ELECTRICITY

A LEVEL PHYSICS

EXAMINATION PREPARATION BOOK

STUDENT BOOK

TOPIC BOOK

NAME	
PHYSICS CLASS	
MODULE TEACHER	
ALPS GRADE	

Please complete all of these questions in this book and store this work in your student files.

This will provide a useful resource for revision.

In the following booklet there are several questions based on the module '3.5 Electricity'. These questions are additional to the work which you must do on your A-Level course.

To gain the highest grade possible in your A-Level examinations it is recommended that you complete these questions in the supervised study sessions carried out in school.

This will both familiarise yourself with both the concepts found in the A-Level syllabus and the examination technique found in examinations.

The mark scheme to the questions is integrated in the book for you to use independently.

To improve competency in answering questions on mechanics and materials and achieve mastery in this module, answer all of these questions independently.

When you have completed your work in this book, please store this work in your student files.

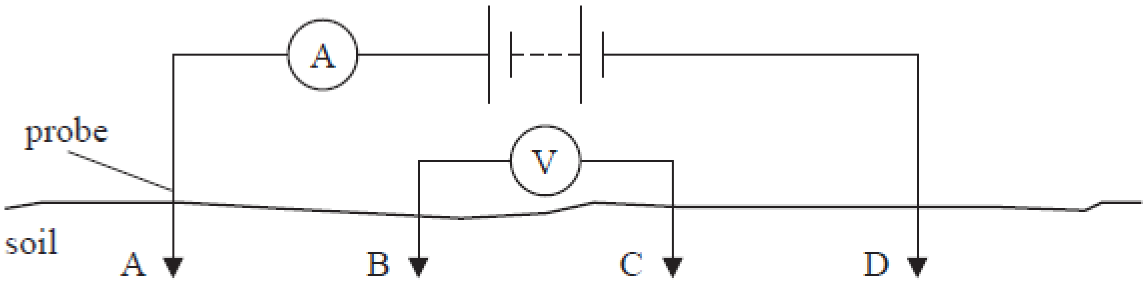
Many thanks for all of your hard work in A-Level Physics.

Mr. Turnbull

QUESTION ONE

1. Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.



Probes are placed at positions **A** and **D** so that the length **AD** of soil forms part of the circuit.

The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions **B** and **C**.

This measures the potential difference between positions **B** and **C** in the soil.

1.1 Explain how the reading on the voltmeter will change if the length **BC** increases.

[2 Marks]

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1.2 The table gives the resistivity of some different materials.

Material	Resistivity / Ω m
Undisturbed clay	4–20
Compacted clay	100–200
Limestone	500–1000
Sandstone	1500–10 000

The probes connected to the voltmeter are kept at a constant separation of 0.75 m and are moved along the soil between positions **A** and **D.**

The current is constant at 9.5 mA. The voltmeter reading varies between 1.8 V and 8.0 V.

It can be assumed that the sample of soil under investigation has a cross-sectional area of 0.65 m^2.

Deduce **two** possible materials that could be present in the soil between positions **A** and **D**.

[4 Marks]

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Reference: EdExcel AS Physics Paper 1 June 2018 Examination

MARK SCHEME

Question Number	Acceptable answers		Additional guidance	Mark
1.1	• The (voltmeter) reading will increase • Resistance increases (with length) **Or** resistance ∝ length	(1) (1)	MP2: accept idea of a potential divider i.e. the ratio of the of BC to the total length AD will be greater, so the proportion of the total voltage will be greater ($\frac{BC}{AD}$ V) MP2: Do not award if there is also a reference to resistivity increasing	2
1.2	• Use of $V = IR$ • Use of $R = \rho l/A$ • (Min) resistivity = 160 (Ω m) **Or** (max) resistivity = 730 (Ω m) • Compacted clay pathways **and** limestone are present in the soil	(1) (1) (1) (1)	Example of calculation $R_{min} = \frac{1.8\ \text{V}}{9.5\times10^{-3}\ \text{A}} = 189.5\ \Omega$ $R_{max} = \frac{8.0\ \text{V}}{9.5\times10^{-3}\ \text{A}} = 842.1\ \Omega$ $\rho_{min} = \frac{RA}{l} = \frac{189.5\ \Omega\times0.650\ \text{m}^2}{0.75\ \text{m}} = 164.2\ \Omega\ \text{m}$ $\rho_{max} = \frac{RA}{l} = \frac{842.1\ \Omega\times0.650\ \text{m}^2}{0.75\ \text{m}} = 729.8\ \Omega\ \text{m}$ conclusion to be consistent with calculated values	4

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWO

(a) A battery of e.m.f. *E* and internal resistance *r* delivers a current *I* to a circuit of resistance *R*.

Write down an equation for *E* in terms of *r*, *I* and *R*.

.... **[1]**

(b) A 'flat' car battery of internal resistance 0.06 Ω is to be charged using a battery charger having an e.m.f. of 14 V and internal resistance of 0.74 Ω, as shown in Fig. 2.1.

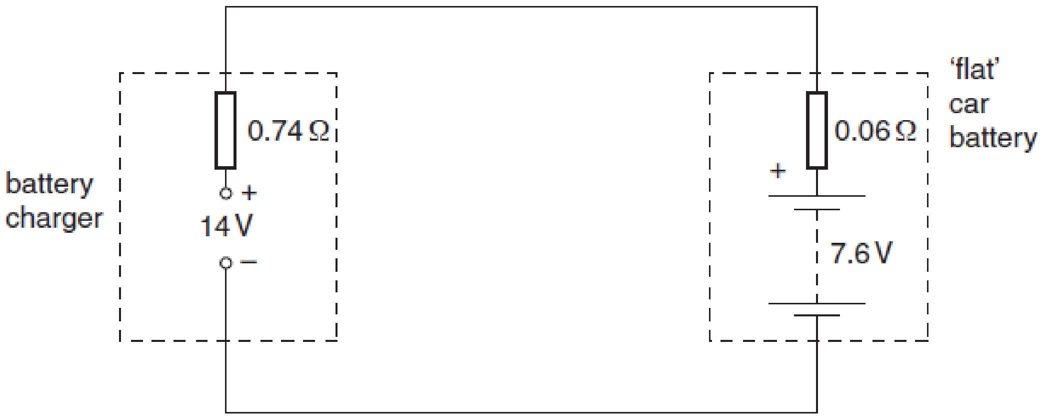


Fig. 2.1

You can see that the battery to be charged has its positive terminal connected to the positive terminal of the battery charger.

At the beginning of the charging process, the e.m.f. of the 'flat' car battery is 7.6 V.

(i) For the circuit of Fig. 2.1, determine

1 the total resistance

resistance = ... Ω **[1]**

2 the sum of the e.m.f.s in the circuit.

e.m.f. = ... V **[1]**

(ii) State Kirchhoff's second law.

....

