Candidate Name	Centre Number	Candidate Number

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

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

542/01

PHYSICS

ASSESSMENT UNIT PH2: QUANTA AND ELECTRICITY

A.M. WEDNESDAY, 12 January 2005

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

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.

For Examiner's use only.	
1	
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5	
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Total	

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	$= 6{\cdot}0 \times 10^{23}\ \text{mol}^{-1}$
Fundamental electronic charge	e	$= 1{\cdot}6 \times 10^{-19}\ \text{C}$
Mass of an electron	m_e	$= 9{\cdot}1 \times 10^{-31}\ \text{kg}$
Mass of a proton	m_p	$= 1{\cdot}67 \times 10^{-27}\ \text{kg}$
Molar gas constant	R	$= 8{\cdot}3\ \text{J mol}^{-1}\ \text{K}^{-1}$
Acceleration due to gravity at sea level	g	$= 9{\cdot}8\ \text{m s}^{-2}$
[Gravitational field strength at sea level	g	$= 9{\cdot}8\ \text{N kg}^{-1}$]
Universal constant of gravitation	G	$= 6{\cdot}7 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Planck constant	h	$= 6{\cdot}6 \times 10^{-34}\ \text{J s}$
Unified mass unit	1 u	$= 1{\cdot}66 \times 10^{-27}\ \text{kg}$
Boltzmann constant	k	$= 1{\cdot}38 \times 10^{-23}\ \text{J K}^{-1}$
Speed of light *in vacuo*	c	$= 3{\cdot}0 \times 10^{8}\ \text{m s}^{-1}$
Permittivity of free space	ε_0	$= 8{\cdot}9 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_0	$= 4\pi \times 10^{-7}\ \text{H m}^{-1}$

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1. *(a)* Each line in the table identifies a different atom or ion.

	Number of protons	Number of neutrons	Number of electrons
A	3	3	3
B	3	4	3
C	4	3	4
D	4	3	3

(i) Which of **A, B, C** or **D** is an *ion*? .... [1]

(ii) Which two out of **A, B, C** and **D** are *isotopes*? .... [1]

(iii) **B, C** and **D** have nearly the same mass *(M)*.

(I) Justify this statement. [2]

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(II) Using just the data in the table, give the mass of **A** as a fraction of *M*. [1]

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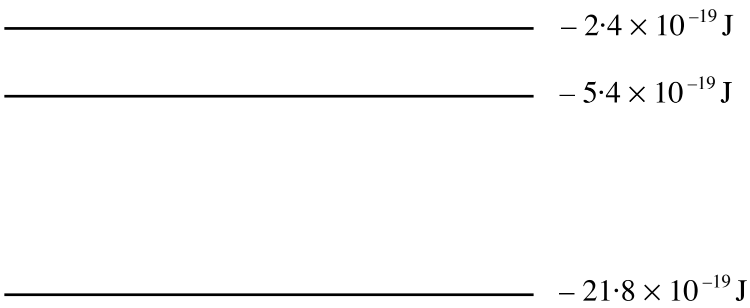
(b) The lowest three energy levels for a hydrogen atom are given in the diagram.



(i) Label with '(i)' the energy level for which the electron is closest to the nucleus. [1]

(ii) Consider possible transitions between the three energy levels.

(I) Show, using an arrow, the transition in which the photon of highest **frequency** is **emitted**. [2]

(II) Calculate this frequency. [Refer to the data on page 2.] [2]

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2. *(a)* There are currently more than 360 wind turbines in Wales, with a **total** capacity for producing about 150 MW of electrical power. A typical fossil-fuel-burning power station produces 2000 MW of electrical power.

