WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

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542/01

PHYSICS

ASSESSMENT UNIT PH2: QUANTA AND ELECTRICITY

P.M. FRIDAY, 6 June 2003

(1 hour 30 minutes)

Centre Number ....

Candidate's Name (in full) ....

Candidate's Examination Number ....

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
Total	

INSTRUCTIONS TO CANDIDATES

Write your centre number, name and candidate number in the spaces provided above.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the "Mathematical Data and Relationships" on the back page of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}6 \times 10^{-19}$ C
Mass of electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Molar ideal gas constant	R	=	$8{\cdot}3$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}8$ m s^{-2}
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Speed of light in vacuo	c	=	$3{\cdot}0 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_0	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}

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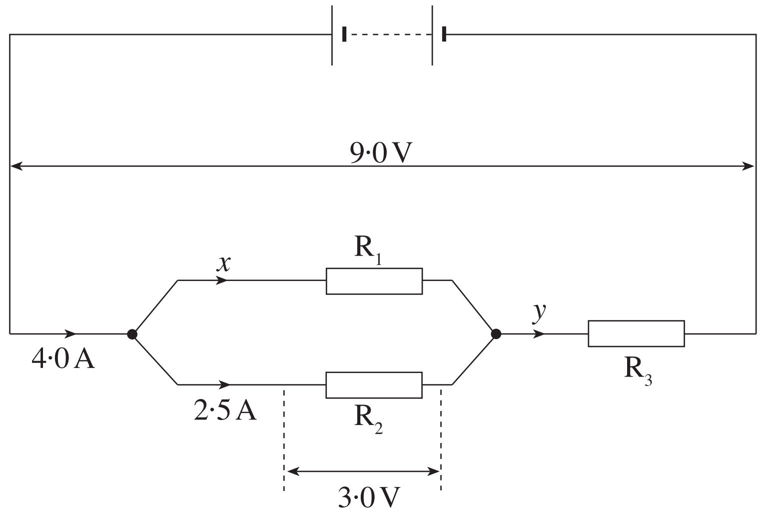
1. *(a)*



Without calculating resistances, write down

(i) the current, x, ... [1]

(ii) the current, y, ... [1]

(iii) the p.d. across R_1, ... [1]

(iv) the p.d. across R_3, ... [1]

(b) Which of your answers to part *(a)* depend directly upon the conservation of electric charge? [2]

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(c) Calculate the resistance of

(i) R_3, [1]

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(ii) the combination of the three resistors. [3]

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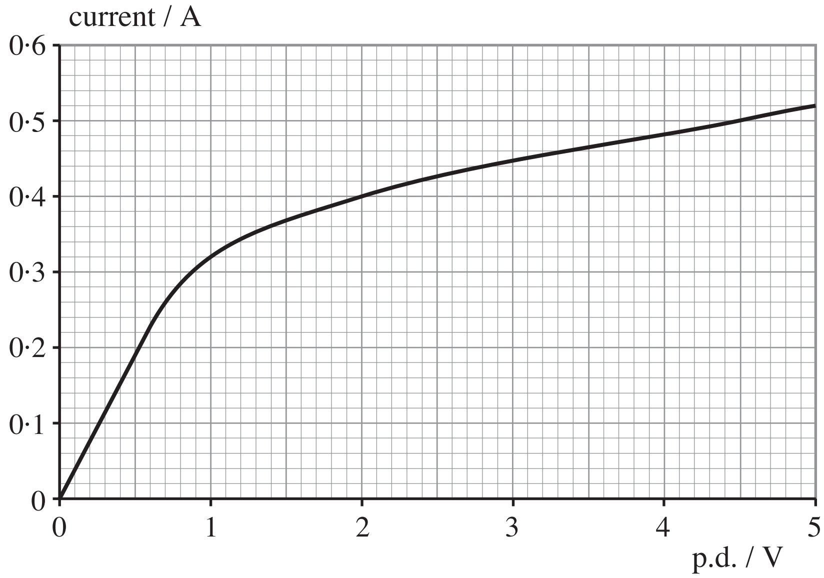
Turn over.