.... **[1]**

(iii) Apply the law to this circuit to calculate the initial charging current.

current = ... A **[2]**

(c) For the majority of the charging time of the car battery in the circuit of Fig. 2.1, the e.m.f. of the car battery is 12 V and the charging current is 2.5 A. The battery is charged at this current for 6.0 hours. Calculate, for this charging time,

(i) the charge that passes through the battery

charge = ... C **[2]**

(ii) the energy supplied by the battery charger of e.m.f. 14 V

energy = ... J **[2]**

(iii) the percentage of the energy supplied by the charger which is dissipated in the internal resistances of the battery charger and the car battery.

percentage of energy = ... % **[2]**

[Total: 12]

Reference: OCR Physics Unit 2 June 2009 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
2	(a)		E = I(R + r)	B1	
	(b)	(i) 1 2	0.80 Ω 6.4 V	B1 B1	
		(ii)	(sum of) e.m.f.s = sum /total of p.d.s/sum of voltages (in a loop)	B1	
		(iii)	6.4 = 0.80I I = 8.0 A	C1 A1	**can be 2 ecf** from **(b)(i)**, eg 21.6/0.8 = 27 A (1 ecf) or 21.8/0.68 = 31.8 A (2 ecf)
	(c)	(i)	Q = It = 2.5 x 6 x 60 x 60 = 54000 (C)	C1 A1	**allow** 1 mark if forgets one or two 60's giving 900 C or 15 C
		(ii)	energy = QE = 54000 x 14 = 756000 (J)	C1 A1	**allow** (use of 12 V gives) 648000 J for 1 mark
		(iii)	energy loss = I2Rt = VIt = 2 x 2.5 x 6.0 x 60 x 60= 108000 J percentage = (108000/756000) x 100 = 14%	C1 A1	**accept** QΔV = 54000 x 2.0 = 108000 J **accept** QΔV/QE = 2.0/14.0 = 14% **not** 756000/54000 = 14%
			Total question 2	**12**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THREE

Fig. 3.1 shows a thermistor and fixed resistor of 200 Ω connected through a switch **S** to a 24 V d.c. supply of negligible internal resistance. The voltmeter across the fixed resistor has a very high resistance.

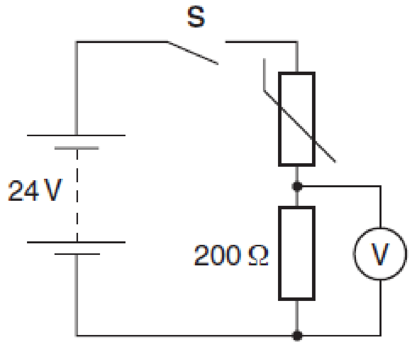


Fig. 3.1

(a) When the switch **S** is closed the voltmeter initially measures 8.0 V.

Calculate

(i) the current I in the circuit

I = ... A **[2]**

(ii) the potential difference V_T across the thermistor

V_T = ... V **[1]**

(iii) the resistance R_T of the thermistor

R_T = ... Ω **[2]**

(iv) the power P_T dissipated in the thermistor.

P_T = ... W **[2]**

(b) A few minutes after closing the switch **S** the voltmeter reading has risen to a steady value of 12 V. The value of the fixed resistor remains at 200 Ω.

Explain why

(i) the potential difference across the fixed resistor has increased

....

....

....

.... **[3]**

(ii) the resistance of the thermistor must now be 200 Ω.

....

.... **[1]**

(c) Sketch, on the labelled axes of Fig. 3.2 below, a possible *I*-*V* characteristic for:

(i) the fixed resistor. Label it **R**. **[2]**

(ii) the thermistor. Label it **T**. **[2]**

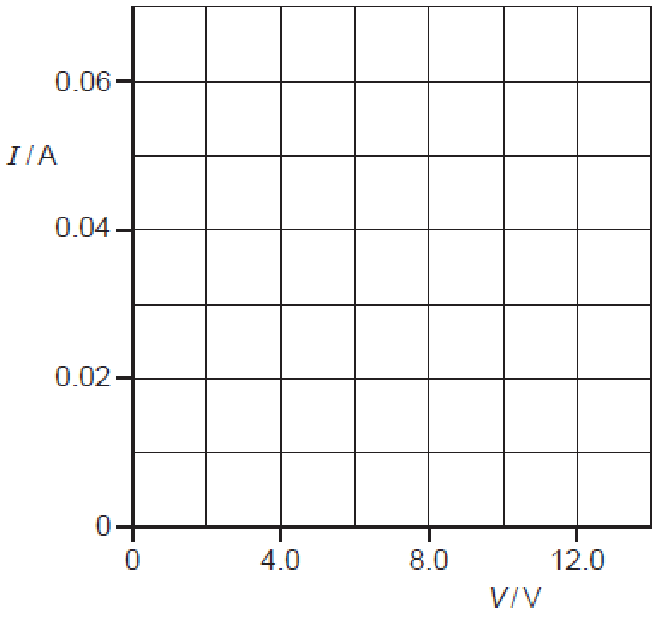


Fig. 3.2

[Total: 15]

Reference: OCR Physics Unit 2 June 2009 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	I = V/R = 8.0/200 I = 0.040 (A)	C1 A1	
		(ii)	V = 24 – 8 = 16 (V)	B1	
		(iii)	R = 16/0.04 giving R = 400 (Ω)	C1 A1	**accept** ratio of p.d.s to ratio of Rs **ecf** from **(i)** & **(ii)** ie **(a)(ii)/(a)(i)**
		(iv)	$P = VI = I^2R = V^2/R$ P = 0.640 (W)	C1 A1	**ecf** from **(i)** & **(ii)** **accept** 640 mW
	(b)	(i)	the thermistor has heated up/ its temperature has increased so its resistance has dropped so the ratio of the voltages across the potential divider changes/AW	B1 M1 A1	**accept** so the current increases **accept** so IR of fixed resistor increases
		(ii)	voltages are equal so resistances are equal	B1	
	(c)	(ii)	straight line through origin labelled R passing through 0.06,12	B1 B1	**allow** correct lines with no labels
		(ii)	upward curve below straight line through origin labelled T passing through 0.06,12	B1 B1	
			Total question 3	**15**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOUR

(a) A 12V 36W lamp is lit to normal brightness using a 12V car battery of negligible internal resistance. The lamp is switched on for one hour (3600 s). For the time of 1 hour, calculate

(i) the energy supplied by the battery

energy = ...J **[2]**

(ii) the charge passing through the lamp

charge = ...unit..........**[3]**

(iii) the total number of electrons passing through the lamp.

number of electrons = ... **[2]**

(b) The wires connecting the 36W lamp to the 12V battery are made of copper. They have a cross-sectional area of 1.1×10^{-7} m^2. The current in the wire is 3.0 A. The number *n* of free electrons per m^3 for copper is 8.0×10^{28} m^{-3}.

(i) Describe what is meant by the term *mean drift velocity* of the electrons in the wire.

....

....

