

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. FRIDAY, 9 June 2006

(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.

**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.

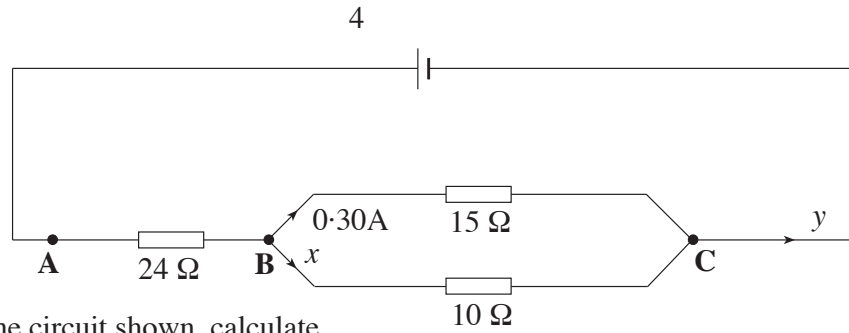
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*Fundamental Constants*

Avogadro constant	$N_A = 6.0 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.6 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.1 \times 10^{-31} \text{ kg}$
Mass of a proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
Molar gas constant	$R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.8 \text{ m s}^{-2}$
[Gravitational field strength at sea level	$g = 9.8 \text{ N kg}^{-1}$ ]
Universal constant of gravitation	$G = 6.7 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.6 \times 10^{-34} \text{ J s}$
Unified mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.0 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.9 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$

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1.



- (a) (i) For the circuit shown, calculate
- (I) the p.d. between **B** and **C**, [1]

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- (II) the current,  $x$ , [1]

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- (III) the current,  $y$ . [1]

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- (ii) Hence show clearly that the p.d. between **A** and **C** is 22.5 V. [2]

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- (b) (i) Use resistance formulae to calculate the resistance of the combination of the three resistors in the above diagram. [3]

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- (ii) Calculate the resistance of the combination using a current and a p.d. chosen from part (a). Show your working clearly. [2]

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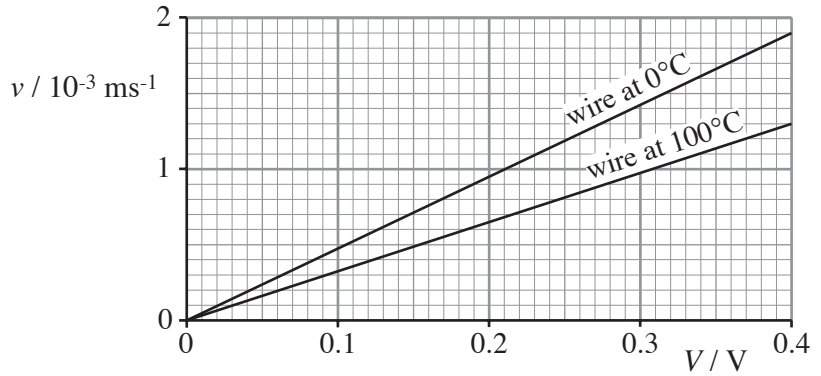
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2. When a potential difference,  $V$ , is applied across the ends of a metal wire, the free electrons acquire a drift velocity,  $v$ . For a copper wire of length 1.0m,  $v$  depends on  $V$  as shown.



(a) Calculate the current which flows in a copper wire of this length, at a temperature of  $0^\circ\text{C}$ , when a p.d. of 0.40 V is applied across its ends. The **diameter** of the copper wire is  $6.0 \times 10^{-4}\text{m}$  and the number of free electrons per unit volume of copper is  $8.5 \times 10^{28}\text{m}^{-3}$ . [Refer to the data on page 2.] [4]

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(b) (i) State *Ohm's Law*. [2]

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(ii) Consider either of the graphs above, and explain why it is consistent with Ohm's Law. [2]

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(c) According to the graphs,  $v$  is greater at  $0^\circ\text{C}$  than at  $100^\circ\text{C}$ , for a given value of  $V$ . Explain, in terms of free electrons, why this is to be expected. [2]

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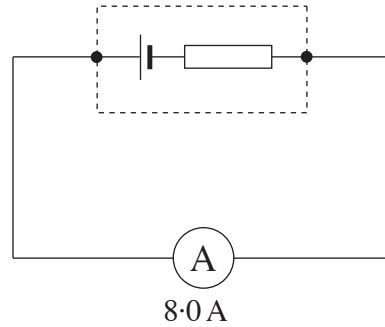
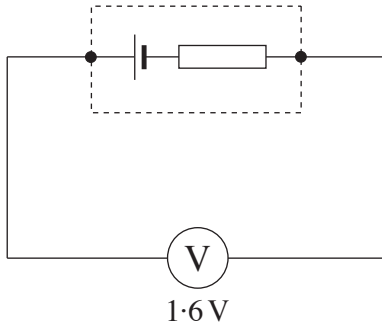
3. (a) Define the *emf* of a cell.

