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

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542/01

PHYSICS

ASSESSMENT UNIT PH2: QUANTA AND ELECTRICITY

A.M. MONDAY, 13 January 2003

(1 hour 30 minutes)

Centre Number ....

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

Candidate's Examination Number ....

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.

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 information "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 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)* A typical fuel-burning (non-nuclear) power station produces 1200 MW of electrical power and 2000 MW of heat. The heat is usually allowed to escape to the environment.

(i) Explain what '1200 MW of power' means, in terms of energy. [2]

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(ii) Assuming that an average home uses 5·0 kW of electrical power, estimate how many homes the power station could supply. [2]

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(iii) It has been suggested that at some time in the future each home will produce its own electrical energy. Assuming that the energy source is still the burning of fuel,

(I) give **two** advantages (social, economic or environmental) of home-production of electrical energy, over large-scale production in a power station, [2]

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(II) and give **two** disadvantages. [2]

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(b) The main fuse in a house allows a maximum current of 60 A. Calculate the maximum electrical power available, if the mains voltage is 230 V. [2]

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2. *(a)* Explain what is meant by the *e.m.f.* of a battery. [2]

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(b) Three cells, **each** of e.m.f. 1·5 V and internal resistance 0·50 Ω, are connected in series to make a battery of e.m.f. 4·5 V. The battery is connected to a resistor, R, of resistance 6·0 Ω.

(i) Sketch a circuit diagram. Include the internal resistance, and label it. [1]

(ii) Calculate the current through the circuit. [2]

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(iii) Calculate the potential difference across the resistor, R. [2]

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(iv) Suppose that one of the cells had been connected the wrong way round. Calculate the current in the circuit in this case. [3]

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3. *(a)* A fixed potential difference of 6·0 V is applied across a coil of copper wire. At a temperature of 0°C the current through the coil is found to be 0·30 A. At 50°C the current is 0·24 A.

(i) Explain **in terms of electrons** why the current is smaller at 50°C than at 0°C. [3]

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(ii) Calculate the temperature coefficient of resistance of copper. [4]

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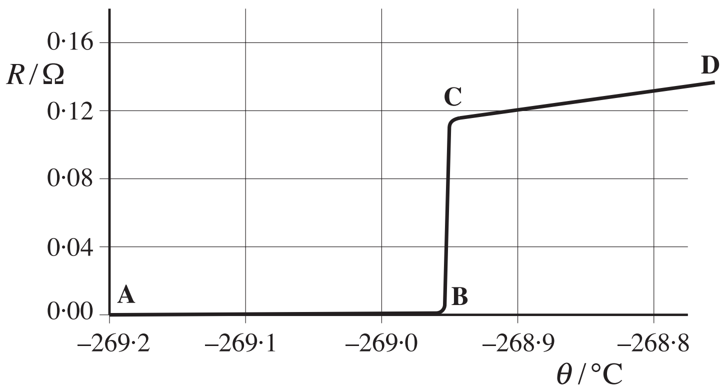
(b) In 1911 a Dutch physicist was investigating the effects of very low temperatures. He plotted a graph (see below) of the measured resistance, R, of a solid mercury specimen against temperature, θ.



(i) What name do we now give to the effect responsible for the region AB? [1]

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(ii) What potential difference would be needed to **maintain** a current of (say) 10 mA in a ring of solid mercury at a temperature of –269·0 °C or lower? [1]

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(iii) No 'points' were obtained for the region BC. Suggest a reason for this. [1]

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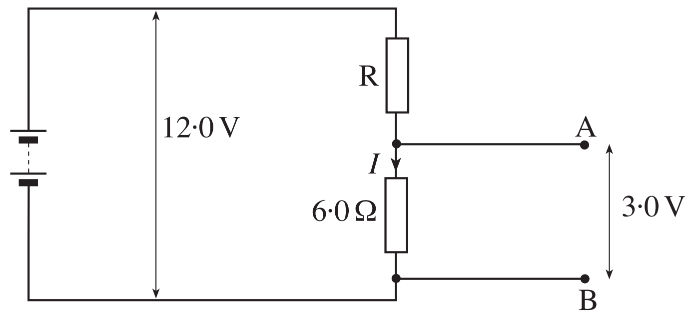
4. *(a)* The diagram shows two resistors connected in a series across a 12·0 V supply to give an 'output' of 3·0 V. [The supply has negligible internal resistance.]