.... **[2]**

(ii) Calculate the mean drift velocity *v* of the electrons in this wire.

v = ... $m\,s^{-1}$ **[3]**

[Total: 12]

Reference: OCR Physics Unit 2 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
1					
	a	i	E = (Pt =) 36 x 3600 = 1.3 x 10^5 (J)	C1 A1	**allow** I = 3 A and E = VIt, etc. **accept** 129600 (J)
		ii	Q = E/V = 1.3 x 10^5/12 **or** Q =It =3 x 3600 = 1.1 x 10^4 unit: C	C1 A1 B1	**ecf (a)(i)** **accept** 1.08 x 10^4 **allow** A s **not** J V^{-1}
		iii	Q/e = 1.1 x 10^4/1.6 x 10^{-19} = 6.9 x 10^{22}	C1 A1	**ecf (a)(ii)** **accept** 6.75 or 6.8 x 10^{22} using 10800
	b	i	the average displacement/distance travelled of the electrons <u>along the wire</u> per second; (over time/on average) they move slowly in one direction through the metal/Cu lattice (when there is a p.d. across the wire); (because) they collide constantly/in a short distance with the lattice/AW	B1 B1 B1	no mark for quoting formula **allow** in one second **max 2 marks** from 3 marking points
		ii	select I = nAev (= 3.0 A) v = 3.0/8.0 x 10^{28} x 1.1 x 10^{-7} x 1.6 x 10^{-19} = 2.1 x 10^{-3} (m s^{-1})	C1 C1 A1	1 mark for correct formula 1 mark for correct substitutions into formula 1 mark for correct answer to 2 or more SF
			Total question 1	**12**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

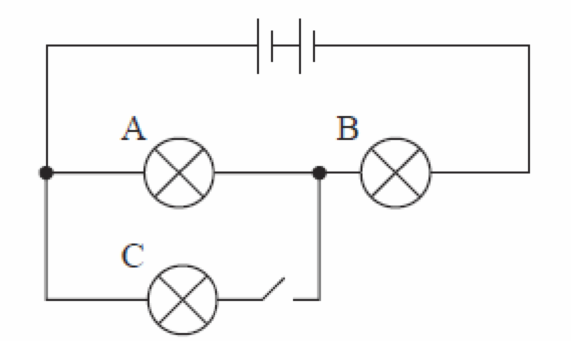
A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIVE

5. A student sets up the circuit shown with three identical lamps and a switch.



Each lamp is marked 1.5 V and two 1.5 V cells of negligible internal resistance are used as a power supply.

The two lamps labelled **A** and **B** light with normal brightness when the switch is open.

5.1 Explain what will happen to the brightness of each lamp when the switch is closed.

[6 Marks]

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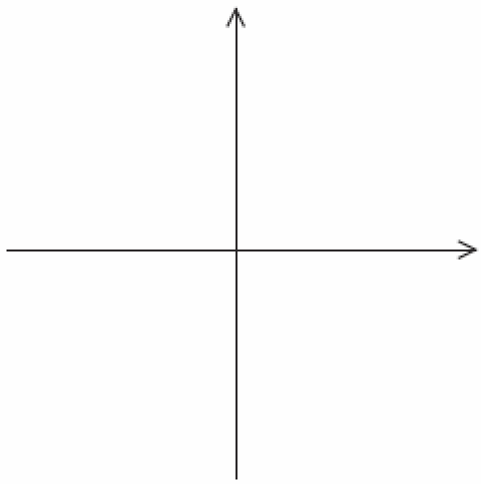
5.2 Sketch a current-potential difference graph for a filament lamp on the axes below.

[2 Marks]



5.3 Explain the shape of this graph in terms of electron movement through the lattice.

[4 Marks]

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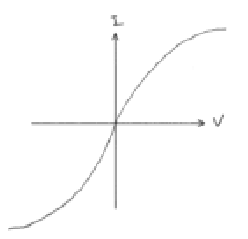
Reference: EdExcel International A Level Physics Paper 2 October 2018 Examination

MARK SCHEME

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>5.1</td><td>
<table>
<tr><td colspan="3">B is brighter and A is dimmer</td></tr>
<tr><td>$P = \frac{V^2}{R}$</td><td>$P = I^2R$</td><td>$P = VI$</td></tr>
<tr><td>Resistance of parallel combination decreases</td><td>Resistance in parallel/circuit decreases</td><td>Resistance in circuit decreases</td></tr>
<tr><td>p.d. across B increases Or p.d. across A (or C) decreases</td><td>Current (in circuit/B) increases</td><td>Current (in circuit) increases</td></tr>
<tr><td>p.d. across A = p.d. across C</td><td>Current shared (equally) between A and C</td><td>Current shared (equally) between A and C</td></tr>
<tr><td colspan="3">(So) A and C are the same brightness (as each other)</td></tr>
</table>
</td><td>(1)
(1)
(1)
(1)
(1)
(1)</td><td>6</td></tr>
<tr><td>5.2</td><td>Correct curve in + + section

Symmetrical negative curve (consistent with their ++ curve)


</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>5.3</td><td>Temperature increases with increasing current or potential difference

(with temperature increase) there is an increase in ion/atom vibrations

Greater rate of collisions between electrons and ions/atoms/lattice (causing an increase in resistance)

The rate of increase of current with p.d. decreases</td><td>(1)

(1)

(1)

(1)</td><td>4</td></tr>
</table>

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

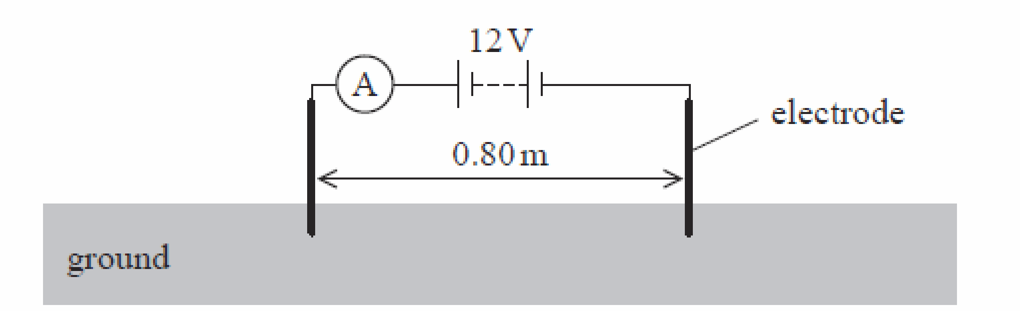
Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIX

6. A geophysicist may use resistivity to determine the different materials within the ground.

Two electrodes and a 12 V battery are connected to two points 0.80 m apart in the ground.



This arrangement is used to measure the current in the ground between the electrodes.

6.1 The effective cross-sectional area of conducting material in the ground is 0.25 m^2.

The current between the electrodes is 8.5 mA.

Calculate the resistivity of the ground between the electrodes.

[3 Marks]

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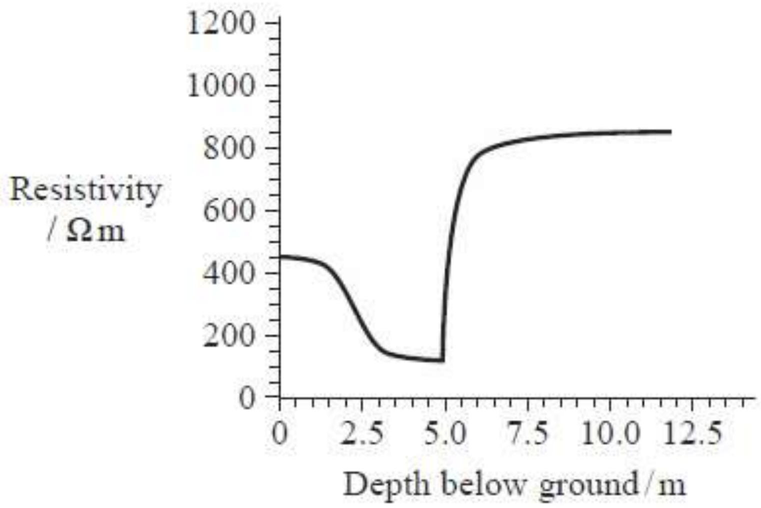
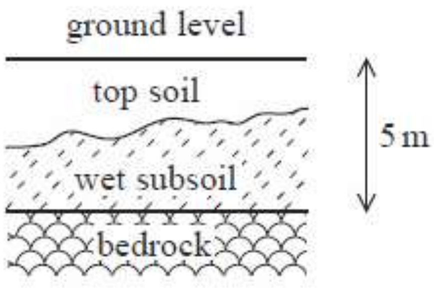
Resistivity = ... Ωm

6.2 The graph shows how the resistivity varies with depth below ground level at a particular location. A geophysicist has also made a sketch of the different layers of material beneath the ground at this location.





