Year 11 Physics NAME_____

Test: Nuclear Models and Radioactivity

1. The basic structure of an atom is a central nucleus surrounded by electrons.

   (a) Compare approximately the mass of an atom's electrons with the mass of an atom's nucleus.

   _____ (1)

   (b) Compare approximately the size of an atom's nucleus to the size of the entire atom.

   _____ (1)

2. Atomic nuclei can be described using their chemical symbol, mass number, and atomic number.

   (a) State the atomic number of $^{235}_{92}\mathrm{U}$

   _____ (2)

   (b) State the mass number of $^{131}_{53}\mathrm{I}$

   _____ (1)

   (c) State the number of neutrons *N* as an equation in terms of *A* and *Z*.

   _____ (1)

   (d) State why isotopes of an element are chemically identical.

   _____ (1)

3. Unstable nuclei will emit different particles depending on the reason for their instability.

   (a) State the type of radioactive decay in which an antineutrino ($\bar{\nu}$) is emitted.

   _____ (1)

   (b) State the nature of an alpha (α) particle.

   _____ (1)

   (c) Name the particles that will be emitted when the nucleus has an excess of protons.

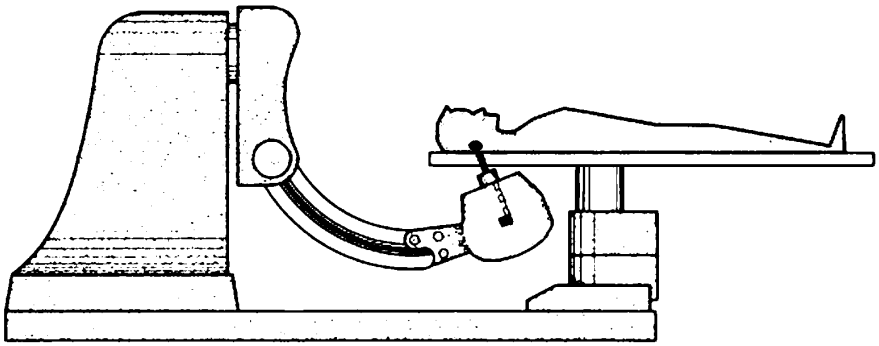
   _____

   _____ (2)

   (d) State the condition that causes an unstable nucleus to undergo gamma decay.

   _____ (1)

4. Boron-neutron capture therapy is a radiotherapy treatment for cancer. Boron is absorbed by cancer cells in the body and then exposed to neutrons, producing a nuclear reaction in which alpha particles are released. The alpha particles can kill the cancer cells.



(a) Explain why alpha particles are more effective than beta particles at killing cancer cells.

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_____ (2)

(b) Explain why alpha particles only affect the cell in which they are released.

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_____ (2)

(c) Some gamma radiation is also emitted during this process. The doctors administering this treatment use shielding to reduce their exposure to the gamma radiation.

Explain one way other than shielding in which the doctors could limit their exposure to this radiation.

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_____ (2)

5. Dr. Freeman is studying a sample of a newly discovered radioisotope in the Anomalous Materials Laboratory.

The sample begins with 5.8×10^{24} nuclei and has a half-life of 57 minutes.

(a) Sketch a graph to show how the number of nuclei changes over 4 hours.

(2)

(b) Determine the number of nuclei remaining after 171 minutes.

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_____ (2)

(c) The activity of the radioisotope sample is related to the number of nuclei remaining.
State the meaning of 'the activity of the radioisotope'.

_____ (1)

(d) It is possible Dr. Freeman will determine a medical application for this radioisotope.
State one advantage and one disadvantage of a 57 minute half-life for medical applications.

Advantage: _____

_____ (1)

Disadvantage: _____

_____ (1)

6. In a fission nuclear reactor, uranium-235 may split into barium-138 and krypton-95.

$$^{235}_{92}\text{U} \rightarrow {}^{138}_{56}\text{Ba} + {}^{95}_{36}\text{Kr} + 2\,{}^{1}_{0}\text{n}$$

(a) State why exactly two neutrons must be emitted in this reaction.

_____ (1)

(b) The masses of the particles are listed below:

$^{235}_{92}\text{U}$ 3.9030×10^{-25} kg

$^{138}_{56}\text{Ba}$ 2.2900×10^{-25} kg

$^{95}_{36}\text{Kr}$ 1.5765×10^{-25} kg

$^{1}_{0}\text{n}$ 1.6749×10^{-27} kg

Calculate the energy released during this reaction.

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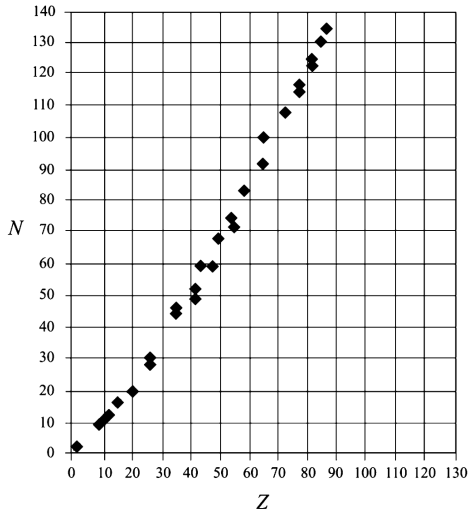
_____ (4)

(c) A graph of *N* (neutron number) against *Z* (atomic number) for some stable nuclei is plotted on the axes below:



On the graph above, plot points for $^{138}_{56}\text{Ba}$ and $^{95}_{36}\text{Kr}$ and label these points Ba and Kr respectively. (2)

(d) Hence explain why the products of nuclear fission are often beta minus emitters.

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_____

_____ (2)

(e) Explain why the uranium fuel for a fission power reactor needs to be enriched.

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_____

_____ (2)

(f) Explain the role of a moderator in a uranium-235 fission power reactor.

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_____

_____ (2)

(g) Nuclear fusion power involves obtaining energy by fusing small nuclei together to make larger nuclei, while nuclear fission power involves obtaining energy by splitting large nuclei.

State one other difference between nuclear fusion power and nuclear fission power.

_____ (1)