay.

..... (*3 marks*)

3 Describe and explain the difference between the decay equations in question **2** and the decay equation for an isotope that decays by emitting gamma radiation.

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..... (*2 marks*)

7 The Sun is halfway through its lifecycle, and was formed about 5 billion years ago.

a Suggest how much longer it will shine for, based on your calculation.

..... (*1 mark*)

b Scientists estimate that the Sun will shine for about another 5 billion years, and know that only hydrogen in the core of the Sun (about 10% of the total hydrogen) undergoes fusion. Suggest how this would affect your calculation.

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..... (*2 marks*)

Part 3: Half-life, using radioactivity and risk

9 **a** Use this data to plot a graph and find the half-life of a radioactive source. (*6 marks*)

Time (hours)	Count rate (counts/min)
0	510
0.5	414
1.0	337
1.5	276
2.0	227
2.5	188

b Use the half-life to calculate the activity after 6 half-lives.

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10 Compare the use of radioisotopes for the investigation of organs and for the control or destruction of unwanted tissue.

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..... (6 *marks*)

11 Describe two things that doctors do to reduce the risk of radiation damage when they use radioactive material to investigate organs.

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..... (*2 marks*)

12 Describe two things that doctors do to reduce the risk of radiation damage when they use radioactive material to kill cancer cells.

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..... (*2 marks*)

13 Name one other person who is at risk from damage from radiation, and suggest one thing they can do to reduce the risk.

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..... (*2 marks*)

14 A doctor has a choice of various isotopes to use in an investigation into the working of a patient's kidneys. Here is a lists of the possible isotopes she can use.

Name	Type of emitter	Half life
technetium-95m	gamma	61 days
technetium-96	gamma	4.3 days
technetium-98	beta, gamma	4 200 000 years
technetium-99	beta	210 000 years
technetium-99m	gamma	6 hours

Write down and explain which isotope the doctor should use.

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..... (*3 marks*)

15 Describe one thing that you can do to reduce the risk of a build-up of radioactive gas in your house.

..... (*1 mark*)