Explain how the sketch corresponds to the graph.

[3 Marks]

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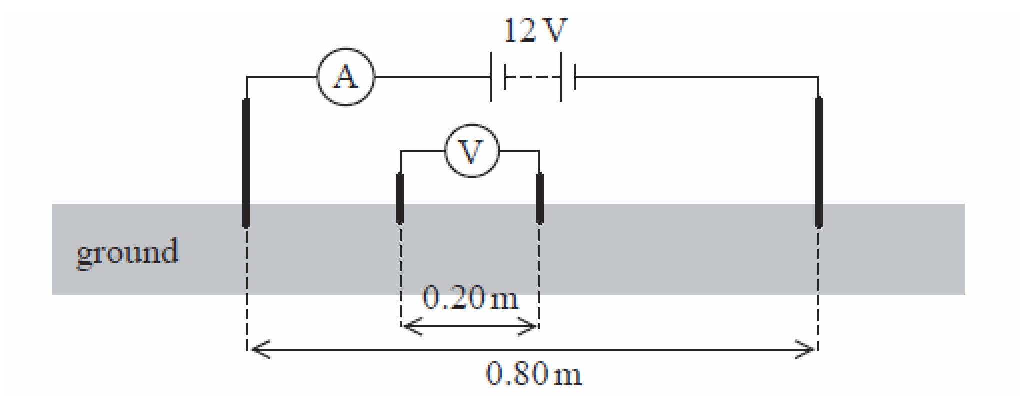
The diagram below illustrates a more accurate method of measuring resistivity.



Two extra electrodes are placed 0.20 m apart and connected to a voltmeter.

6.3 Explain the value you would expect to observe on the voltmeter if the cross-sectional area of the ground through which the current is passing were constant.

[3 Marks]

………

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6.4 Give **one** reason why this method leads to more accurate results than the method described in part **6.3.**

[1 Mark]

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Reference: EdExcel International A Level Physics Paper 2 October 2018 Examination

MARK SCHEME

Question Number	Answer		Mark
6.1	Use of $V=IR$	(1)	
	Use of $R=\frac{\rho l}{A}$	(1)	
	$\rho = 440\ \Omega\ \text{m}$	(1)	**3**
	<u>Example of calculation</u> $R=\frac{12\ \text{V}}{8.5\times10^{-3}\ \text{A}}=1412\ \Omega$ $\rho=\frac{1412\ \Omega\times0.25\ \text{m}^2}{0.80\ \text{m}}=441\ \Omega\ \text{m}$		
6.2	States a value for the resistivity of a layer	(1)	
	Makes a comparison between the resistivity of layers	(1)	
	(Between topsoil and subsoil) the resistivity decreases slowly indicating the varying depth **or** incline of the subsoil **Or** (At 5 m) resistivity increases suddenly indicating the constant depth of bedrock	(1)	**3**
6.3	Potential divider **Or** resistance is proportional to length	(1)	
	so V is proportional to l	(1)	
	$V = 3\ \text{V}$	(1)	**3**
6.4	**Max 1** Cross sectional area will be more constant (over a small length) Less variation in resistance/resistivity/material (over a shorter length) Eliminates contact resistance of electrodes with the ground (Second arrangement) combines both methods so two values of resistivity can be calculated and compared	(1)	**1**
	Total for question 18		**10**

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SEVEN

(a) Fig. 4.1 shows the I-V characteristic of a light-emitting diode (LED).

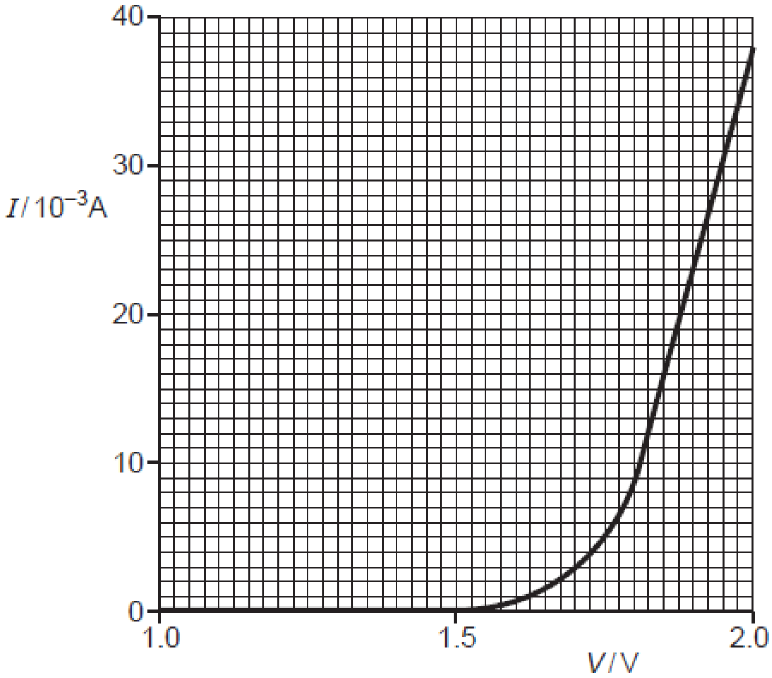

Fig. 4.1

(i) Describe the significant features of the graph in terms of current, voltage and resistance.

In your answer you should make clear how the features of the graph are related to the action of an LED.

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....

.... **[5]**

(ii) Calculate the resistance of the LED

1 at 1.2V

resistance = ... Ω **[1]**

2 at 1.9V.

resistance = ... Ω **[2]**

(b) In order to carry out an investigation to determine the *I*-*V* characteristic of an LED a student connects the circuit shown in Fig. 4.2.

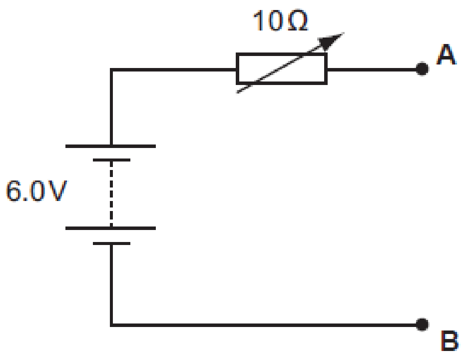

Fig. 4.2

On Fig. 4.2 add an LED with a 100 Ω resistor in series, an ammeter and a voltmeter to complete the circuit between terminals **A** and **B**. **[3]**

(c) When designing a circuit which includes an LED, it is normal practice to connect a resistor in series with the LED, in this case 100 Ω. Suggest and explain the purpose of this resistor.