(i) What is the name for a resistor combination used in this way? [1]

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(ii) Calculate the current, *I*. [1]

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(iii) State the potential difference across the resistor R. .... [1]

(iv) Calculate the resistance of R. [2]

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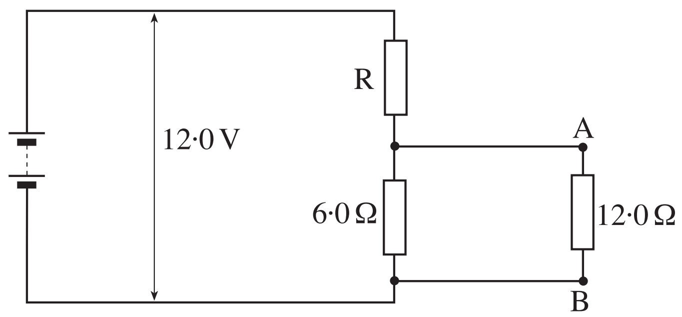
(b) A 12·0 Ω 'load' resistor is now connected across the output terminals, A and B, as shown.



(i) Calculate the resistance of the parallel combination of 6·0 Ω and 12·0 Ω resistors. [2]

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(ii) Calculate the current through resistor R. [2]

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(iii) Calculate the new potential difference between A and B. [1]

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

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(b) Ultraviolet radiation of frequency $1{\cdot}5 \times 10^{15}$ Hz is incident on a zinc surface of work function $6{\cdot}7 \times 10^{-19}$ J.

(i) Write down the minimum energy needed to liberate one electron from the zinc surface. [1]

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(ii) Calculate the energy of one photon of the ultraviolet radiation. [Refer to the list of constants on page 2.] [2]

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(iii) State Einstein's photoelectric equation and use it to calculate the maximum kinetic energy of an emitted electron. [3]

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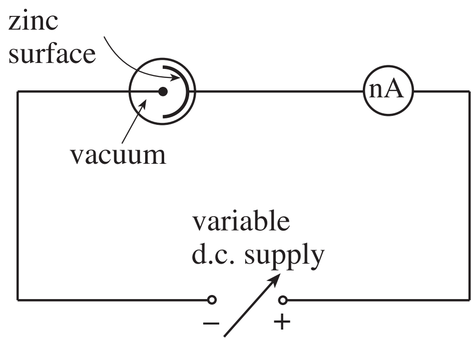
(iv)



Calculate the minimum voltage that the supply must produce in order to prevent any current in the circuit shown. The zinc is illuminated with ultraviolet radiation of frequency $1{\cdot}5 \times 10^{15}$ Hz. [2]

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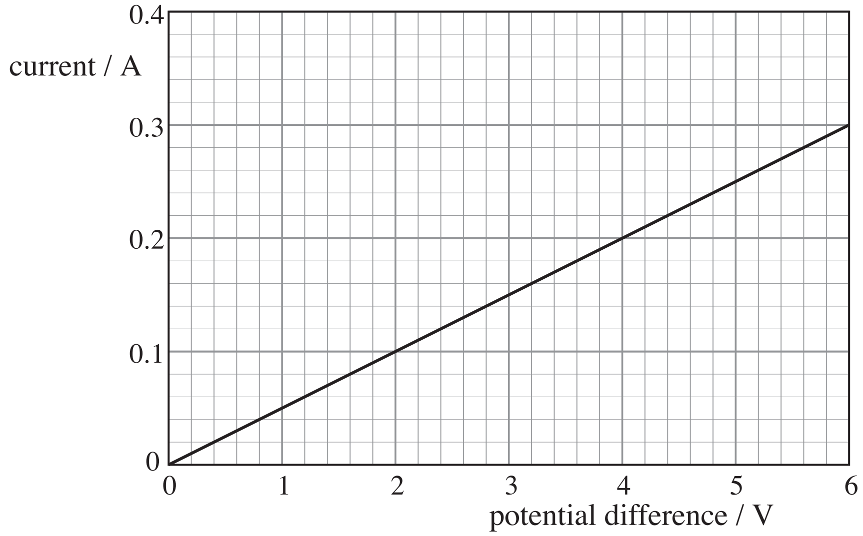
6. *(a)* A graph of current against applied potential difference is given for a piece of alloy wire.



(i) Draw a circuit diagram of an arrangement that could have been used to obtain the readings. Show the alloy wire as a resistor labelled 'W'. [3]

(ii) Calculate the resistance of the wire. [1]

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(iii) Calculate the current in the wire if a potential difference of 14 V were applied, stating any assumption you are making. [2]

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(iv) The wire has a length of 8·0 m and a **diameter** of $2{\cdot}5 \times 10^{-4}$ m. Calculate

(I) its cross-sectional area, [2]

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(II) the resistivity of the alloy. [3]

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(v) Draw on the same graph-grid (facing page) the current against voltage graphs for

(I) a wire, made of the same alloy, of diameter $2{\cdot}5 \times 10^{-4}$ m and length 24 m. [Label this graph 'I'] [1]

(II) a wire, made of the same alloy, of diameter $5{\cdot}0 \times 10^{-4}$ m and length 8·0 m. [Label this graph 'II'] [2]

(b) The current in a metal wire of cross-sectional area A is given by the formula

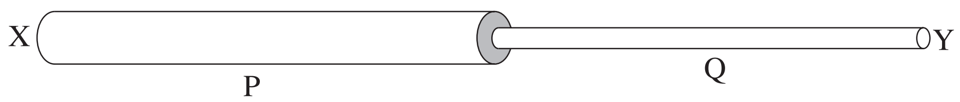
$$I = nAve$$

(i) State the meanings of n and of v. [2]

n: ....

v: ....

