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90522

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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2009

90522 Demonstrate understanding of atoms, photons and nuclei

Credits: Three
9.30 am Tuesday 24 November 2009

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 each numerical answer, full working must be shown. The answer should be given with an SI unit to an appropriate number of significant figures.

For each 'describe' or 'explain' question, the answer should be written or drawn clearly with all logic fully explained.

Formulae you may find useful are given on page 2.

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

Check that this booklet has pages 2–11 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.

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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 (all criteria within a column are met)		

You are advised to spend 35 minutes answering the questions in this booklet.

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You may find the following formulae useful.

$E = \mathrm{h}f$	$\mathrm{h}f = \phi + E_K$	$E = \Delta mc^2$	$E_n = -\frac{\mathrm{hcR}}{n^2}$
$\frac{1}{\lambda} = \mathrm{R}(\frac{1}{S^2} - \frac{1}{L^2})$	$E_\mathrm{P} = qV$	$v = f\lambda$	

Speed of light = 3.00×10^8 m s^{-1}
Charge on the electron = 1.60×10^{-19} C
Planck's constant = 6.63×10^{-34} J s
Rydberg constant = 1.097×10^7 m^{-1}

QUESTION ONE: THE HYDROGEN SPECTRUM

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http://www.assumption.edu/users/bniece/Spectra/Tutorials/AS_HSpectrum.html

(a) Briefly describe how the light that formed the hydrogen line spectrum illustrated could be produced experimentally.

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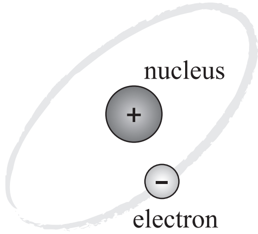
(b) Rutherford's model pictured an atom with 'electrons orbiting a solar nucleus', as illustrated below. The Bohr model was proposed to explain the line spectra of hydrogen, something that the Rutherford model could not explain.



The Rutherford model for a hydrogen atom.

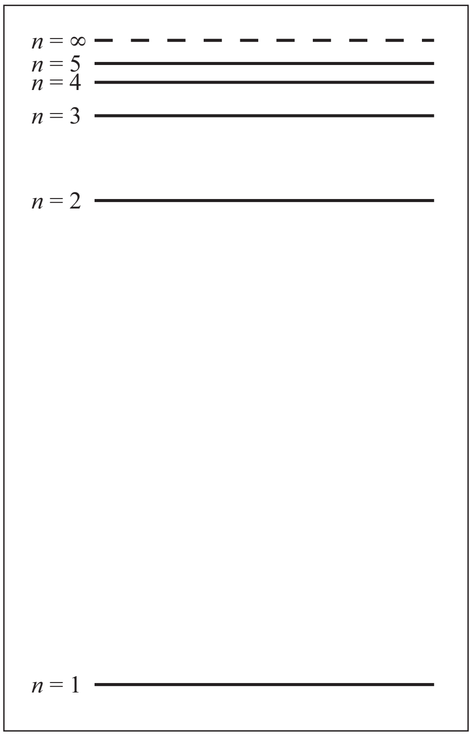
Discuss how the Bohr model was able to explain the line spectrum that the Rutherford model could not.

(c) The hydrogen spectrum in the visible region is part of the Balmer series. Energy transitions that give rise to this series are to the $n = 2$ level (emission) and from the $n = 2$ level (absorption).

Calculate the energy of the $n = 2$ level.

energy = ______________

(d) The diagram shows energy levels in a hydrogen atom



A continuous spectrum from a star shows absorption lines in the visible part of the spectrum. One dark line indicates the absorption of photons with an energy of 2.86 eV. An astronomer believes that this is due to the presence of hydrogen atoms surrounding the star.