(i) Give **two** reasons for continuing to erect wind turbines. [2]

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(ii) Give **two** reasons for **not** continuing to erect wind turbines. [2]

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(b) (i) In the electricity distribution system a particular wire is several kilometres long and has a resistance of 4·0 Ω. It carries a current of 750 A. Calculate the power dissipated in the wire. [2]

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(ii) Explain what is meant by *superconductivity*. [2]

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(iii) Making the wires in the electricity distribution system superconducting would prevent their dissipating power. Explain why it is not practicable to do this. [2]

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3. Electrical energy is distributed to the wall sockets in a house by means of a long cable called a 'ring-main'.

(a) Each of the current-carrying copper wires in the cable has a resistance of 0·17 Ω for each 25 m of its length. The resistivity of copper at room temperature is $1{\cdot}7 \times 10^{-8}$ Ωm. Calculate the cross-sectional area of the wire. [3]

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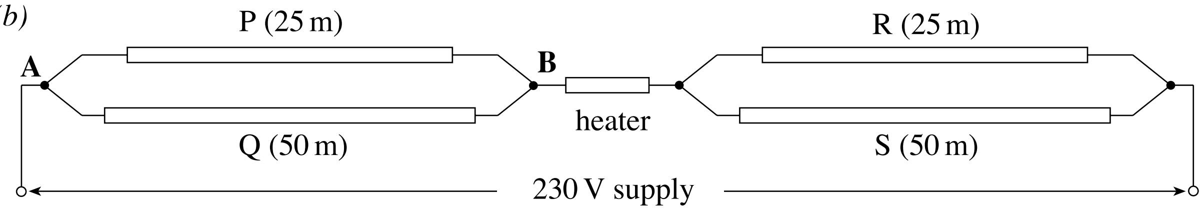
(b)



With one appliance, a heater, plugged into the ring-main of part *(a)*, the circuit can be represented as shown. P, Q, R and S are wires in the ring-main. Their lengths are given in brackets.

(i) Calculate the resistance of P and Q in parallel. [3]

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(ii) The current through the heater is 8·5 A. Calculate

(I) the potential difference between **A** and **B**, [1]

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(II) the current through P, [1]

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(III) the potential difference across the heater. [2]

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4. A doorbell is operated by pressing a button. This connects a cell across an electromagnet of resistance 0·70 Ω which operates the chimes.

(a) The cell has an e.m.f. of 1·6 V and an internal resistance of 0·53 Ω.

(i) In the space to the right, draw a labelled circuit diagram, including the cell's internal resistance. The electromagnet may be shown as a resistor. [1]

(ii) Show that the current when the button is pushed is 1·3 A. [2]

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(iii) Calculate the **change** in potential difference across the cell's terminals when the button is pushed, explaining whether it is an increase or a decrease. [3]

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(b) When the cell has run out of energy, the owner replaces it with a cell of e.m.f. 1·2 V and internal resistance of 0·10 Ω.

(i) Calculate the new current when the button is pressed. [1]

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(ii) Show that, while operating the electromagnet, the new cell's energy is used at a lower rate (in watts) than the old cell's energy was used. [2]

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(iii) Is it safe to conclude that the new cell will last longer than the old? Justify your answer briefly. [1]

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5. *(a)* The electrons in an X-ray tube are accelerated by a potential difference of 50 kV.

(i) What is the kinetic energy of an electron after acceleration

(I) in electron volts? [1]

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(II) in joules? [Refer to the data on page 2.] [2]

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(ii) Calculate the minimum wavelength of X-rays emitted when these electrons hit the metal target in an X-ray tube. [Refer to the data on page 2.] [3]