(ii)



Two copper wires, P and Q, are connected in series. P has 10 times the cross-sectional area of Q. A battery is connected between the ends, X and Y, of the combination.

(I) List the quantities in the equation above which have the same value in both P and Q. [2]

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(II) Deduce how the value of v in P compares with the value of v in Q, explaining your reasoning. [2]

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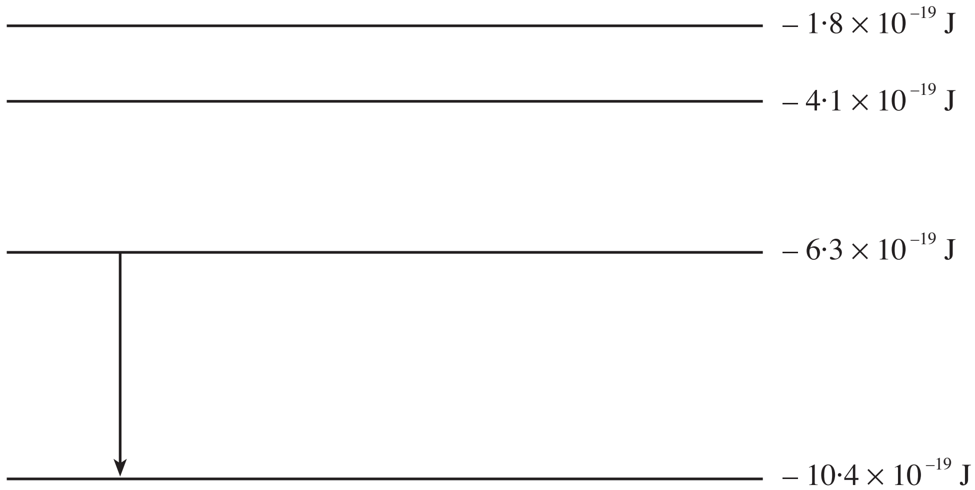
7. *(a)* The diagram shows four atomic energy levels, labelled with their energies.



(i) (I) Calculate the wavelength of radiation resulting from the transistion shown by the arrow. [Refer to the list of constants on page 2.] [3]

(II) In what region of the electromagnetic spectrum does this radiation lie? [1]

(ii) Draw another arrow on the diagram to show the transition giving rise to the longest wavelength. [1]

(iii) How many different transitions could possibly be made between these four levels? [1]

(b) Iron (symbol:Fe) has atomic number 26.

(i) What does this tell us about the nucleus of an iron atom? [1]

(ii) State the numbers *A* and *Z* in the nuclear notation, $^{A}_{Z}\mathrm{Fe}$, for an isotope of iron with 30 neutrons in its nucleus. [2]

A: ....

Z: ....

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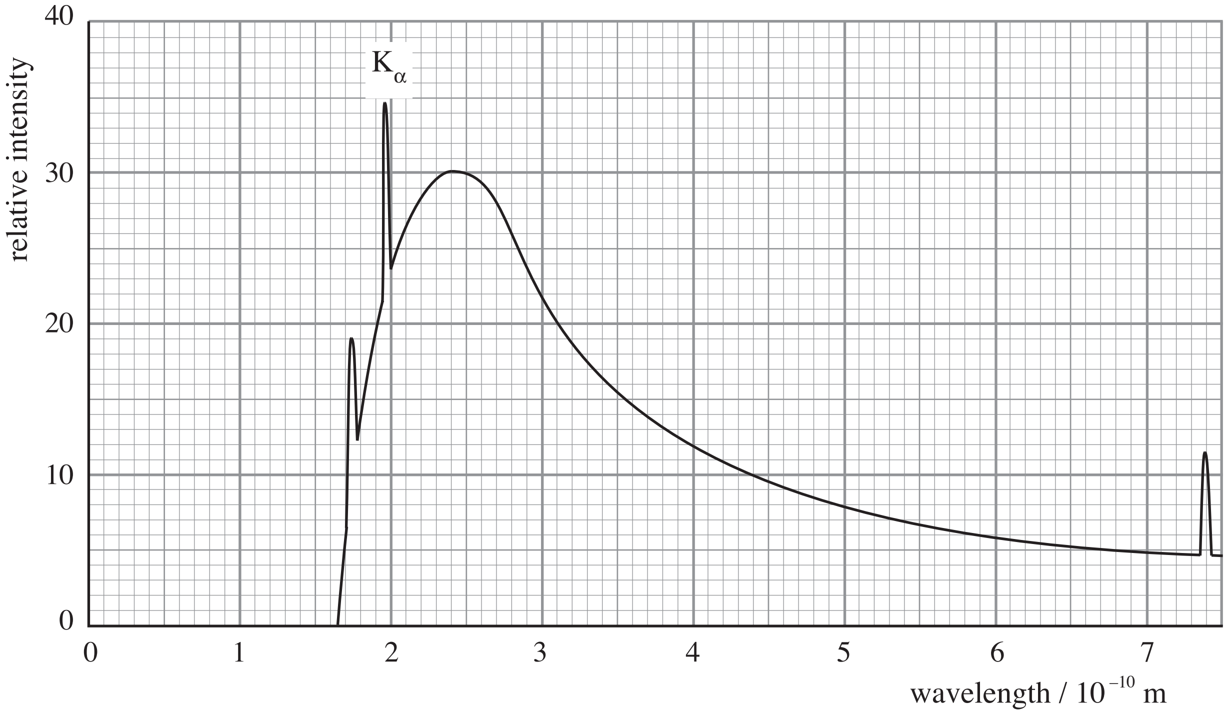
(c) The X-ray spectrum produced when electrons strike an iron target is shown below.



