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

P.M. MONDAY, 14 June 2004

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this examination 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	
2	
3	
4	
5	
6	
7	
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.

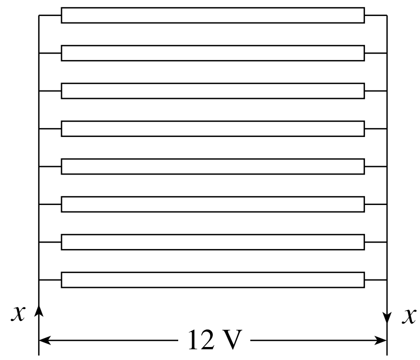
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}6 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Molar 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}
[Gravitational field strength at sea level	g	=	$9{\cdot}8$ N kg^{-1}]
Universal constant of gravitation	G	=	$6{\cdot}7 \times 10^{-11}$ N m^{2} kg^{-2}
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Unified mass unit	1 u	=	$1{\cdot}66 \times 10^{-27}$ kg
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_o	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}

Examiner only
Arholwr yn unig

1. A rear-window heater for a car consists of 8 strips of copper, bonded to the glass and connected in parallel, as shown. **Each** strip has a resistance of 5·0 Ω.



(a) A potential difference of 12 V is applied across the combination. Calculate

(i) the current through each strip, [1]

....

....

(ii) the current, x, through the combination, [1]

....

(iii) the resistance of the combination. [1]

....

....

(b) If the strips were to be connected *in series* the current, y, would be too small to give a useful heating effect. Calculate the ratio $^{x}/_{y}$. [2]

....

....

....

(c) Each strip of copper is 1·1 m long and the resistivity of copper is $1{\cdot}7 \times 10^{-8}$ Ωm.

(i) Calculate the cross-sectional area of a strip. [3]

....

....

....

....

(ii) Each strip is 1·5 mm wide and its thickness is uniform. Calculate this thickness. [2]

....

....

....

Examiner only
Arholwr yn unig

2. *(a)* Describe an experiment to investigate how the resistance of a coil of iron wire varies with temperature in the range 20°C to 100°C. A labelled diagram of the apparatus is needed. [6]

....

....

....

....

....

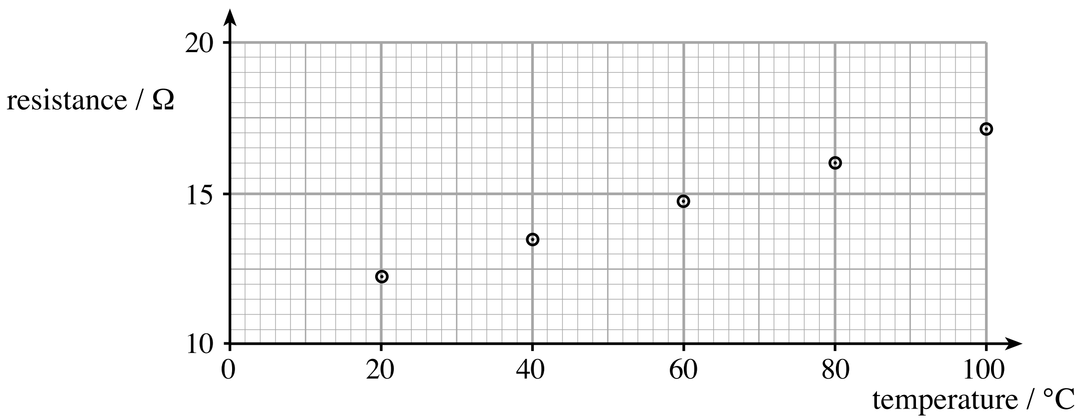
....

....

....

....

(b) Results from such an experiment are plotted below. Obtain a value for the temperature coefficient of resistance of iron. [4]



....

....

....

....

....

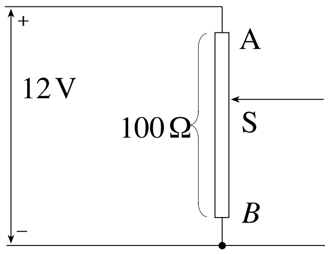
Examiner only
Arholwr yn unig

3. *(a)* State Ohm's Law. [2]

....

....

(b) The diagram shows a variable potential divider consisting of a carbon track, AB, of resistance 100 Ω. An 'input' of 12·0 V is applied across AB. The sliding contact, S, is positioned so that the p.d. between S and B is 8·4 V.