....

....

.... **[2]**

(d) Another student uses the 10 Ω variable resistor as a potentiometer (potential divider) as shown in Fig. 4.3. The rest of the circuit is then completed between terminals **A** and **B** as for Fig. 4.2 in **(b)**.

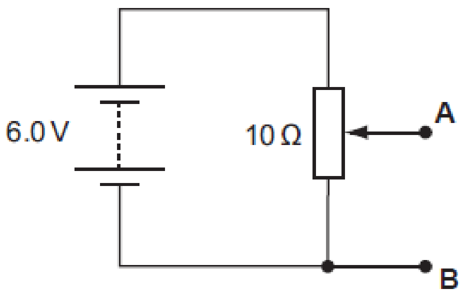

Fig. 4.3

Explain why the circuit of Fig. 4.3 is more suitable for obtaining the I-V characteristic of the LED than the circuit of Fig. 4.2.

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.... **[3]**

[Total: 16]

Reference: OCR Physics Unit 2 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
4					
	a	i	no current/no light/does not conduct until V is greater than 1.5 V brightness/intensity of LED increases with current/voltage above 1.5 V above 1.8 V current rises almost linearly with increase in p.d./AW the LED does not obey Ohm's law as I is not proportional to V/AW below 1.5 V, LED acts as an infinite R/ very high R/acts as open switch above 1.5 V, LED resistance decreases (with increasing current/voltage)	B1 B1 B1 M1 A1 B1 B1	**allow** 1.4 to 1.6 V (QWC mark) (alternative QWC mark) **max 5 marks** which must include at least one of the first 2 marking points
		ii 1 2	infinite resistance $I = 23.0 \pm 1.0$ (mA) $R = 1.9 \times 10^3/(23 \pm 1) = 83 \pm 4\ \Omega$	B1 C1 A1	 **apply** POT error for 0.083 Ω
	b		LED symbol with correct orientation resistor (need not be labelled) and ammeter in series with it voltmeter in parallel across LED only	B1 B1 B1	diode symbol + circle + at least one arrow pointing away
	c		the resistor limits the <u>current</u> in the circuit (when the LED conducts) otherwise it could overheat/burn out/be damaged/AW	B1 B1	
	d		in fig 4.3 the <u>voltage</u> range is from zero to maximum possible in fig. 4.2 the resistance variation is small/AW (so) in fig. 4.2 voltage variation across LED is small	B1 B1 B1	**allow** 6.0 V **accept** the LED is part of a potential divider **accept** only at the top end of the range/AW
			Total question 4	**16**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION EIGHT

(a) State the difference between the directions of conventional current and electron flow.

....

.... **[1]**

(b) Circle one or more of the combinations of units which could act as a unit for current.

J s   C s^{-1} V Ω^{-1} J C^{-1}

[2]

(c) Fig. 1.1 shows a current I in a thick metal wire **X** connected to a longer thinner wire **Y** of the same metal as shown in Fig. 1.1.

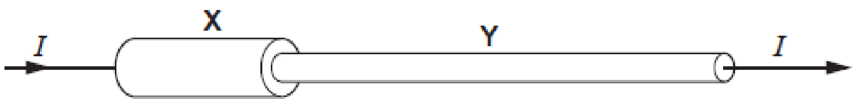


Fig. 1.1

(i) State why the current in **Y** must also be I.

....

.... **[1]**

(ii) Wire **Y** has half the cross-sectional area of the thicker wire **X** and is three times as long.

The resistance R_X of **X** is 12.0 Ω.

1 Show that the resistance R_Y of **Y** is 72 Ω.

2 Calculate the total resistance R of both wires.

R = ... Ω **[4]**

(iii) The mean drift velocity v_X of electrons in **X** is $2.0 \times 10^{-5}\,\mathrm{m\,s^{-1}}$.

Use the fact that **X** has twice the cross-sectional area of the thinner wire **Y** to calculate the mean drift velocity v_Y of electrons in **Y**. Show your working.

v_Y = ... $\mathrm{m\,s^{-1}}$ **[2]**

[Total: 10]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
1					
	a		current moves from + to – (of battery in circuit) **and** electrons move from – to +	B1	
	b		$C\ s^{-1}$ $V\ \Omega^{-1}$	B1 B1	2 correct 2 marks; 1 correct 1 mark, withhold a mark for each additional answer given
	c	i	statement of Kirchhoff's first law or conservation of charge	B1	**accept** wires are in <u>series</u> or current is the same (at every point) in a <u>series</u> circuit/AW **not** current in = current out
		ii1	$R = \rho l/A$ calculation to justify $R = 72\ \Omega$	B1 A1	accept $R \propto l$ and $R \propto 1/A$ **or** similar method/argument must be convincing **accept** 3/½ x12 but **not** 3 x 2 x 12
		ii2	R = sum of Rs $R = 84\ \Omega$	C1 A1	**accept** Rs in series **ecf (c)(ii)1**
		iii	select $I = nAev$ $v = 4.0 \times 10^{-5}$ ($m\ s^{-1}$)	B1 B1	**allow** $v \propto 1/A$ **accept** 4×10^{-5} ($m\ s^{-1}$) **no** SF error
			Total question 1	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION NINE

(a) Two filament lamps are described as being 230V, 25W and 230V, 60W.

(i) Describe what is meant by '230V, 25W' for a lamp.

....

....

....

.... **[2]**

(ii) Calculate the resistance of the 25W lamp when connected to a 230V supply.

resistance = ... Ω **[2]**

(iii) Each of the two lamps is connected across a 230V supply. Explain which lamp has the greater current.

....

....

....

.... **[2]**

(iv) Both lamps are connected in parallel across the 230V supply. The resistance of the 60W lamp in the circuit is 880Ω. Calculate

1 the total resistance R across the supply

R = ... Ω

2 the current I drawn from the supply.

I = ... A **[4]**

(b) The 60W filament lamp is connected to a 6.0V battery. The resistance of the lamp in this circuit is 70Ω. Explain why this value differs from the value given in **(a)(iv)** when the lamp is connected to the 230V supply.

In your answer, you should make clear how your explanation links with the observations.

....

....

....

....

.... **[2]**

(c) By mistake a householder leaves a 60W filament lamp switched on overnight for a period of 8.0 hours.

The cost of 1.0 kilowatt-hour of electricity is 21 pence.

(i) Define the *kilowatt-hour* (kWh).

....

....