(i) Explain how the sharp peaks (making up the line spectrum) arise. You will need to refer to energy levels and photons. [4]

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Turn over.

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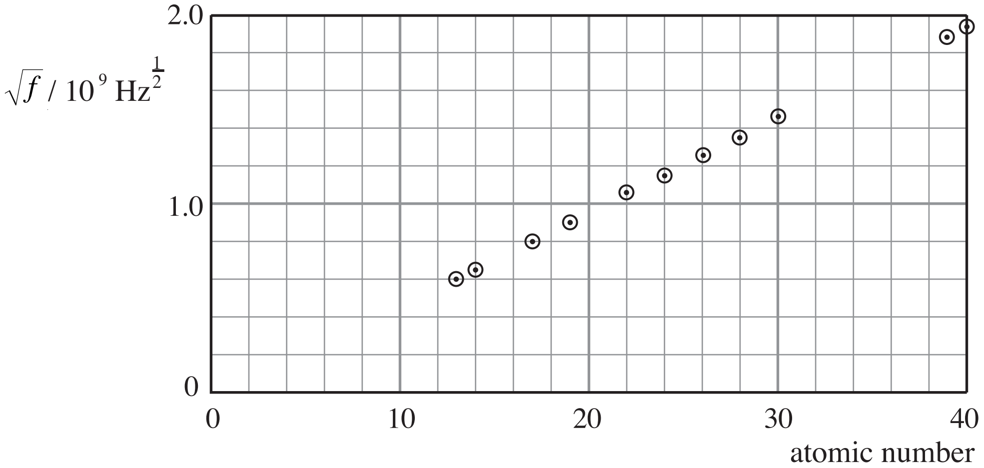
(ii) Different elements have the same general form of X-ray spectrum. The 'K_α' line (see spectrum on previous page) has a different wavelength, and therefore a different frequency, *f*, for each element. On the grid below, $\sqrt{f}$ is plotted against atomic number.



(I) A student suggests that $\sqrt{f}$ is proportional to the atomic number. Draw in the line of best fit and discuss whether or not the data on this grid confirm the student's suggestion. [3]

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(II) Check whether $\sqrt{f}$ for iron as plotted above is consistent with the wavelength of the K_α line for iron as read from the spectrum on the previous page. [Atomic number of iron = 26. Refer to the list of constants on page 2.] [4]

$\sqrt{f}$ from plot on grid above = ...

wavelength of K_α line from spectrum = ...

consistency check:

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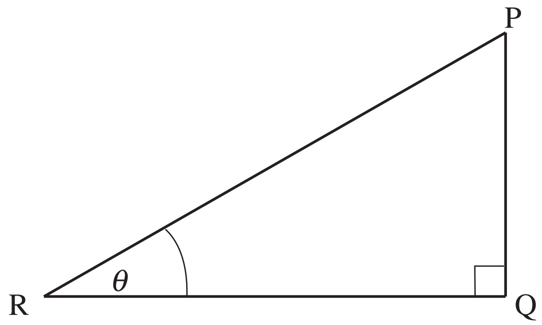
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-18}	atto	a	10^{-2}	centi	c
10^{-15}	femto	f	10^{3}	kilo	k
10^{-12}	pico	p	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-6}	micro	μ	10^{12}	tera	T
10^{-3}	milli	m	10^{15}	peta	P

Geometry and trigonometry



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

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

Areas and Volumes

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

Area of a triangle $= \frac{1}{2}$ base $\times$ height

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