[2]

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(b) A voltmeter connected (by itself) across a cell reads 1.6 V. An ammeter (whose resistance may be taken as zero) reads 8.0 A when connected briefly across the cell.



(i) Write down the value of the *emf* of the cell.

[1]

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(ii) Calculate the cell's internal resistance.

[1]

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(iii) Give **one** reason for not leaving the ammeter connected for long.

[1]

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(c) (i) Calculate the current through an electromagnet of resistance  $3.0 \Omega$  connected across the cell.

[2]

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- (ii) How many cells of this type need to be connected in series with the electromagnet in order to drive a current 2.0 A through it? Justify your answer clearly. [3]

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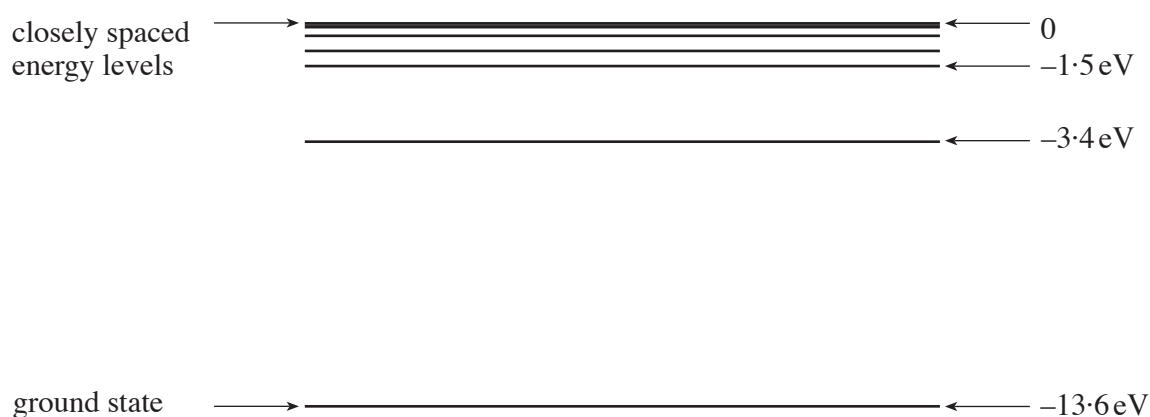
4. (a) Explain, in terms of particles, why hydrogen ( ${}^1_1\text{H}$ ) is the simplest of atoms. [2]

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- (b) The diagram shows the energy levels of a hydrogen atom. Label the *first excited state*. [1]



- (c) Hydrogen atoms **in their ground state** are exposed to ultraviolet radiation containing photons of the following energies:

3.4 eV, 6.9 eV, 10.2 eV, 11.6 eV, 14.6 eV,

- (i) (I) Photons of which energy (on the list) are capable of ionising the hydrogen atoms? [1]

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- (II) Explain what *ionising* the hydrogen atoms means. [1]

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- (ii) (I) Photons of which energy (on the list) are capable of *exciting* (but not ionising) the hydrogen atoms? [1]

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- (II) Represent the atomic transition which takes place during this excitation by means of an arrow on the energy level diagram. [2]

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- (III) State what is likely to happen next. [2]

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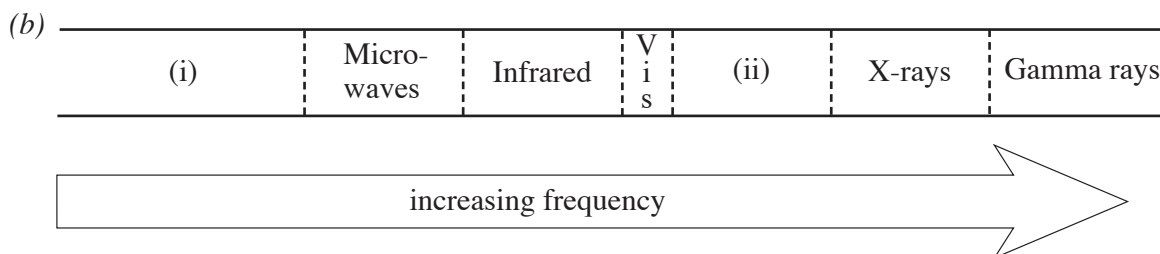
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5. (a) All electromagnetic waves carry energy and exhibit interference, diffraction, reflection and refraction. Give **two other** properties of all electromagnetic waves. [2]

