Christ Church Grammar School

Science Department
Year 11 2020

ATAR PHYSICS
UNIT 1 – Nuclear Physics
TEST 2020

Student Name:

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Teacher: JRM PCW CJO SA
(Please circle)

Time allowed for this paper
Working time for paper: 50 minutes.

Instructions to candidates:

- You must include **all** working to be awarded full marks for a question.
- Answers shall be expressed to 3 significant figures unless otherwise instructed.
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Mark:	/ 54
=	%

Question 1 **(10 marks)**

When a neutron hits a boron-10 nucleus, the nucleus absorbs the neutron and emits an alpha particle.

(a) Write the nuclear equation for the absorption reaction.

(2 marks)

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(b) Name the isotope formed in the reaction.

(1 mark)

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(c) Calculate the binding energy per nucleon of a boron-10 nucleus.

(5 marks)

Particle	**Atomic mass (u)**
Proton	1.007276
Neutron	1.008665
Electron	0.0005486
Hydrogen	1.007825
Boron 10	10.012938

(d) Explain how a nucleus stays together even though the sub-atomic particles within the nucleus repel each other.

(2 marks)

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Question 2 **(19 marks)**

When uranium-235 is bombarded with a neutron, it becomes uranium-236 before decaying. One of the decay reactions creates barium-144 and krypton-89.

(a) Balance the equation below.

(1 mark)

$$^{236}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + energy + \_\_\_\_\_$$

(b) Calculate the energy released from each decay event.

(5 marks)

Particle	**Atomic mass (u)**
Proton	1.007276
Neutron	1.008665
Electron	0.0005486
Hydrogen	1.007825
Uranium 236	236.04557
Barium 144	143.92295
Krypton 89	88.91763

(c) With reference to the equation above, explain how a chain reaction can occur.

(3 marks)

(d) Explain the function of coolant in a nuclear reactor.

(2 marks)

(e) Explain the function of a moderator in a nuclear reactor.

(2 marks)

Current nuclear reactors are all based on fission reactions. Various countries around the world are working hard to create reactors which are based on fusion reactions.

(f) State and explain two benefits of a fusion reactor compared to a fission reactor.

(4 marks)

(g) State the major obstacle needed to overcome in order to create a fusion reactor.

(2 marks)

Question 3 **(6 marks)**

An old wooden spear is found in outback Australia. The current activity of C-14 is measured and calculated to be only 12.5% of it's initial activity. The half life of C-14 is 5370 years.

(a) Calculate the age of the spear.

(3 marks)

(b) Carbon dating ceases to be reliable after 10 half lives. If the initial activity of the sample is 3.20 decays per minute, calculate the activity of the sample when carbon dating is no longer reliable.

(3 marks)

Question 4 **(19 marks)**

Nuclear medical specialists will often use radioactive iodine to diagnose different illnesses. The isotope iodine-123 is typically injected into the body and it's radioactive behaviour can be monitored. Iodine will undergo gamma decay during the time spent in the body. A patient that undergoes this type of diagnostic procedure receives 105 J of energy during the course of their treatment. The patient has a mass of 67.0 kg.

(a) Calculate the absorbed dose and dose equivalent of this procedure.

(4 marks)

(b) Based on the information provided or your own knowledge, explain why iodine-123 was likely selected for this procedure.

(3 marks)

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(c) State and explain two ways the medical team can reduce or eliminate the effects of radiation on their own body when treating patients.

(4 marks)

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Using the iodine-123 procedure, the doctors have detected a tumour which has a mass of 48.0 g that is situated in the thyroid. As a treatment, they have decided to insert a radioactive implant that contains a sample of an alpha emitter with a very long half life. This implant will be placed next to the tumour and will be removed when the tumour has received sufficient radiation. The activity of the sample is 62.0 kBq and each event releases 22.4 MeV of energy. Doctors have calculated that the tumour needs to receive an equivalent dose of 80.0 Sv.

(d) Calculate the time in days the implant must remain in the patient's body in order for the tumour to receive the required dose.

(6 marks)

(e) State two assumptions that you have made in the calculation above.

(2 marks)

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END OF TEST