Physics ATAR - Year 11

Nuclear Physics
Unit Test
2019

Mark:	/ 53
=	%

Name:

Teacher: JRM PCW RLT
(Please circle)

Time Allowed: 50 minutes

Notes to Students:

- You must include **all** working to be awarded full marks for a question.
- Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
- **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(6 marks)**

Complete the following nuclear equations.

(a) $^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + \square + \square$

(1 mark)

(b) $^{241}_{95}Am \rightarrow \square + {}^{4}_{2}\alpha$

(1 mark)

(c) $\square \rightarrow {}^{10}_{5}B + {}^{0}_{1}\beta^{+} + \upsilon$

(1 mark)

(d) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{91}_{36}Kr + {}^{142}_{56}Ba + \square$

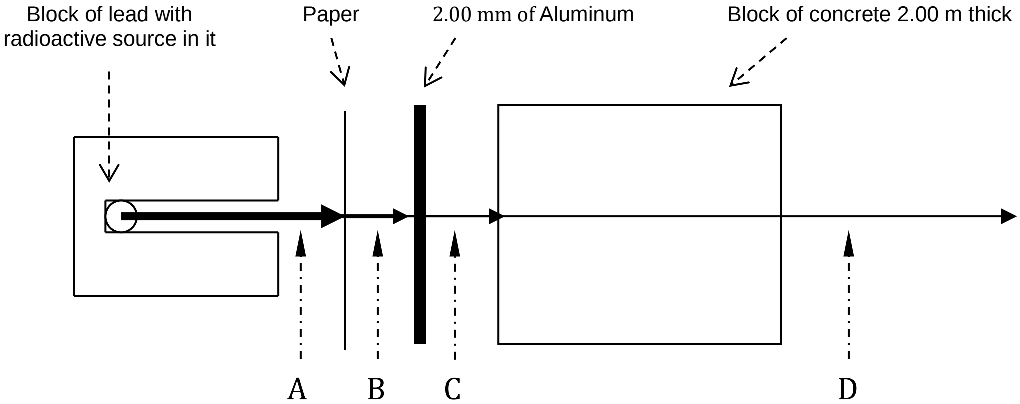
(2 marks)

(e) $\square \rightarrow {}^{131}_{54}Xe + {}^{0}_{0}\gamma$

(1 mark)

Question 2 **(6 marks)**

A mixture of alpha(α), beta (β), gamma (γ), and radiation are directed at close range in a vacuum towards the barriers shown in the below diagram.



(a) What type**s** of radiation are present at points A, B, C, and D?

(4 marks)

A ______________________ B ______________________

C ______________________ D ______________________

(b) Justify your answer to point C.

(2 marks)

