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MANA TOHU MĀTAURANGA O AOTEAROA

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SUPERVISOR'S USE ONLY

Level 3 Physics, 2011

90522 Demonstrate understanding of atoms, photons and nuclei

9.30 am Friday 25 November 2011
Credits: Three

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words and / or diagrams as required.

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–6 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

ASSESSOR'S USE ONLY	Achievement Criteria	
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles. ☐	Give descriptions or explanations in terms of phenomena, concepts, principles and / or relationships. ☐	Give explanations that show clear understanding in terms of phenomena, concepts, principles and / or relationships. ☐
Solve straightforward problems. ☐	Solve problems. ☐	Solve complex problems. ☐
Overall level of performance ☐		

You are advised to spend 30 minutes answering the questions in this booklet.

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All formulae are provided in the separate Resource Booklet L3-PHYSR.

Rest mass values:

Neutron	1.6749×10^{-27} kg
Proton	1.6726×10^{-27} kg
Uranium-235 nucleus	390.2182×10^{-27} kg
Krypton-92 nucleus	152.6167×10^{-27} kg
Barium-141 nucleus	233.9450×10^{-27} kg

QUESTION ONE: NUCLEAR PHYSICS

Fission reactions take place in a nuclear reactor when moving neutrons hit $^{235}_{92}\text{U}$ nuclei.

In one of the possible fission reactions, one neutron hits a nucleus and breaks it into $^{92}_{36}\text{Kr}$ and $^{141}_{56}\text{Ba}$.

(a) Write a nuclear equation for the reaction, and name the other particles produced during the reaction.

(b) If the moving neutron has kinetic energy 7.45×10^{-16} J, show that this energy contributes negligible mass to the mass of the moving neutron.

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(c) If all the energy released from the fission of one U-235 nucleus is converted to a single photon, calculate the frequency of the photon produced.

frequency = _____

(d) Calculate the total binding energy of a uranium-235 nucleus.

binding energy = _____

(e) Explain, in terms of binding energy, why the mass of a uranium-235 nucleus is less than the total mass of its constituent nucleons.

QUESTION TWO: ATOMS AND PHOTONS

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(a) State what a photon is, and describe how it can be produced by electrons within an atom.

X-rays are used to take photographs of bones inside the body. X-ray photons typically have frequencies in the range 10^{16} Hz to 10^{19} Hz.

(b) An X-ray photon has energy of 191 eV.

Calculate the frequency of the photon.

frequency = _____

When X-ray photons hit calcium, electrons are released.

(c) The frequency of a photon will have to be **more** than the threshold frequency if an electron is to be **released**.

Discuss this statement in terms of the underlying physical principles.

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(d) X-rays of frequency 1.53×10^{16} Hz cause the emission of electrons from a material with a maximum kinetic energy of 2.18×10^{-18} J.

Calculate the threshold frequency for the release of electrons from the material.

threshold frequency = _____

(e) Explain why, if a photon causes an electron to jump to a higher energy level, the exact energy of the photon is critical, but if it is used to release an electron from the atom, it is only the minimum energy of the photon that is critical.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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