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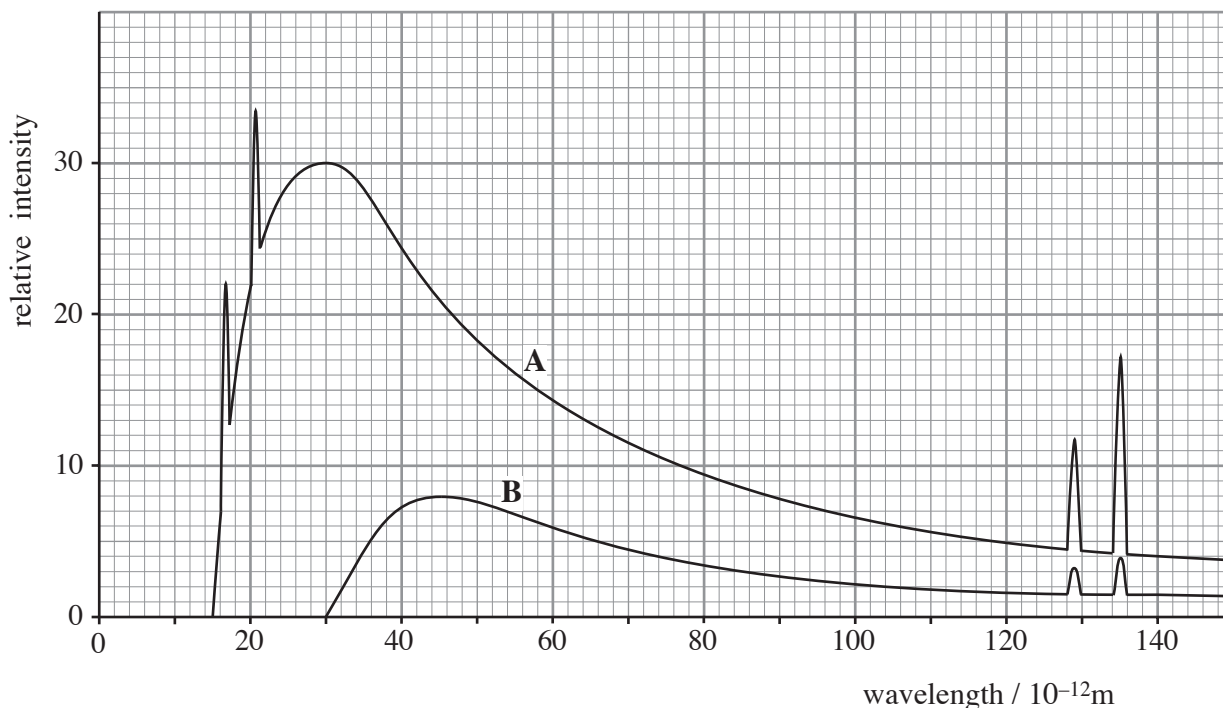


Name the regions of the electromagnetic spectrum labelled '(i)' and '(ii)' above.

(i) ..... [1]

(ii) ..... [1]

- (c) The diagram below shows two X-ray spectra produced by X-ray tubes.



- (i) The material of the target is the same in both cases. Explain how the graphs support this statement. [2]

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(ii) Spectrum **A** was produced using an accelerating voltage of 80 kV.

(I) Showing your reasoning, calculate a value for the Planck constant, using the relationship

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

[Use the values of  $e$  and  $c$  given in the data on page 2.]

[2]

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(II) Calculate the accelerating voltage used to produce spectrum **B**.

[2]

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6. (a) (i) State what is meant by the *work function*,  $\phi$ , of a surface.

[1]

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(ii)  $\phi$  is one of three terms in Einstein's photoelectric equation. Write down this equation.

[1]

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(iii) Copper requires illumination by ultraviolet radiation in order to exhibit the photoelectric effect. Caesium will exhibit the effect with visible light. Which metal, copper or caesium, has the greater work function? Explain your reasoning carefully.