____

____

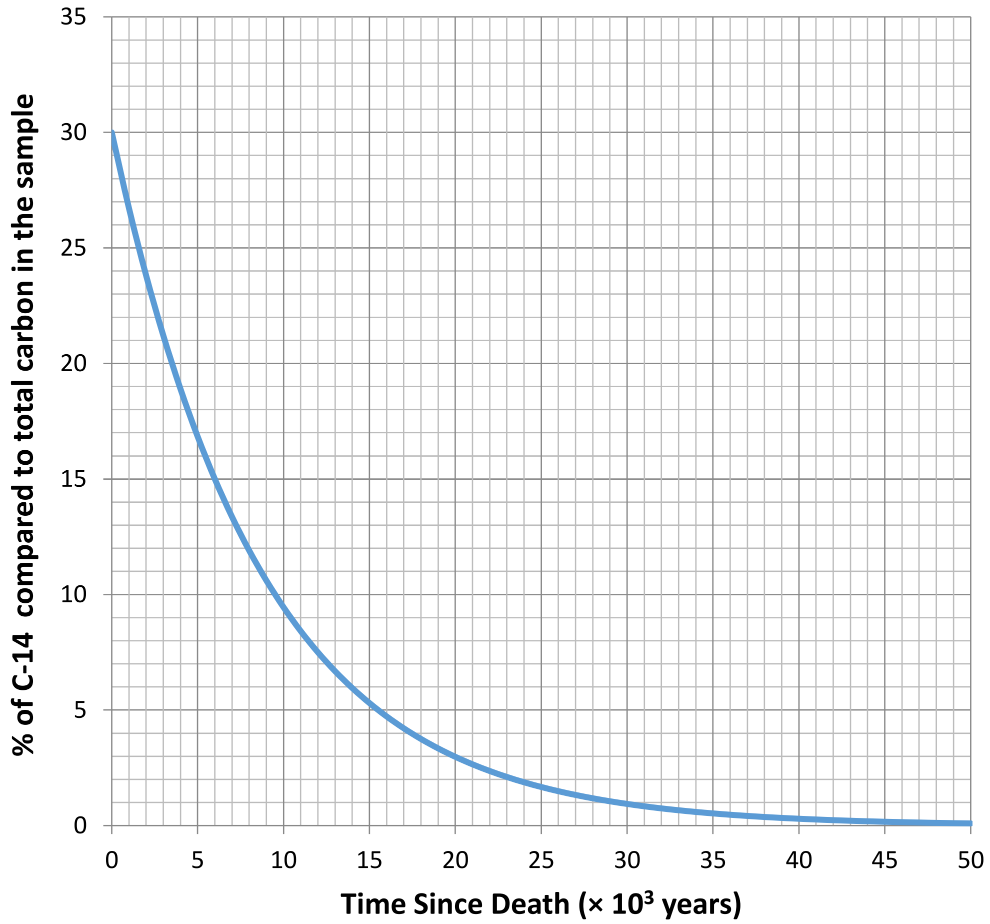
____

Question 3 **(11 marks)**

Radio carbon dating is a useful technique for establishing the date of death of organic matter. Two pieces of information are required;

- the half-life of carbon-14
- the ratio of carbon-14 to non-radioactive forms of carbon the organic matter contained while it was alive.

The fraction of carbon-14 compared to total carbon for a sample as a function of time is shown below.



(a) State the percentage of carbon in this organic matter that was not radioactive while the organism was alive.

(1 marks)

(b) Determine the half-life of carbon-14 as indicated by the graph. Show evidence of how you determined your answer on the graph.

(2 marks)

(c) Determine, by use of a calculation, the number of half-lives of carbon-14 has undergone in the sample after 12,000 years. (If you could not complete (b), use $t_{1/2}$ = 3,000 years)

(2 marks)

(d) The graph scale reveals the percentage of carbon-14 becomes negligible at 40 thousand years since time of death. Determine, by use of a calculation, what the likely percentage of carbon-14 is after 40 thousand years has passed. (If you could not complete (b), use $t_{1/2}$ = 3,000 years)

(4 marks)

(e) On the graph, sketch the curve showing the percentage of carbon-14 for a sample that had 20% carbon-14 prior to its death.

(2 marks)

Question 4 **(9 marks)**

The nuclear fission of uranium-235 within nuclear fuel rods has a range of possible products. While the average mass of a fission fragment is 118, it is unlikely to find fragments of this mass since the uranium nucleus usually splits unevenly. The most common fission result is barium-137 and krypton-95 in addition to some neutrons. The mass of reactants and products of this common reaction are found in the table.

Particle	**Mass (u)**
Uranium-235	235.043930
Barium-137	136.905827
Krypton-95	94.939844
Neutron	1.008665

(a) Write the nuclear reaction showing the most commonly occurring fission of uranium-235.

(3 marks)

(b) Calculate the mass defect of this fission reaction.

(2 marks)

(c) Calculate the energy released by a single fission event in joules.

(3 marks)

(d) State the form that this energy is released as.

(1 mark)

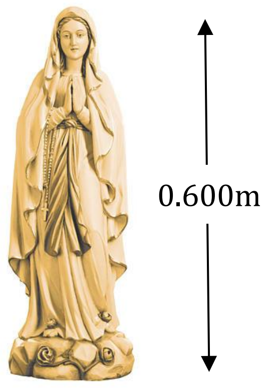
Question 5 **(5 marks)**

The aluminum - 27 atom has an atomic mass of 26.981538 u. Calculate the binding energy per nucleon of the aluminum - 27 atom in eV.

Name	Mass of atom (u)
Proton	1.007 276
Neutron	1.008 665
Electron	0.000 548 58
Hydrogen	1.007 825

Question 6 **(16 marks)**

Organic items imported into Australia can be bombarded with ionising radiation at customs if there is a risk of foreign flora or fauna being brought unintentionally. Consider a large wooden statue similar to the one shown.



(a) State and explain which form of ionising radiation would be most suited to destroying any organic material contained in the statue.

(3 marks)

___

___

___

___

A 3.50 kg statue receives a full-body exposure of ionizing radiation with a Quality Factor of x1.50 and an activity of 12.4 TBq for a time of 15.0 minutes.

(b) Assuming that 24.0% of the radiation is absorbed by the statue, calculate the number of ionizing particles absorbed by the statue in this time.

(3 marks)

Each ionising particle imparts 5.40 $x10^5$ eV to the molecules in the statue

(c) Calculate the energy in Joules that the molecules receives per ionizing particle.

(2 marks)

(d) Calculate the absorbed dose and dose equivalent for the wooden statue.
(If you could not complete (b) use n = 1.00 $x10^{15}$)

(4 marks)

(e) State and explain two precautions that workers at customs would employ to prevent any unwanted personal health issues.

(4 marks)

1.

2.

END OF TEST