Calculate the final energy level, *n*, when a photon of light of this frequency is absorbed by an atom of hydrogen.

energy level (*n*) = ____________

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QUESTION TWO: THE PHOTOELECTRIC EFFECT

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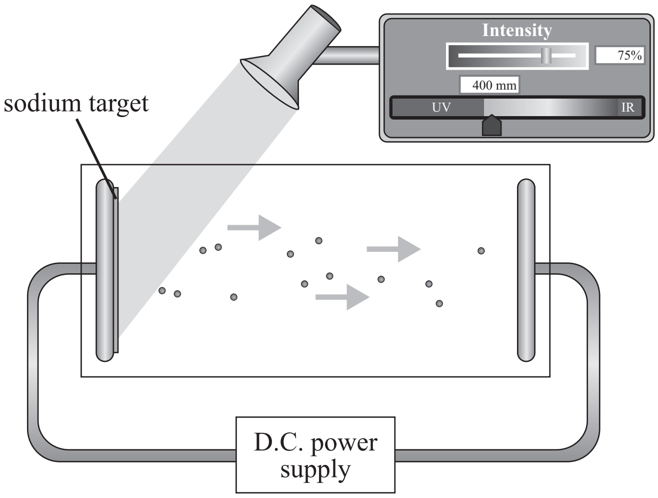

The diagram shows a simulation of the photoelectric effect. As violet light is shone on the sodium target, electrons leave the sodium and move to the right, causing a small current in the circuit.

(a) When the wavelength of the light is increased, the light becomes red and no electrons leave the sodium.

Explain why violet light, but not red light, causes electron emission.

(b) While violet light shines at the sodium, a student studies the effect of varying the intensity of the light.

Describe and explain how this will affect the rate of electron emission, the maximum speed of the emitted electrons and the current in the circuit.

(c) With violet light of wavelength 4.00×10^{-7} m shining at the target, the D.C. power supply is changed until there is no current. This stopping potential is 0.80 V .

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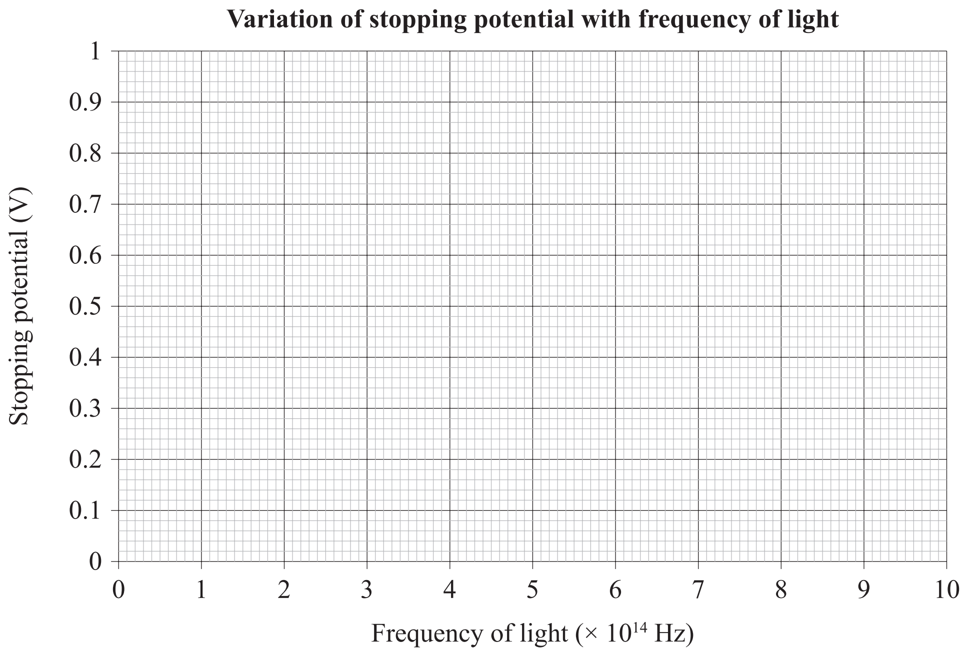
(i) Calculate the maximum kinetic energy (in joules) of the electrons leaving the surface of the sodium.

kinetic energy = ________________

(ii) Calculate the threshold frequency for sodium. Use this value to draw a line on the graph which shows how stopping potential varies with the frequency of the light shone at the sodium surface. Clearly show your method for the calculation of all quantities.