[3]

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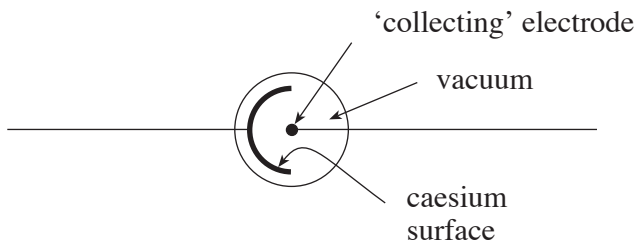
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(b) A caesium surface in a vacuum photocell (see diagram) is illustrated with light of known frequency. Explain how you would find the maximum kinetic energy **in joules** of electrons emitted from the caesium.

You should start by including the photocell below in a circuit diagram, together with meters and a variable power supply. Remember to show the polarity of the supply.



[3]

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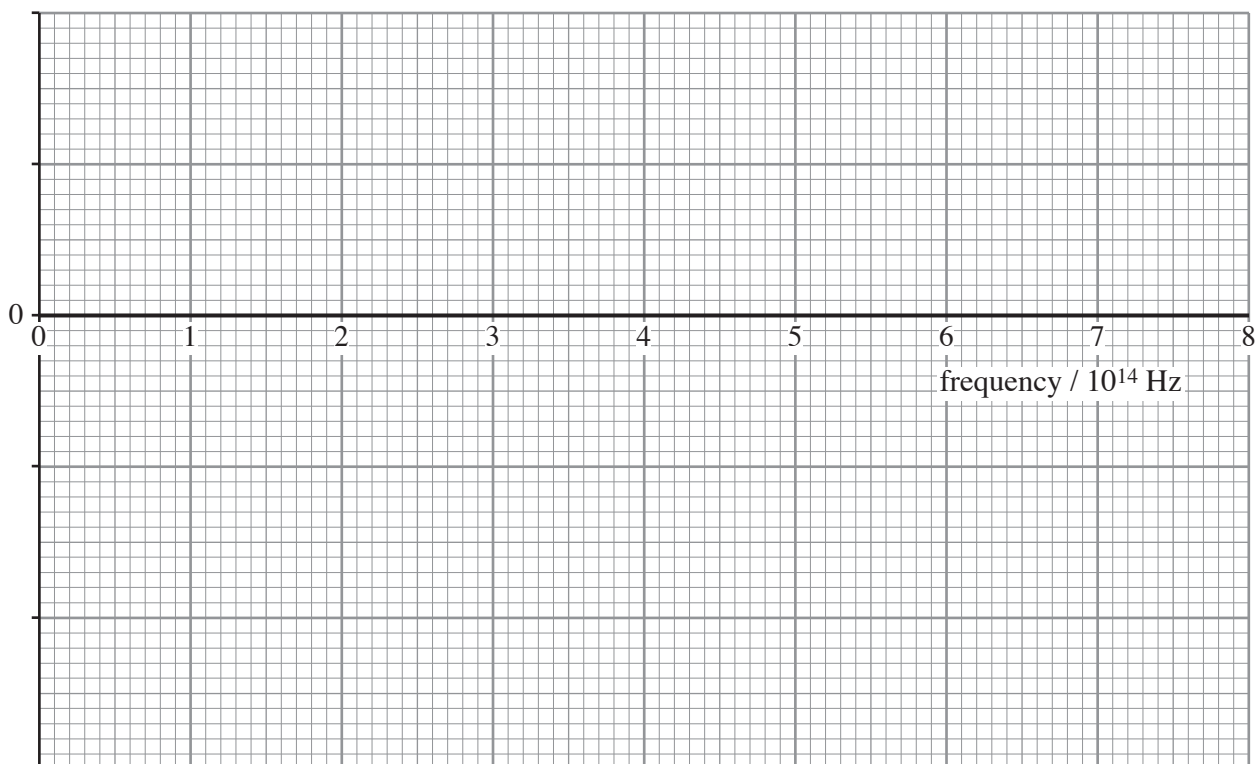
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[4]

- (c) The following results were obtained in an experiment with the caesium photocell using three light sources in succession.

Frequency of light / $10^{14}\text{Hz}$	4.7	5.9	6.9
$\text{KE}_{\text{max}} / 10^{-20}\text{J}$	2.0	9.9	16.5

- (i) Plot these results on the grid below, putting a scale and label on the vertical axis. [3]



- (ii) Hence find a value for the work function of caesium. [2]

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- (iii) Suppose that, instead of caesium, a surface of higher work function had been used in the photocell.

