Extended Homework Task
Physics P7 Radioactivity
Aiming for Grade 8

Name ……

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

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:

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. Here are some facts about the Sun.

- The mass of the Sun is 2×10^{30} kg
- Only 75% of the Sun is hydrogen
- The mass of a proton is 1.667×10^{-27} kg
- Number of protons needed for a fusion reaction = 4
- The mass of 4 protons is 6.693×10^{-27} kg
- The mass on one helium nucleus is 6.645×10^{-27} kg
- Energy = mass difference × (speed of light)^2
- The luminosity of the Sun is about 4×10^{26} W which means that it radiates 4×10^{26} J/s

You could do the calculation in 3 parts:

A Calculate the number of fusion reactions given the mass of the Sun and the proton, and the number of protons needed for each reaction.

B Calculate the energy produced in each fusion reaction using $E = mc^2$.

C Calculate the energy released in total, then use the energy radiated by the Sun each second to find the time. Convert this to billions of years.

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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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*)

4 Explain how a nucleus can emit an electron when it only contains protons and neutrons.

..... (*1 mark*)

Part 2: Modelling the atom and fission, and calculating with fusion

5 One of the most important experiments was the Geiger and Marsden experiment.

a Describe what Geiger and Marsden did in this experiment.

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b Describe the observations that they made.

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..... (*2 marks*)

c Explain why these observations changed ideas about the atom.

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..... (*1 mark*)

6 Describe the evidence that led to the change from Rutherford's model to Bohr's model.

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7 Describe in detail the model that you use in science lessons today.

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..... (*4 marks*)

8 Describe and explain one other idea in science that has changed over time. Include the evidence that led to the change in your answer

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..... (*2 marks*)

9 Suggest two differences between the way that Geiger and Marsden worked and the way that scientists work to investigate sub-atomic particles today.

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..... (*2 marks*)

10 Only elements where $90 \leq Z \leq 100$, and isotopes with $2 \times Z - N = 43 \pm 2$ undergo fission when they absorb a neutron, where Z is the atomic number and N is the number of neutrons.

a Write down what this means in words, and in terms of protons and neutrons. Use your periodic table to look up the elements mentioned.

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11 Explain the difference between a nuclear reaction, a chain reaction, and a chemical reaction.

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..... (*3 marks*)

12 Suggest how your teacher could model a chain reaction with some tall matches and a tray of sand. Include a risk assessment for your teacher in your answer.

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..... (*4 marks*)

14 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. Suggest what fraction of the protons in the Sun are actually involved in fusion reactions.

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..... (*1 mark*)

15 It is not possible for the Sun to use coal as a fuel.

a Give one reason why.

..... (*1 mark*)

b Burning one kilogram of coal produces 5×10^6 joules. Use this information to calculate how long the Sun would last if it was made entirely of coal and produced the energy per second that it produces.

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c Comment on your answer to part **b** in the light of the age of the Sun.

..... (*1 mark*)

Part 3: Half-life, using radioactivity and risk

17 a Use this data to plot a graph and find the half-life of a radioactive source.

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

(*6 marks*)

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

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

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19 Discuss two of the main ways of reducing risk when you are using radioactive materials with patients in a hospital.

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20 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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21 Describe one thing that you can do to reduce the risk of a build-up of radioactive gas in your house.

..... (*1 mark*)