Calculate

(i) the resistance of the carbon track between S and B, [2]

....

....

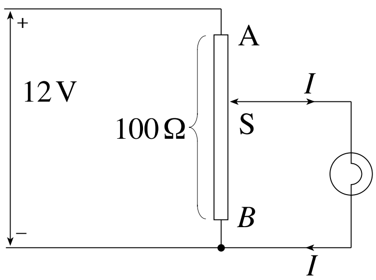
....

(ii) the p.d. between A and S. [1]

....

....

(c) A filament lamp is now connected between S and B in the circuit of part *(b)*. S remains in the same position. A current, *I*, flows through the lamp, as shown. State, **with reasons**, whether the following quantities increase, decrease, or stay the same when the lamp is connected:



(i) the current through the track between A and S; [2]

....

....

....

(ii) the p.d. between A and S; [1]

....

....

(iii) the p.d. between S and B. [2]

....

....

....

Turn over.

Examiner only
Arholwr yn unig

4. *(a)* A useful equation applying to a cell of e.*m.f.* E and internal resistance r is

$$V = E - Ir.$$

(i) State what is meant by the *e.m.f.* of the cell. [2]

....

....

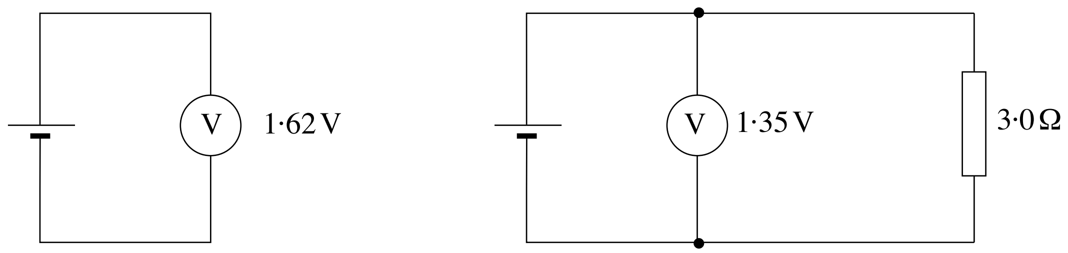
(ii) What does V represent? [1]

....

(iii) What does Ir represent? [1]

....

(b) A voltmeter connected across the terminals of a cell reads 1·62 V. The reading drops to 1·35 V when a 3·0 Ω resistor is connected in parallel with the voltmeter.



(i) (I) State the value of the e.m.f. of the cell. [1]

....

(II) Calculate the cell's internal resistance. [2]

....

....

....

....

(ii) Calculate the rate, in watts, at which the cell's stored energy is converted when the resistor is connected. [2]

....

....

....

(iii) Calculate the power which is dissipated in the 3·0 Ω resistor. [1]

....

....

....

Examiner only
Arholwr yn unig

5. This question is about the application, to an aluminium conductor, of the equation

$$I = nAve.$$

(a) Calculate a value for n, given that there are $6{\cdot}0 \times 10^{22}$ atoms in a cube of aluminium measuring $0{\cdot}010\,\text{m} \times 0{\cdot}010\,\text{m} \times 0{\cdot}010\,\text{m}$, and each atom contributes 3 free electrons. [3]

....

....

....

....

(b) Hence calculate the drift velocity when there is a current of 0·50 A in an aluminium wire of diameter $4{\cdot}0 \times 10^{-4}\,\text{m}$. [Refer to the list of constants on page 2.] [2]

....

....

....

....

(c) A constant potential difference is applied across a piece of aluminium wire. The temperature of the wire is increased gradually.

(i) Explain, in microscopic terms, what effect this temperature increase has on the drift velocity of the free electrons. [3]

....

....

....

....

(ii) Hence explain what happens to the *resistance* of the wire, justifying the steps in your argument. [2]

....

....

....

....

