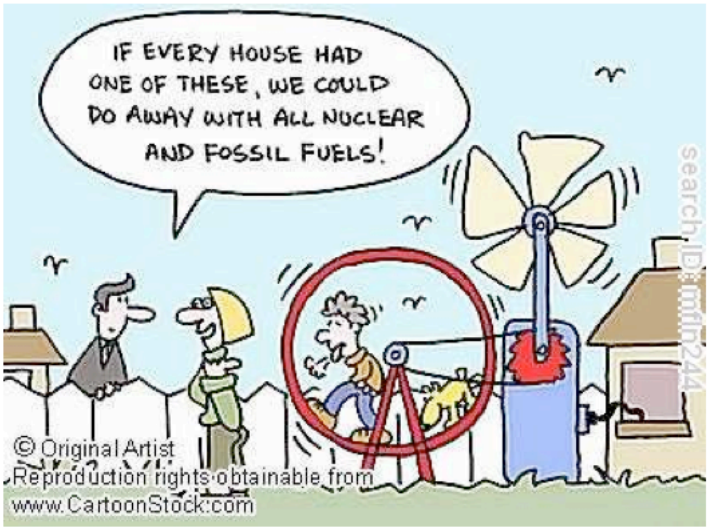
WILLETTON SENIOR HIGH SCHOOL

Physics Stage 2 – 2013

Nuclear Physics Test



Student name: _____

Teacher

- Mr Boughton □
- Mrs Davies □
- Mr Dopson □
- Mrs Pitts □

45

TIME: **1 Hour**

* Data sheet supplied

NOTE:

1. Calculations must show clear working with answers stated to **three significant figures.**
2. Marks will be allocated for clear and logical setting out.
3. To help identify your answer, underline each answer.
4. State **assumptions** if working on open ended type questions.

1. During a fission reaction, uranium-235 is bombarded by a neutron which splits into two daughter products and emits two neutrons. Part of the nuclear equation is shown below.

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

a. Write the elemental symbol for the missing daughter product labelled **X**.

_____ (1 mark)

b. What is the mass number and atomic number of the daughter product **X**:

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)

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3. Why do therapeutic radioisotopes used for cancer need to be alpha, beta, and gamma emitters? (3 marks)

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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.a. Define what is meant by the “binding energy” of a nucleus. (2 marks)

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b. What is the relationship between the binding energy per nucleon of a nucleus and the stability of a nucleus? (2 marks)

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c. Use the graph below to approximately determine the mass number of the most stable element. (1 mark)

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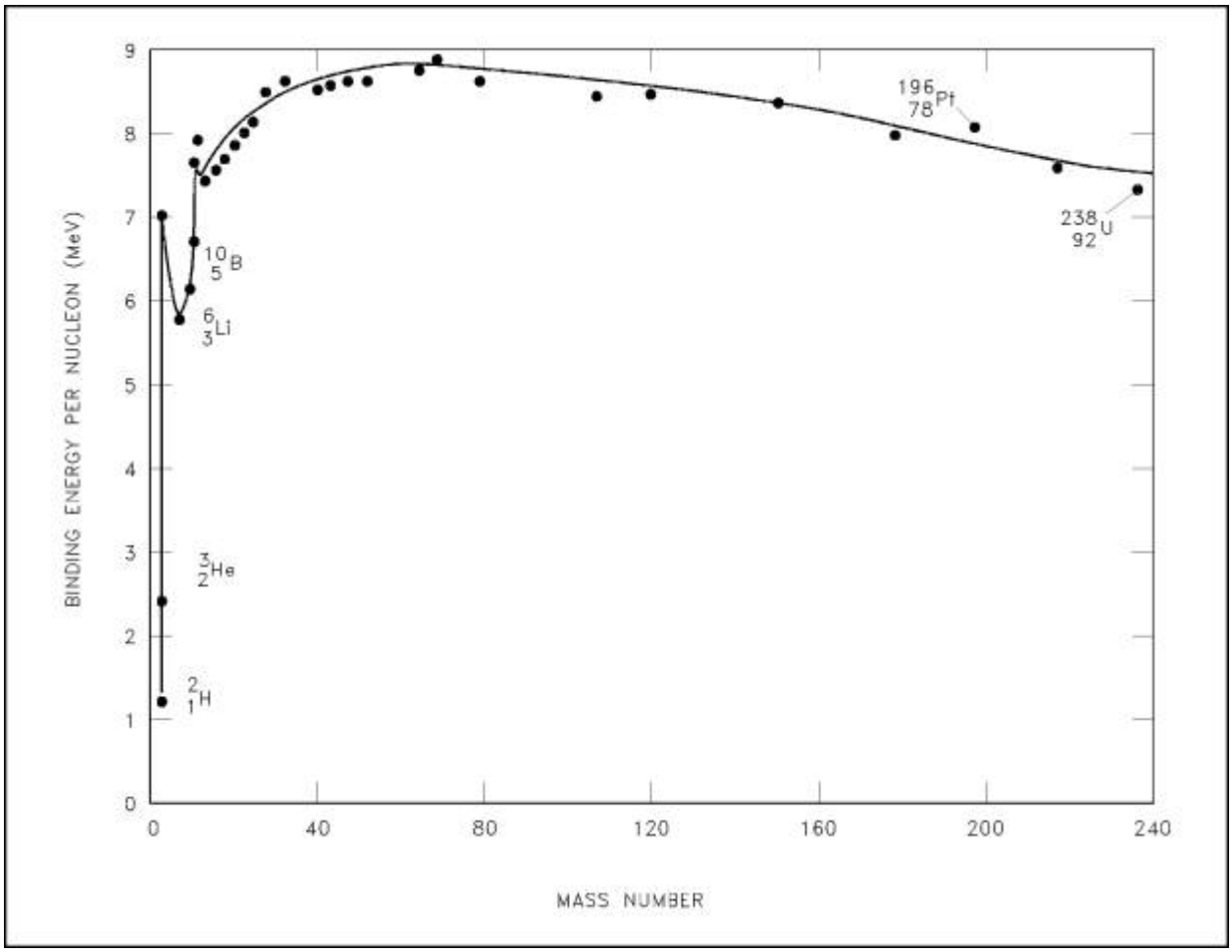