2. A graph of current against potential difference is given for a bulb with a metal filament.



(a) (i) State how the graph shows that Ohm's Law does not apply to the bulb over the range of values given. [1]

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(ii) Calculate the resistance of the bulb when the p.d. across it is

(I) 2·0 V, [1]

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(II) 4·5 V. [1]

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(iii) By considering what happens to the filament as the p.d. across it is increased, explain briefly why you would expect the resistances in (ii) to be different from each other. [2]

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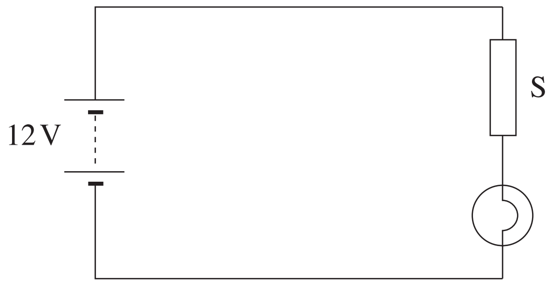
(b) To provide emergency lighting the bulb has to be powered from the only available source, a 12 V battery (of negligible internal resistance). The bulb needs a p.d. of 4·5 V to work as intended, so a series resistor, S, is included as shown.



(i) Show that the resistance of S should be 15 Ω. Explain your reasoning clearly. [2]

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(ii) When the battery is almost exhausted the p.d. across **the bulb** has fallen to 2·0 V. Calculate the p.d. across the battery terminals at this stage. [3]

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Turn over.

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3. *(a)* The current, *I*, in a wire of cross-sectional area *A* is given by the formula

$$I = nAve$$

(i) State the meanings of the symbols

(I) *n*, ... [2]

....

(II) *v*. .... [1]

(ii) Derive the formula, giving a labelled diagram. [3]

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(b) Calculate the length of metal wire of **diameter** $4{\cdot}0 \times 10^{-4}$ m needed to make a resistor of resistance $10{\cdot}0\,\Omega$. The resistivity of the metal is $4{\cdot}9 \times 10^{-7}\,\Omega\,$m. [4]

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4. *(a)* Write a paragraph about the nature and properties of X-rays. [4]

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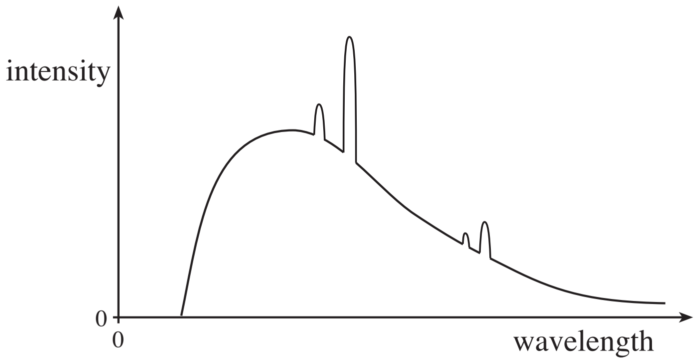
(b) The 'spectrum' of X-rays from an X-ray tube is sketched below.



Label

(i) the line spectrum, [1]

(ii) the cut-off wavelength, λ_{min}. [1]

(c) (i) Explain how the continuous spectrum arises. [2]

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(ii) The cut-off wavelength, λ_{min}, is given by the formula

$$\frac{hc}{\lambda_{min}} = eV$$

Explain this formula in terms of electron and photon energies. [2]

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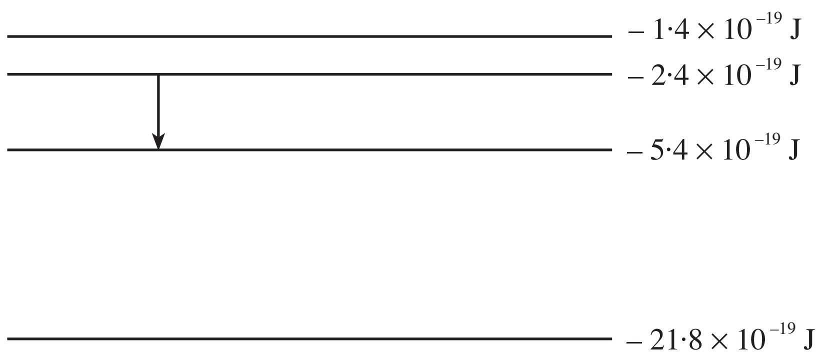
5. *(a)* The nucleus of an isotope of hydrogen is represented as $^{2}_{1}H$. Describe an **atom** of this isotope. [3]

(b) The lowest four energy levels of a hydrogen atom are shown in the diagram. They are labelled with their energies.