.... **[1]**

(ii) Calculate the cost of this mistake to the householder.

cost = ... pence **[2]**

[Total: 15]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
2					
	a	i	When connected/using/AW to the 230 V supply the power/energy per second from supply/output/dissipated/AW is 25 W	B1 B1	**accept** when working normally/AW **not** 230 V (going) through/into lamp/AW **accept** transferred from electrical (into other) form(s) is 25 W
		ii	$25 = 230^2/R$ R = 2100 Ω **or** 2.1 kΩ	C1 A1	**accept** I = 25/230 = 0.11 A R = 230/0.11 = 2100 Ω (2116 Ω)
		iii	Using the equation in the form P = VI, for larger P need larger I so 60 W	M1 A1	accept $P = V^2/R$, for larger P need smaller R so larger I; do **not** allow any argument using 880 Ω unless this value is calculated here
		iv1	1/R = 1/2100 + 1/880 R = 620 Ω	C1 A1	substitution into formula for Rs in parallel **ecf (a)(ii)**
		iv2	I = 230/620 I = 0.37 (A)	C1 A1	**ecf (a)(iv)1** using 1/R gives 143 kA accept total P = 85 W so I = 85/230 ;= 0.37 (A)
	b		the resistivity/resistance (of a metal) increases with temperature **or** R is greater when hot(ter) at 6V/low I little heating effect **or** at 230 V/high I large heating effect	B1 A1	**ora** less when colder **QWC mark**: explanation linked to observations
	c	i	(a unit of) energy equal to 3.6 MJ **or** 1 kW for 1 h/AW	B1	**eg** 1000 W for 3600 s or similar
		ii	0.06 x 8 = 0.48 (kWh) or 60 x 8 = 480 (Wh) 0.48 x 21 = 10(.1) p	C1 A1	no marks for using s instead of h POT error e.g. 100 or 10000 p
			Total question 2	**15**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TEN

(a) A student wishes to determine the power dissipated in a variable resistor connected to a cell.

(i) Part of the circuit for this experiment is shown in Fig. 3.1. Complete the circuit of Fig. 3.1 showing how the variable resistor is connected and how the potential difference across it is measured. **[3]**

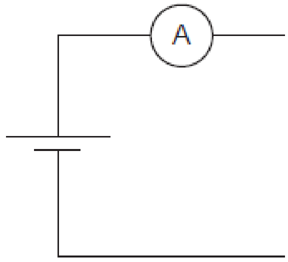


Fig. 3.1

(ii) Fig. 3.2 shows the variation of the potential difference *V* across the variable resistor with the current *I* in it.

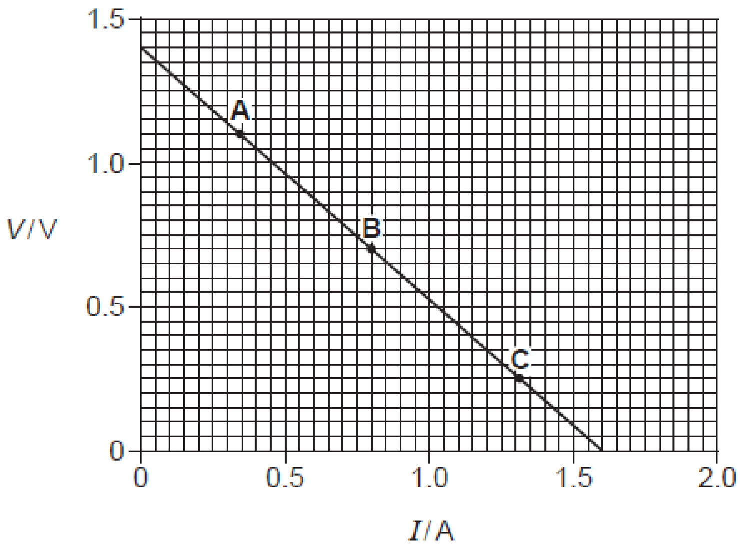


Fig. 3.2

1 The potential difference *V* across the variable resistor is also the terminal p.d. across the cell. Describe how the potential difference across the cell varies with the **resistance** *R* of the variable resistor. Suggest why the terminal p.d. varies in this way.

....

....

....

....

....

.... **[3]**

2 By referring to the points **A** and **C**, justify that the power dissipated in the variable resistor is a maximum at or near point **B**.

....

....

....

....

.... **[3]**

3 Determine the e.m.f. E of the cell.

E = ... V **[1]**

4 Calculate the internal resistance r of the cell.

r = ... Ω **[2]**

(b) In Fig. 3.1, the cell is replaced by a solar cell as the source of e.m.f.
A solar cell transforms light energy into electrical energy. The maximum intensity of sunlight on the solar cell is $800\,W\,m^{-2}$. The surface area of the cell is $2.5 \times 10^{-3}\,m^2$.

(i) Define the term *intensity*.

....

.... **[1]**

(ii) The maximum power delivered by the solar cell to the variable resistor is 0.25W. Determine the maximum efficiency of the solar cell.

maximum efficiency = ... **[3]**

[Total: 16]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
3					
	a	i	correct symbols (variable) R in series with ammeter and cell voltmeter correctly in parallel with variable R	B1 B1 B1	variable R and voltmeter needed **ecf** variable resistor symbol **accept** voltmeter in parallel with cell
		ii1	V decreases as I increases caused by R decreasing V is large when R is large **or** V is small when R is small V = e.m.f. when R is infinite/open circuit **or** V = 0 when R = 0 3.14 Ω at A; 0.88 Ω at B and 0.19 Ω at C any correct reference to internal resistance of cell	B1 B1 B1	**max 3 marks** with 2 marks for first two or second two marking points or three numbers and 1 mark for reference to r **allow** as R increases (decreases) V increases (decreases) for 1 mark but **not** as V increases R increases; **award 0/2** if reason given as V α R or I is constant
		ii2	at A I is small or V is much bigger than I/AW at C V is small or I is much bigger than V/AW product of V. and I is largest when the values of both quantities are about equal/half of the maximum value	B1 B1 B1	**accept** numerical answers, e.g. 0.39 W at A, 0.33 W at C 0.56 W at B for 2 marks comment on values for third mark
		ii3	1.4 (V)	B1	
		ii4	appreciating V against I is a straight line graph with gradient –r; giving r = 0.88 ± 0.02 Ω	C1 A1	**accept** using V = E – Ir **not** just quoting formula **allow** 0.8 ± 0.02 for calculation using any point on line N.B. can also have **ecf(ii)3**
	b	i	intensity is the (incident) energy <u>per</u> unit area <u>per</u> second	B1	**accept** power per unit area or power per m^2 or (total) power/(surface) area
		ii	efficiency = power out/power in = 0.25/(800 x 2.5 x 10^{-3}) = 0.125 or 12.5%	C1 C1 A1	**not** energy out/energy in **accept** 13%
			Total question 3	**16**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION ELEVEN

Fig. 4.1 shows how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light incident on it.

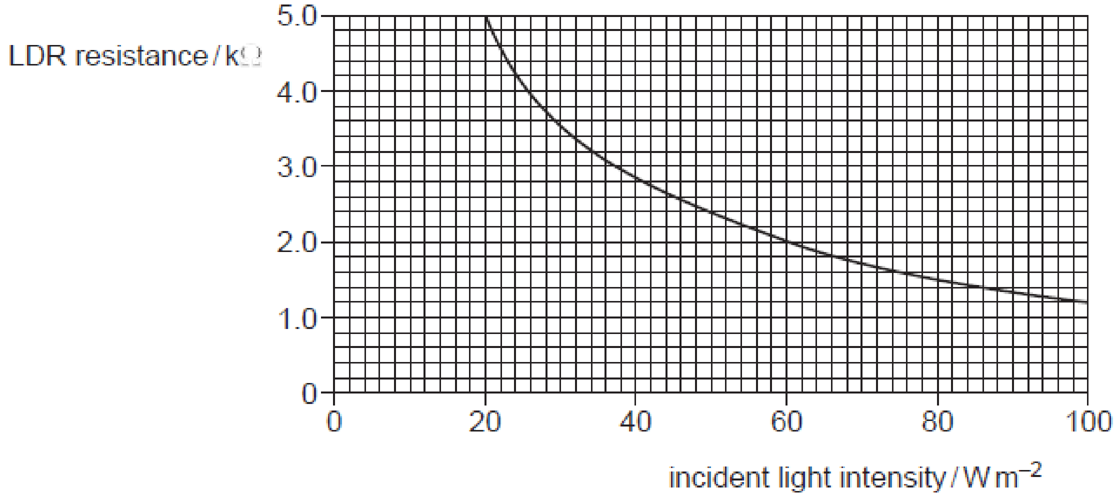


Fig. 4.1

(a) State how the resistance of the LDR changes with light intensity.