d. Why do some nuclei undergo radioactive decay, or possibly fission or fusion? (2 marks)

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6. If the original activity of a radioactive sample is 42.0 kBq and it has a half-life of 4.00 days, what will be the theoretical activity after 12.0 days? Show all working to arrive at your answer. (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 below **the most 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)

State two good reasons for your choice of isotope. (2 marks)

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8. When a plant or animal dies it stops taking in carbon-14 and radioactive decay begins to decrease the amount of carbon-14 in the tissues. The age of the deceased organism can then be predicted by measuring the activity of carbon-14 left in the remnants.

   A 30.0 g sample of carbon from a skeleton has a carbon-14 decay rate of 240.0 decays per minute. Considering the activity of carbon-14 in a living organism is 16.0 decays $minute^{-1}$ g^{-1} and the half-life of carbon-14 is 5730 years, what is the approximate age of the skeleton? (4 marks)

9. A miner in a uranium mine is unaware that he is breathing in radon-222 gas, which unfortunately is 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 the radioisotope is not eliminated from the body, as it will settle into the tissue of his lungs. After a month the dangerous gas is discovered and the mine is closed (assume a month is 30 days).

   a. Calculate the total energy the miner absorbed into his lungs during this time.

   (2 marks)

b. Calculate the absorbed dose he received in one month if he has a mass of 75.0 kg. (*If you were unable to obtain a value for part (a), 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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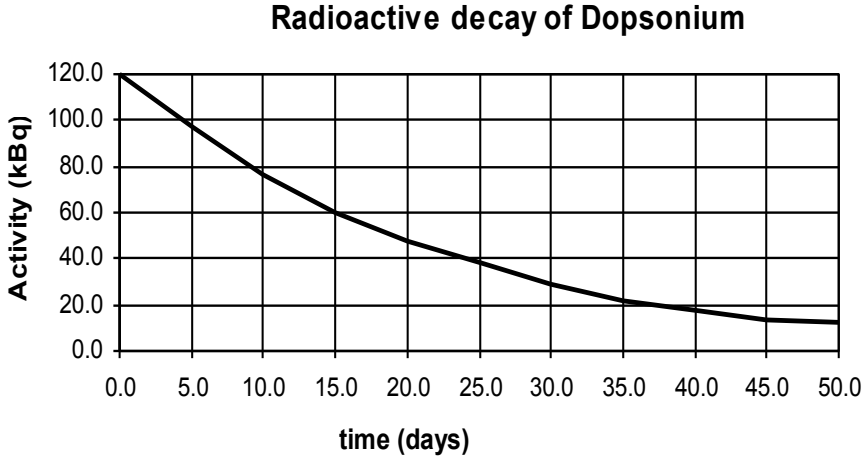
10. Determine the half-life of Dopsonium from the graph.



