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90522

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 3 Physics, 2004

90522 Demonstrate understanding of atoms, photons and nuclei

Credits: Three
9.30 am Thursday 18 November 2004

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 answer ALL the questions in this booklet.

For all 'describe' or 'explain' questions, the answers should be written or drawn clearly with all logic fully explained.

For all numerical answers, full working must be shown and the answer must be rounded to the correct number of significant figures and given with an SI unit.

Formulae you may find useful are given on page 2.

If you need more space for any answer, use the page provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–8 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.

Achievement Criteria *For Assessor's use only*		
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 concise 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 (all criteria within a column are met) ☐		

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

You may find the following formulae useful.

$E = \mathrm{h}f$	$\mathrm{h}f = \phi + E_K$	$E = \Delta m\mathrm{c}^2$	$E_n = -\frac{\mathrm{hc}R}{n^2}$
$\frac{1}{\lambda} = R(\frac{1}{S^2} - \frac{1}{L^2})$	$E_P = qV$	$v = f\lambda$	

THE SUN

Life on Earth depends on the energy that comes from the Sun in the form of heat and light. The source of this energy is the nuclear reactions that take place in the core of the Sun.

[For copyright reasons, this resource cannot be reproduced here. See below.]

Source: NASA

QUESTION ONE

Use the following information when answering this question:

Nuclear rest masses:	deuteron	${}^{2}_{1}\mathrm{H}$	is 3.3436×10^{-27} kg
	helion	${}^{3}_{2}\mathrm{He}$	is 5.0064×10^{-27} kg
	alpha particle	${}^{4}_{2}\mathrm{He}$	is 6.6447×10^{-27} kg
	proton	${}^{1}_{1}\mathrm{p}$	is 1.6726×10^{-27} kg
	neutron	${}^{1}_{0}\mathrm{n}$	is 1.6749×10^{-27} kg
	electron	e^{-1}	is $0.000\,911 \times 10^{-27}$ kg

Speed of light	=	3.00×10^{8} m s^{-1}
The size of the charge on an electron	=	1.60×10^{-19} C
Planck's constant	=	6.63×10^{-34} J s

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(a) Name the type of nuclear reaction that takes place in the Sun.

_____

The reaction is a multi-step process. One of these steps is: ${}_{1}^{2}\mathrm{H} + {}_{1}^{1}\mathrm{p} \rightarrow {}_{2}^{3}\mathrm{He} + \gamma$

(b) Show that the mass equivalent of the gamma photon is 9.8×10^{-30} kg.

_____

_____

_____

(c) Calculate the energy of the gamma photon in electron volts.

_____

_____

_____

_____

_____

energy of the gamma photon = _____ eV

The multi-step process is equivalent to the following single process:

$$4\,{}_{1}^{1}\mathrm{p} + 2\mathrm{e}^{-} \rightarrow {}_{2}^{4}\mathrm{He} + 2\nu + 6\gamma$$

ν is a neutrino and each one carries 4.005×10^{-14} J of energy.

(d) Calculate the average frequency of the gamma radiation produced.

_____

_____

_____

_____

_____

average frequency = _____

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(e) The deuteron $^{2}_{1}H$ comprises one proton and one neutron.

(i) Calculate the mass deficit of the deuteron.

mass deficit = _____

(ii) Explain why there is a mass deficit.

QUESTION TWO

Use the following information when answering this question:

Speed of light = 3.00×10^{8} m s^{-1}
Planck's constant = 6.63×10^{-34} J s
Rydberg's constant = 1.10×10^{7} m^{-1}

Light energy is produced when the excited electrons of atoms drop from higher energy levels to lower energy levels.

(a) The electron in a hydrogen atom falls from the 5th energy level to the 2nd energy level.

(i) Calculate the energy of the electron at the 2nd energy level. Give your answer to an appropriate number of significant figures.

energy = _____

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(ii) Calculate the wavelength of the light emitted by this electron transition.

wavelength = _____

The hydrogen atom, whose electron is in the 2nd energy level, is now ionised.

(b) Calculate the minimum frequency of the photon that can ionise the hydrogen atom.

minimum frequency = _____

In a hydrogen atom, electron transitions to the 2nd energy level produce visible light.

(c) Which transition will produce visible light of the lowest frequency? Explain your answer.

QUESTION THREE

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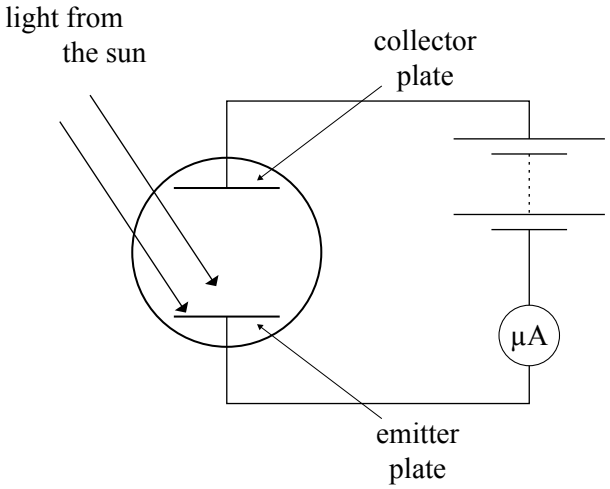
Use the following information when answering this question:

Speed of light = 3.00×10^{8} m s^{-1}
Planck's constant = 6.63×10^{-34} J s

Light energy from the Sun can be changed into electrical energy by a photoelectric cell.

The diagram shows an experimental set-up that can be used to investigate this energy change. The emitter plate has work function energy of 3.0×10^{-19} J.



(a) State why it is necessary to make the collector plate positive.

(b) Explain why the sun's light energy can cause a current in this circuit.

(c) Calculate the maximum wavelength of light that will cause a current.

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wavelength = _____

Extra paper for continuation of answers if required.
Clearly number the question.

Question number

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