.... **[1]**

(b) Fig. 4.2 shows a light-sensing potential divider circuit where the LDR is connected in parallel to a voltmeter and data-logger.

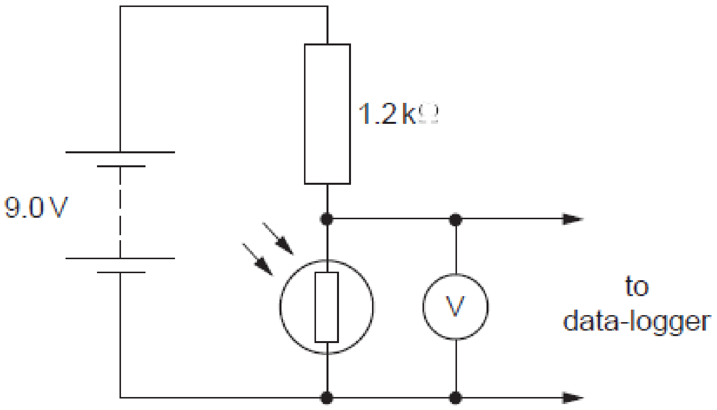


Fig. 4.2

The battery has an e.m.f. of 9.0 V and negligible internal resistance. The 1.2 kΩ resistor is made of carbon. The potential difference across the LDR is 6.0 V.

(i) State the potential difference across the 1.2 kΩ resistor.

potential difference = ... V **[1]**

(ii) Calculate the resistance R of the LDR.

R = ... kΩ **[3]**

(iii) Use Fig. 4.1 to determine the light intensity when the p.d. across the LDR is 6.0V.

light intensity = ... $W m^{-2}$ **[1]**

(c) **(i)** Fig. 4.1 shows that the change in resistance when the light intensity rises from $60 W m^{-2}$ to $80 W m^{-2}$ is 0.5kΩ. State the change in resistance when the light intensity rises from $20 W m^{-2}$ to $40 W m^{-2}$.

change in resistance = ... kΩ **[1]**

(ii) Larger changes in data-logger voltage are observed for changes at low light intensity rather than at high light intensity. Explain this.

....

....

....

.... **[2]**

(d) When the circuit of Fig. 4.2 is operated for a long time, the carbon resistor becomes hot. The resistivity of carbon falls as the temperature rises. State and explain the effect on the potential difference across the LDR.

....

....

....

....

....

.... **[3]**

(e) Describe briefly **two** advantages of using a data-logger to monitor the variation of light intensity falling on the LDR.

....

....

....

....

.... **[2]**

[Total: 14]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
4					
	a		resistance decreases with increase in light intensity	B1	**ora**
	b	i	3.0 (V)	B1	**accept** 3 V, no SF error
		ii	$3.0 = I.1.2 \times 10^3$ giving $I = 2.5 \times 10^{-3}$ A $6.0 / 2.5\ 10^{-3} = R = 2400\ \Omega$ 2.4 kΩ	C1 C1 A1	**accept** 6 = (R/ R + 1.2 k).9 2R + 2.4 k = 3R or similar R = 2.4 k ;**give** 2 with POT error **accept** ratio of resistors 6/3 x 1.2 good candidates can do this by inspection with no working – full marks **allow** 2400 written on answer line rather than 2.4 if 2400 Ω within body of text
		iii	49 **or** 50 (W m^{-2})	B1	**ecf (b)(ii)** if on R within graph range
	c	i	2.2 (kΩ)	B1	**allow** any value from 2.1 to 2.2
		ii	large(r) <u>changes in</u> R at low light intensities relating change in R to change in V	B1 B1	**allow** greater sensitivity of LDR at low light **or** steeper gradient/AW **e.g.** bigger change in I so in V **or** use of $V = R/(R + 1200)\ V_s$ **or** bigger change in V ratio across Rs
	d		V across 1.2 kΩ falls so V across LDR rises because ratio of Rs changes in favour of LDR/ potential divider argument **or** total V is constant	B1 B1 B1	**alternative** I increases because <u>total</u> R is less so V across LDR rises do **not** award B marks where there is CON e.g. V across 1.2 k rises so V across LDR rises
	e		continuous record for very long time scale of observation can record very short time scale signals (at intervals) automatic recording/remote sensing data can be fed directly to computer (for analysis)	B1 B1	**allow** any two sensible suggestions which fall within the 4 categories listed for 2 marks
			Total question 4	**14**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWELVE

A resistor **X** is constructed from a rod of cross-sectional area $9.0 \times 10^{-6}\,m^2$ and length 0.012 m as shown in Fig. 1.1. The resistivity of the material of the rod is $2.4\,\Omega\,m$.

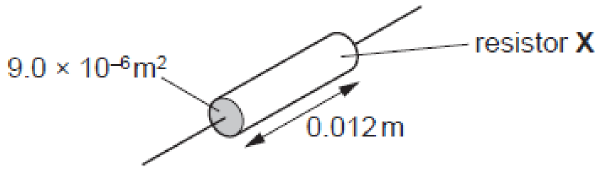


Fig. 1.1

(a) Show that the resistance of the resistor **X** is 3.2 kΩ.

[2]

(b) The power rating of resistor **X** is 0.125 W. Show that the maximum potential difference which should be applied safely across the resistor is 20 V.

[2]

(c) A student needs a resistor of the same resistance as **X** but with a power rating of 0.50 W. The only resistors available are identical to **X**. It is suggested that four of these resistors could be connected as shown in Fig. 1.2 to solve the problem. The potential difference across the combination of resistors is 40 V.

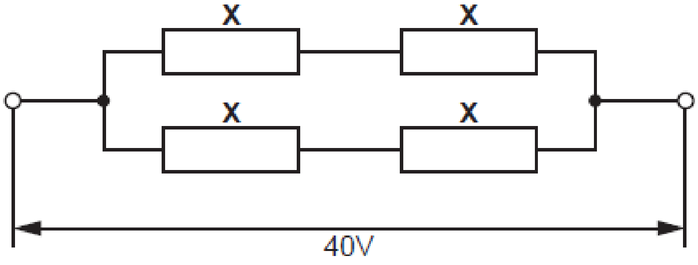


Fig. 1.2

(i) Show that the total resistance of the combination in Fig. 1.2 is 3.2 kΩ.

[2]

(ii) Show that the power dissipation in each resistor is 0.125 W.

....

....

....

.... **[2]**

(d) Another resistor **Y** is constructed from the same material but has twice the length and twice the diameter of resistor **X**.

(i) Show that the resistance R_Y of **Y** is half the resistance R_X of resistor **X**.