- (I) State how the gradient of the graph of  $\text{KE}_{\text{max}}$  against frequency would compare with the gradient of the graph you have just plotted for caesium. [1]

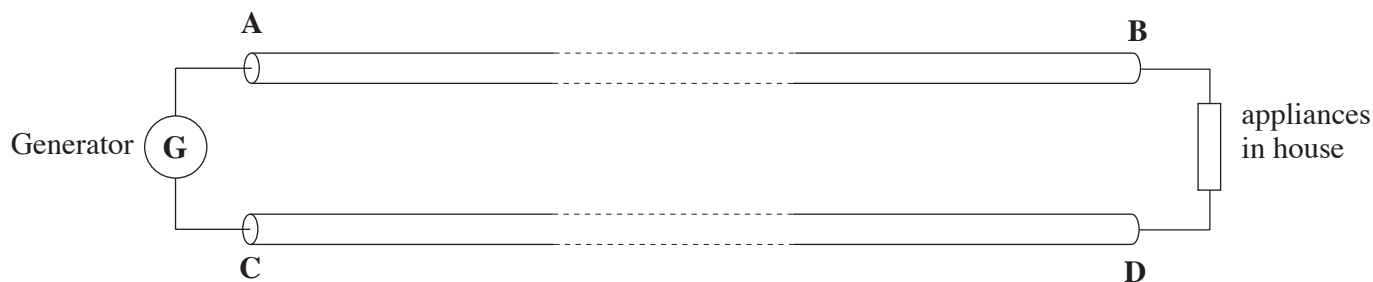
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- (II) Give a reason for your answer. [1]

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- (III) Sketch a possible graph for the new surface on the grid above. [1]

7. A house in a remote location is to be supplied with electrical energy by a generator, **G**, in an out-building. Each of the wires, **AB** and **CD**, from the generator to the house is 120 m long.



- (a) It is decided that 100 W is an acceptable power dissipation in **each** wire when a current of 25 A is flowing, and the wires are selected accordingly. Calculate

- (i) the p.d. across each wire (that is the p.d. between **A** and **B**, or between **C** and **D**) when 25 A is flowing, [2]

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- (ii) the resistance of each wire. [1]

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- (b) (i) Calculate the cross-sectional area of the wires if they are made of

- (I) copper (resistivity =  $1.70 \times 10^{-8} \Omega\text{m}$ ) [3]

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- (II) aluminium (resistivity =  $2.65 \times 10^{-8} \Omega\text{m}$ ) [1]

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- (ii) Hence compare the cost of the metal for the wires using these data:  
price of copper = £110 000 per  $\text{m}^3$ , price of aluminium = £40 000 per  $\text{m}^3$ . [3]

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(c) The p.d. across the generator terminals (that is, between **A** and **C**) is 230 V, and its internal resistance is negligible.

(i) (I) Referring to part (a), calculate the p.d. supplied to the house (that is the p.d. between **B** and **D**) when the current is 25 A. [2]

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(II) State, giving a reason, the p.d. between **B** and **D** when there is no current (because all household appliances are turned off). [2]

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(ii) (I) Calculate the electrical power supplied by the generator when the current is 25 A. [1]

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(II) Calculate the cost of supplying this power for a time of one hour, given that the fuel for the generator costs 5.0p for each megajoule of electrical energy produced. [3]

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(III) Determine whether this cost is more or less than the cost of the same quantity of electrical energy from a mains supply, at 8.0p per 'unit' [A *unit* or *kilowatt hour* is the energy used in one hour at a rate of consumption of 1.0kW.] [2]

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**Turn over.**

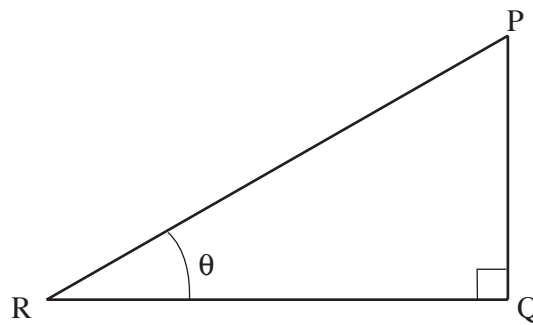
### Mathematical Data and Relationships

#### SI multipliers

Multiple	Prefix	Symbol
$10^{-18}$	atto	a
$10^{-15}$	femto	f
$10^{-12}$	pico	p
$10^{-9}$	nano	n
$10^{-6}$	micro	$\mu$
$10^{-3}$	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

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

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

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