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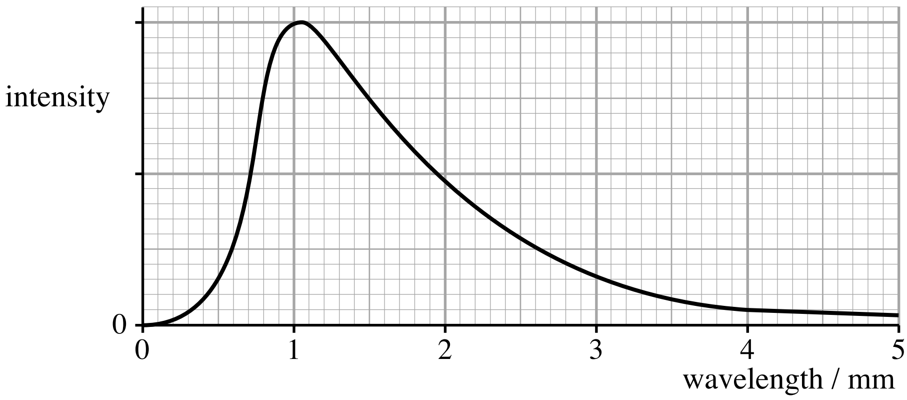
(b) The Earth is surrounded by electromagnetic radiation which came from the Big Bang. A graph of intensity against wavelength for this radiation is given.



(i) Name the region of the electromagnetic spectrum in which the peak wavelength lies. [1]

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(ii) Give **two** ways (apart from the range of wavelengths) in which this graph differs from the corresponding graph for X-rays from an X-ray tube. [2]

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(iii) The readings for the graph (above) were obtained from a satellite orbiting beyond the Earth's atmosphere. Suggest **one** reason why readings taken on the Earth's surface would not be satisfactory. [1]

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6. *(a)* What is the *photoelectric effect*? [2]

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(b) Einstein's photoelectric equation is an example of energy conservation. It may be written

$$hf = \frac{1}{2}mv_{\max}^2 + \phi$$

(i) What is the meaning of $\frac{1}{2}mv_{\max}^2$? [1]

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(ii) According to the equation $\frac{1}{2}mv_{\max}^2$ is less than the photon energy, hf, by an amount ϕ. Explain, in terms of energy, why this is so. [2]

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(c) When light of frequency $6{\cdot}0 \times 10^{14}$ Hz falls on a caesium surface, $\frac{1}{2}mv_{\max}^2$ is $9{\cdot}6 \times 10^{-20}$ J.

(i) Calculate ϕ for caesium. [Refer to the data on page 2.] [2]

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(ii) Explain whether or not photoelectric emission would take place if light of frequency $4{\cdot}4 \times 10^{14}$ Hz were shone on to a caesium surface. [3]

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(iii) $\frac{1}{2}mv_{\max}^2$ is found by measuring the 'stopping voltage', V_s (the p.d. that has to be applied between the caesium surface and a nearby electrode, in order to stop emitted electrons reaching the electrode). Calculate V_s for light of frequency $6{\cdot}0 \times 10^{14}$ Hz. [Refer to the data on page 2.] [2]

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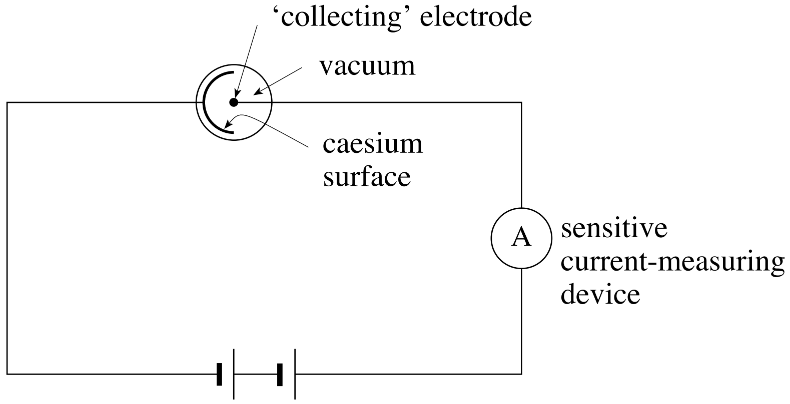
(d) The circuit shown below is set up.



(i) Give **three** reasons why the circuit, as shown, would **not** enable one to measure the stopping voltage, V_S. [3]

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(ii) The current indicated is $4{\cdot}8 \times 10^{-8}$ A.