Examiner only
Arholwr yn unig

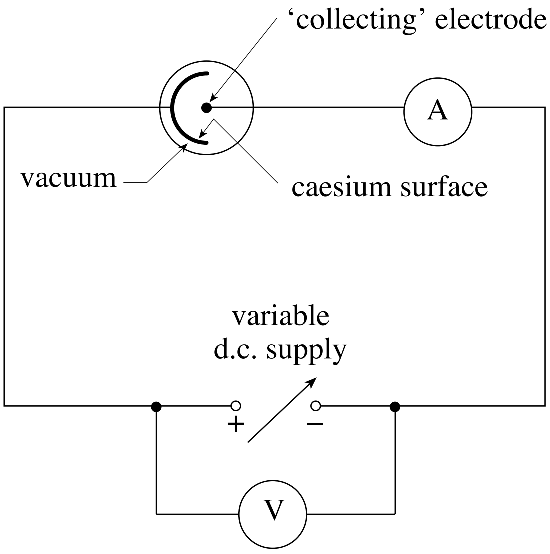
6. *(a)* Explain what is meant by the *photoelectric effect*. [2]

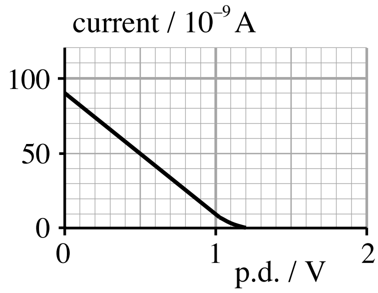
....

....

....

(b) Apparatus is set up as shown below to investigate the photoelectric effect. Monochromatic light is shone onto the caesium surface. Readings of the current and p.d. are then taken as the p.d. applied between the electrodes in the cell is increased, **making the collecting electrode increasingly negative**. The results are plotted below.





(i) (I) Calculate the number of electrons flowing per second through the circuit when the applied p.d. is zero. [Refer to the list of constants on page 2.] [2]

....

(II) Explain, in terms of energy, how a current can flow when the applied p.d. is zero. [2]

....

....

(ii) (I) Write down the value of the *stopping voltage*. [1]

....

(II) Calculate the maximum kinetic energy, in joules, of the emitted electrons. [1]

....

....

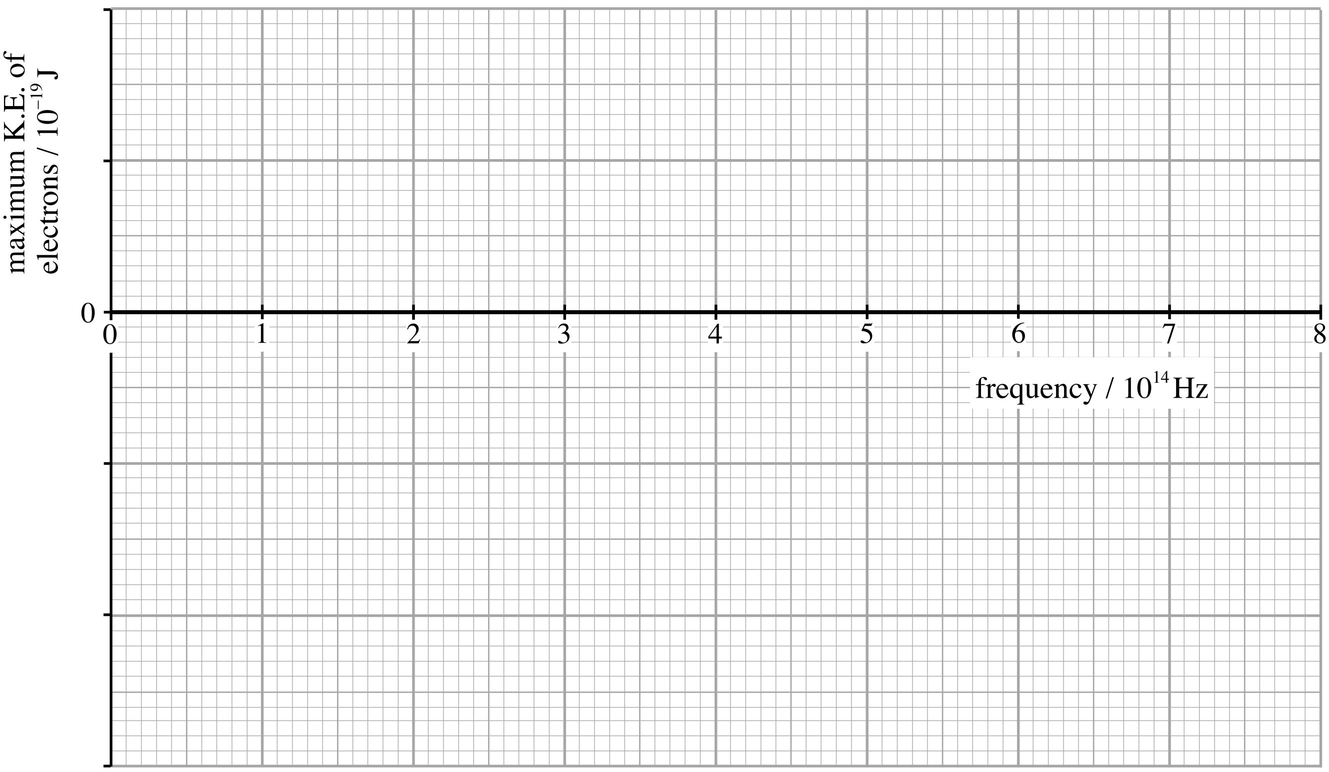
Turn over.