If you need to redraw this line, use the grid on page 10.

threshold energy = ________________

QUESTION THREE: ENERGY FROM STARS

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Speed of light = 3.00×10^8 m s^{-1}

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http://en.wikipedia.org/wiki/File:Binding_energy_curve_-_common_isotopes.svg

Stars emit a huge amount of energy from nuclear fusion reactions.

(a) State the meaning of the term nuclear fusion.

When stars first form, they are composed almost entirely of hydrogen. 'Hydrogen burning' converts hydrogen-1 (H_1^1) into helium-4 (He_2^4) in a complex series of reactions.

(b) Using the information from the graph, show that 28 MeV is released when one nucleus of He_2^4 forms from its constituent nucleons. Explain your reasoning.

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(c) Using the table below, show that the mass deficit when hydrogen-2 (H_1^2) is formed from its constituent nucleons, is 3.965×10^{-30} kg.

Mass of a proton	1.672621×10^{-27} kg
Mass of a neutron	1.674927×10^{-27} kg
Mass of a nucleus of hydrogen-2	3.343583×10^{-27} kg

(d) Calculate the binding energy per nucleon for hydrogen-2 and compare your answer with the value from the graph opposite.

Calculation:

binding energy =

Comparison:

If you need to redraw the line on the graph from page 7, draw it on the grid below. Make sure it is clear which graph you want marked.

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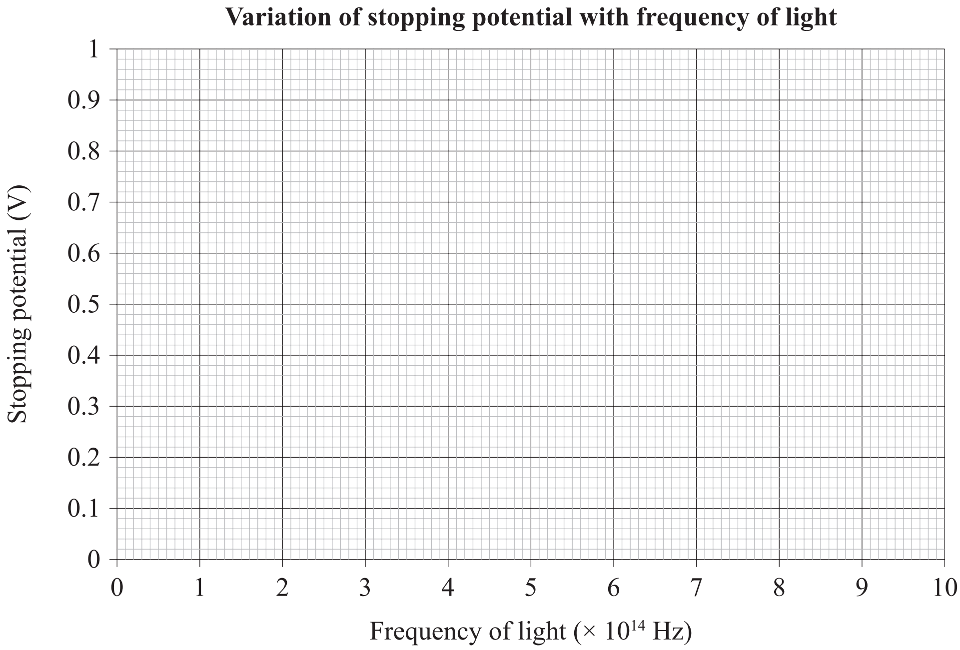

Extra paper for continuation of answers if required.
Clearly number the question.

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