(I) Calculate the number of electrons emitted per second from the caesium surface. [Refer to the data on page 2.] [1]

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(II) What assumption are you making? [1]

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(iii) In order to produce this current, $9{\cdot}5 \times 10^{-6}$ J of light energy of frequency $6{\cdot}0 \times 10^{14}$ Hz must arrive at the caesium surface each second.

(I) Calculate the number of photons striking the surface per second. [Refer to the data on page 2.] [2]

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(II) Calculate the fraction of these photons which cause electron emission. [1]

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Turn over.

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7. *(a)* The current, I, through a metal wire is related to the drift velocity, v, of the free electrons inside it by the formula

$$I = nAve$$

For the metal tungsten, $n = 6{\cdot}3 \times 10^{28}\,\text{m}^{-3}$.

(i) State the meaning of n. [1]

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(ii) Calculate the drift velocity for a tungsten lamp filament of **diameter** $0{\cdot}20 \times 10^{-3}$ m, through which a current of 2·0 A is passing. [3]

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(b) (i) Explain, in terms of free electrons, why a large enough current flowing through the lamp filament makes it hot. [4]

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(ii) Old lamp filaments become thin in places. Use the equation $I = nAve$ to explain why these thin places become hotter than the rest of the filament. [2]

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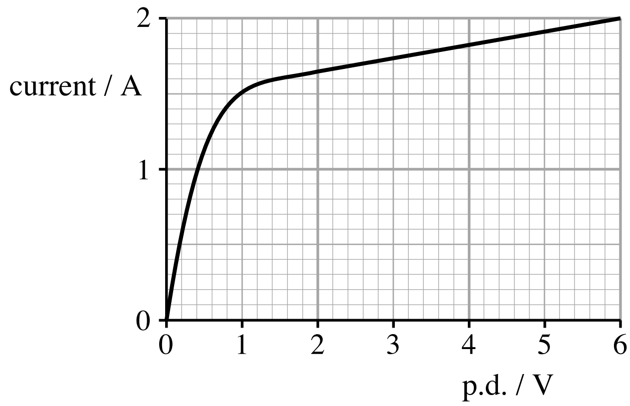
(c) A graph of current against potential difference is given for a tungsten lamp filament.



(i) Draw a labelled circuit diagram of a circuit which could have been used to obtain the results for the graph. [2]

(ii) Calculate the resistance of the filament

(I) for a p.d. of 0·40 V, [1]

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(II) for a p.d. of 6·0 V. [1]

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(iii) The temperature coefficient of resistance of a material is given by the equation

$$\alpha = \frac{R_\theta - R_0}{R_0 \theta} .$$

(I) What does R_0 stand for? [1]

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(II) **Taking your answer to *(c)*(ii)(I) as R_0**, calculate a value for the temperature of the lamp filament when there is a p.d. of 6·0 V across it. The temperature coefficient of resistance of tungsten is 0·0058°C $^{-1}$. [3]

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(III) Explain whether the true value of R_0 is likely to be larger or smaller than your answer to *(c)*(ii)(I). [2]

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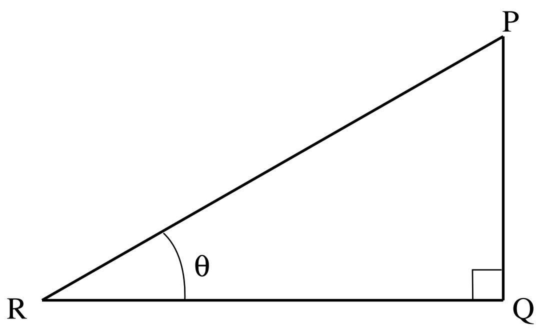
Mathematical Data and Relationships

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



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

$$PR^2 = PQ^2 + QR^2$$

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	$4\pi r^2$	$\frac{4}{3}\pi r^3$