Examiner only
Arholwr yn unig

(c) Different frequencies of monochromatic light are used in the investigation of part *(a)*. The following results are obtained.

Frequency / 10^{14} Hz	5·1	6·0	7·5
Maximum K.E. of electrons / 10^{-19} J	0·36	0·93	1·95

(i) Plot a graph of these results on the grid provided. The frequency scale has been put in for you. [3]



(ii) (I) Define the *work function*, ϕ, of a surface. [1]

....

....

(II) Define the *threshold frequency*, f_0, of a surface. [1]

....

....

Examiner only
Arholwr yn unig

(III) Write down *Einstein's photoelectric equation* and use it to show that

$$\phi = hf_0 .$$ [2]

....

....

....

(IV) Use your graph to obtain a value for the work function of caesium. [2]

....

....

(iii) Obtain a value for the *Planck constant*, showing your reasoning clearly. [3]

....

....

....

....

7. *(a)* The *ionisation energy* of a hydrogen atom is 13·6 eV.

(i) Explain what is meant by *ionisation* of an atom. [1]

....

(ii) What does an ionised hydrogen $\left({}^{1}_{1}\text{H}\right)$ atom consist of? [1]

....

(iii) Some electromagnetic radiation can ionise atoms.

(I) Write down the minimum photon energy needed to ionise a hydrogen atom (in its ground state). [1]

....

(II) Name two regions of the electromagnetic spectrum whose radiation ionises atoms. [2]

....

....

(III) Explain why some electromagnetic radiation cannot ionise atoms. [1]

....

....

(b) (i) Sketch a typical graph of intensity against wavelength for the X-rays from an X-ray tube. [3]

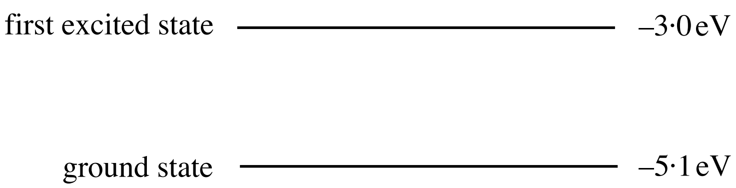
(ii) (I) Label a feature of the graph whose wavelength value does not depend on the material of the tube's target. [1]

(II) What *does* its wavelength depend upon? [1]

....

Examiner only
Arholwr yn unig

(c) The diagram shows the lowest two energy levels of a sodium atom, labelled with their energies.



(i) Calculate the **wavelength** of a photon emitted by an atomic transition from the first excited state to the ground state. [Refer to the list of constants on page 2.] [4]

(ii) White light is shone through a vapour of sodium atoms, and the light that emerges is examined with a spectrometer. A *line absorption spectrum* is observed.

(I) Describe the appearance of a line absorption spectrum. [2]

(II) Write down the wavelength of one line in this absorption spectrum, and explain how this line arises. [3]

Turn over.

Examiner only
Arholwr yn unig

Examiner only
Arholwr yn unig

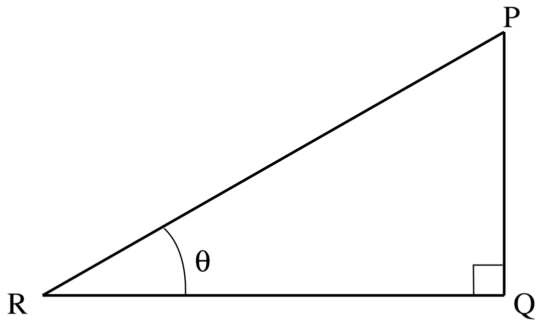
Mathematical Data and Relationships

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