(i) The arrow shows a transition giving rise to a red line in the hydrogen emission spectrum. Calculate its wavelength. [You will need to refer to the list of constants on page 2.] [3]

(ii) Draw two arrows **on the diagram**, one labelled 'i-r' and the other, 'u-v', to show transitions giving rise to lines in the infrared (i-r) and ultraviolet (u-v) regions. [2]

(iii) Explain how you made your choice for the ultraviolet transition in *(b)* (ii). [2]

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6. *(a)* Explain what is meant by

(i) the *photoelectric effect,* [2]

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(ii) the photoelectric *threshold frequency.* [2]

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(b) Apply Einstein's photoelectric equation to a surface of work function $2{\cdot}0 \times 10^{-19}$ J to calculate

(i) the frequency of radiation needed to eject electrons from the surface with a maximum kinetic energy of $3{\cdot}0 \times 10^{-19}$ J, [3]

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(ii) the threshold frequency. [2]

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(c) In an experiment to find the Planck constant using the photoelectric effect the following apparatus is available:

- a variable d.c supply
- a voltmeter
- a galvanometer or sensitive current-measuring device
- a vacuum photocell with a caesium electrode to emit electrons and a 'collecting electrode'
- three monochromatic light sources of suitable known frequencies.

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(i) Draw a labelled circuit diagram of the arrangement you would set up. [4]

(ii) State what you would do and what measurements you would make. [4]

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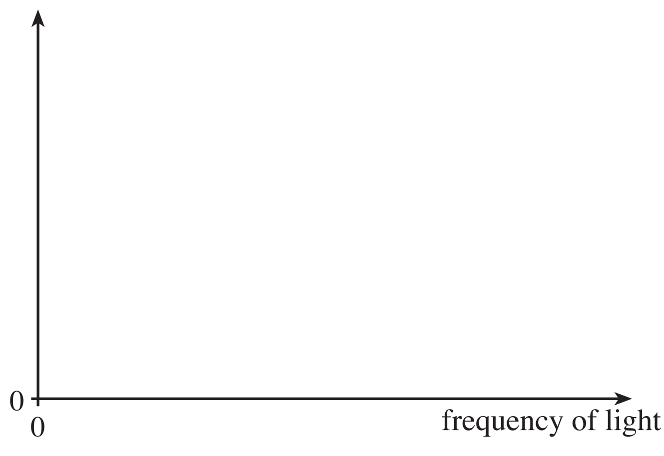
(iii) In order to find the Planck constant a graph should be plotted using your measurements. Sketch the graph you would expect to obtain on the axes provided, labelling the vertical axis with the appropriate quantity. [2]



(iv) State how the Planck constant is found from your graph. [1]

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7. A small electric torch is powered by a single cell costing 80 pence. When the torch is switched on, the cell supplies a constant current of 0·50 A to a bulb, X. The potential difference across the bulb is 1·2 V.

(a) The cell lasts for 50 **minutes** before it is exhausted. Calculate

(i) the charge which passes through the bulb during this time, [3]

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(ii) the energy converted by the bulb during this time. [2]

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(b) Calculate the energy, in joules, which 80 pence would buy, at a price of 8 pence per 'unit', from a mains electricity supply company. [A 'unit', or *kilowatt hour*, is the energy converted in one hour by a device operating at a power of 1000 W.] [3]

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(c) Draw a circuit diagram of the torch, including a resistor, labelled '*r*', to represent the cell's internal resistance. [2]

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(d) The cell supplies 1·6 J of energy per coulomb to the charge passing through it.

(i) 1·6 V is called the .... of the cell. [1]

(ii) Show clearly that the internal resistance, *r,* of the cell is 0·80 Ω. [Refer to the data at the beginning of the question.] [2]

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(e) The bulb, X, is replaced by a different one, Y, which is found to take a current of 0·30 A.

(i) Calculate

(I) the new p.d. across the internal resistance, [2]

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(II) the p.d. across Y. [1]

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(ii) **Discuss** which bulb, X or Y, makes better use of the energy stored in the cell. [4]

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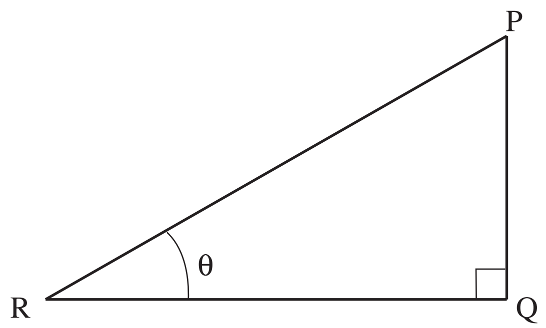
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Geometry and trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{RQ}{PR}, \quad \tan\theta = \frac{PQ}{RQ}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + RQ^2$$

Areas and Volumes

Area of a circle $= \pi r^2 = \dfrac{\pi d^2}{4}$

Area of a triangle = ½ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$