Half-life = _____ (1 mark)

11. When U-235 undergoes fission it releases energy. If there are enough U-235 nuclei, the process will escalate to form a chain reaction. Describe, with the aid of a diagram, how a chain reaction occurs. (2 marks)

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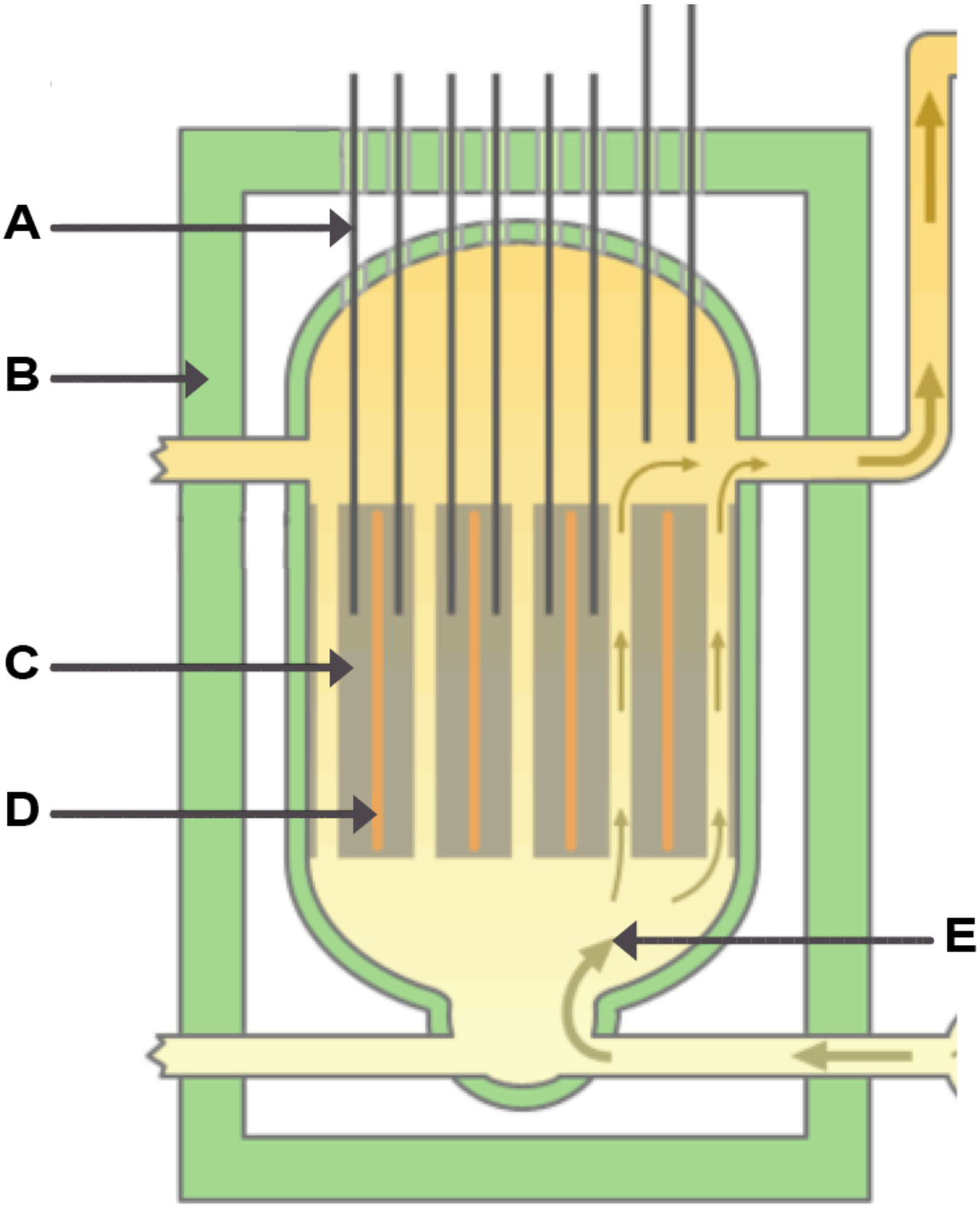
12. The diagram below indicates the location of the key parts of a thermal nuclear reactor. Complete the table on the next page by describing the purpose of each component and its composition (*what it is made of*). (5 marks)



Letter Component Name	Purpose of this Component	Component Composition
A Control Rods		
B Radiation Shielding		
C Moderator		
D Fuel Rods		
E Coolant		