Student's name: _____

Supervisor's signature: _____

SIDE Teachers name _____

Physics 2A

Nuclear Physics 2014

Test 3

This test is worth 40 marks.

Time allowed: 60 minutes

Instructions

- This is a test – you do not have access to notes, books or other resources.
- You may use an approved scientific calculator that has been authorised by your teacher.
- You must show all working where requested in a question.
- The Physics Formulae Sheet is provided with this test.
- This test paper should be returned to the teacher as soon as possible.

SCORE: _____ / 40

1. Within a nuclear reactor, uranium-235 is bombarded by a neutron to split into two daughter products also emitting two neutrons. Part of the nuclear equation is shown below.

$$^{235}_{92}\mathbf{U} + {}^{1}_{0}\mathbf{n} \rightarrow \mathbf{X} + {}^{91}_{38}\mathbf{Sr} + \mathbf{2}\,{}^{1}_{0}\mathbf{n}$$

   a. Write the nuclide for the missing daughter product labelled **X**. _____need periodic table_____

   (1 mark)

   b. What is the atomic and mass numbers of the daughter product:

   Mass number _____ (1 mark) Atomic number _____ (1 mark)

2. In terms of the properties of alpha and beta radiation, explain why alpha radiation cannot penetrate paper but beta radiation can. (4 marks)

3. For an atomic bomb to explode the amount of uranium-235 must reach critical mass and then the fission reaction created from a neutron induced chain reaction becomes uncontrollable. What is a neutron induced chain reaction and why does it need critical mass to explode?

   (4 marks)

4. A radioactive isotope has a count of 3.85×10^3 decays in one hour. Calculate the activity of the source in Bq. (2 marks)

5. Calculate the binding energy per nucleon in MeV of the helium-3 atom given the mass of He-3 = 5.00×10^{-27} kg. (4 marks)

6. If the original activity of a sample is 42.0 kBq and it has a half-life of 4.00 days, how much will be left after 12.0 days? (3 marks)

7. A radiation source and a detector can be used to measure the thickness of very thin aluminium foil during manufacture. Select, from the table, a suitable radioisotope to be used as a radiation source.

RADIOISOTOPE	MOST USEFUL RADIATION EMITTED	HALF-LIFE
Americium-241	alpha	432 years
Cesium-137	gamma	30 years
Cobalt-60	gamma	5.27 days
Iodine-131	beta	8.04 days
Radium-223	alpha	11.4 years
Strontium-90	beta	29 years

Choice: _____ 1 mark)

Reason for choice: (3 marks)

8. The forming of a new element during radioactive decay is called transmutation. Explain why emitting alpha and beta radiation causes a transmutation but emitting gamma radiation does not. (3 marks)

9. A miner in a uranium mine is unaware that he is breathing in radon-222 gas, an alpha emitter. The gas has a very long half life with an activity of 3.40kBq which will be unchanged during his time in the mine. Each decay of the isotope releases 3.8×10^{-12} J of energy into the body and that the radioisotope is not eliminated from the body as it settles into the tissue of his lung. After a month the gas is discovered and the mine closed (assume a month is 30 days).

   a. Calculate the total energy the miner absorbed into his lungs during this time. (3 marks)

   b. Calculate the absorbed dose he received in one month if he has a mass of 75 kg. (If you were unable to obtain a value for (a) above use 0.035 J) (2 marks)

   c. Calculate the dose equivalent if the alpha radiation has a quality factor of 20. (2 marks)

   d. Should the miner be concerned about his exposure? Explain. (2 marks)

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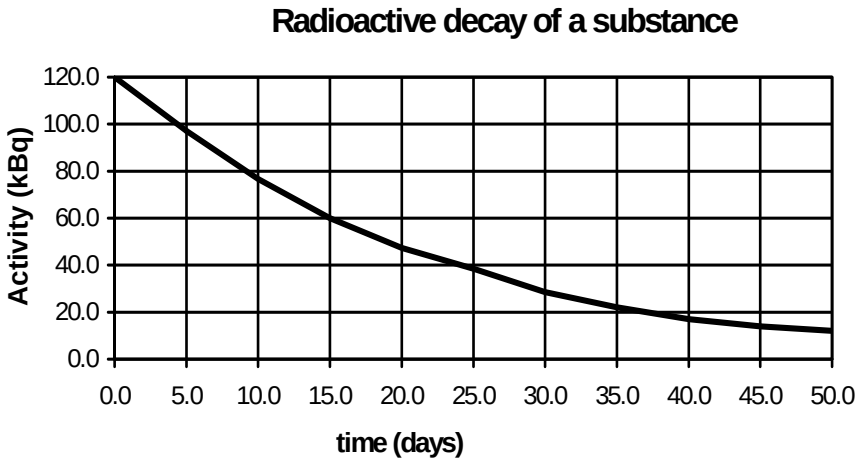
10. Determine the half-life of the substance from the graph.



Half-life = _____ (1 mark)

11. When Pu-238 (atomic number 94) is bombarded with a neutron, fission occurs to form Sn-128 (atomic number 50), Ru-108 (atomic number 44) and some neutrons.

a. Complete the nuclear equation showing the number of neutrons released. (1 mark)

$$^{1}_{0}n + {}^{238}_{94}Pu \rightarrow {}^{128}_{50}Sn + {}^{108}_{44}Ru + \_\_\_\_\_ {}^{1}_{0}n$$

b. How much energy is released per reaction using the information on your data sheet and below. (3 marks)

Pu-238 = 396.82×10^{-27} kg
Sn-128 = 212.33×10^{-27} kg
Ru-108 = 179.13×10^{-27} kg

END OF TEST