[2]

(ii) The two resistors **X** and **Y**, where $R_Y = R_X/2$, are connected in series to a d.c. power supply as shown in Fig. 1.3.

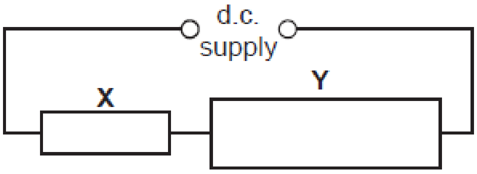


Fig. 1.3

State and explain which resistor dissipates greater power.

....

....

....

....

.... **[3]**

[Total: 13]

Reference: OCR Physics Unit 2 January 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
1	a		use of $R = \rho l/A$ $= 2.4 \times 12 \times 10^{-3}/9.0 \times 10^{-6}$ $= 3.2 \times 10^{3}$ (Ω)	C1 M1 A0	
	b		$V^2 = PR$ $= 0.125 \times 3.2 \times 10^{3}$ $V = 20$(V)	C1 M1 A0	**allow** $V = \sqrt{(0.125 \times 3.2 \times 10^{3})}$ **allow** substituting V = 20 to prove P = 0.125 W
	c	i	adding resistors in series and then in parallel to show that total resistance is 3.2 kΩ	B1 B1	**do not allow** any reference to values of V or P, etc in answer
		ii	p.d across each resistor is 20 V so power dissipated is 0.125 W	B1 B1	**accept** $P = 40^2/3.2$ k = 0.50 W so P per resistor = 0.50/4 = 0.125 W **do not accept** P_{total} = 0.50 W without proof – scores zero
	d	i	using $R_X = \rho l/A$; $A \rightarrow 4A$ and $l \rightarrow 2l$ $R_Y = \rho 2l/4A = \rho l/2A = R_X/2$	M1 A1	**accept** figures 24×10^{-3} m and 36×10^{-6} m^2 to give 1.6×10^{3} Ω
		ii	same current in X and Y (as in series) power dissipated is I^2R **or** IV where $V_X = 2V_Y$ so X has larger P (dissipation)	B1 M1 A1	**allow** $P = V^2/R$; $V_X = 2V_Y$ etc. **allow** 1 mark only for using $P = V^2/R$ or IV and V is larger across X (i.e. not quantitative) so X has larger P
			Total question 1	**13**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THIRTEEN

(a) A 12V car battery contains an electrolyte. The battery is connected to an electric motor **M**. There is a current in the motor and the battery. See Fig. 2.1.

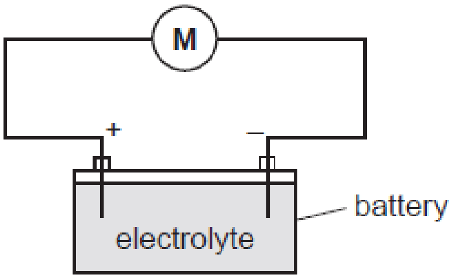


Fig. 2.1

State

(i) the charge carriers in the electrolyte

.... **[1]**

(ii) the charge carriers moving through the electrolyte to the positive terminal of the battery

.... **[1]**

(iii) the charge carriers moving through the wires to the positive terminal of the battery.

.... **[1]**

(b) When used to start the engine of the car, the electric motor draws 40 A from the battery of e.m.f. 12 V. The potential difference across the motor at this time is only 8.0 V.

(i) Explain why the potential difference across the motor at this time is not the same as the e.m.f. of the car battery.

....

....

....

.... **[2]**

(ii) Show that the internal resistance of the battery is 0.10 Ω.

[3]

(iii) It takes 1.2 s for the electric motor to start the engine. Calculate the charge Q which passes through the electric motor in this time.

Q = ... C **[2]**

(c) The car has two 12 V headlamps each rated at 54 W, connected in parallel to the battery. In normal working conditions the current in each lamp is 4.5 A.

(i) Explain how and why the resistance of the headlamp filament varies with the current passing through it.

....

....

....

....

.... **[2]**

(ii) Suggest a value for the current rating of a fuse for the headlamp circuit. Justify your choice.

....

....

.... **[2]**

(iii) A car contains a number of different fuses for its various electrical circuits. Suggest why this is necessary.

....

....

.... **[1]**

[Total: 15]

Reference: OCR Physics Unit 2 January 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
2	a	i	ions	B1	
		ii	positive ions	B1	**allow** positive charges / cations
		iii	electrons	B1	
	b	i	the battery has an internal resistance/AW some of the emf is across the (internal) resistance (leaving a smaller p.d. across motor)	B1 B1	**accept** connecting leads have resistance **accept** V = E - Ir or 'lost volts'/p.d. across r
		ii	use E = V + Ir giving 12 = 8 + 40r r = (12 – 8)/40 **or** 4/40 = 0.10 Ω	C1 M1 M1 A0	**accept** reverse solution, 0.10 Ω → 8 V→ 12 V substitution and or solution showing working
		iii	Q = It = 40 x 1.2 I= 48 (C)	C1 A1	
	c	i	The current heats the filament The resistance/resistivity (of the metal filament) increases (with temperature). .	B1 B1	no mention of temperature increase or heating scores zero
		ii	4.5 to 8 A in each (parallel) arm **or** 9 to 16 A for both together needs to be great enough to cover initial surge/current **or** use antisurge fuses	B1 B1	no mark if fuse value outside range
		iii	e.g. the starter motor draws 40 A so would need a bigger fuse than headlamp circuit so need different fuses for different situations **or** if battery used for starter motor with lights on will need too large a fuse – damage occurs before fuse blows/AW	B1	**accept** headlamp circuit damaged before fuse blows if 40 A fuse only used **or** fuse blows in starter circuit if 10 A used, etc.
			Total question 2	**15**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOURTEEN

(a) The following electrical quantities are often used when analysing circuits. Draw a straight line from each quantity on the left-hand side to its correct units on the right-hand side.

potential difference	$C\,s^{-1}$
resistance	$J\,C^{-1}$
power	$V\,A^{-1}$
current	$J\,s^{-1}$

[3]

(b) Fig. 3.1 shows a battery of e.m.f. 6.0V and negligible internal resistance connected in series with a thermistor and a 560 Ω resistor.

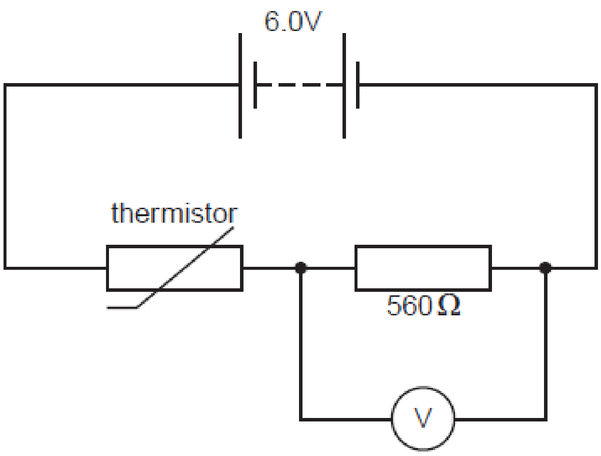


Fig. 3.1

The voltmeter across the resistor has infinite resistance.

(i) The reading on the voltmeter is 2.4V. Calculate the resistance R_T of the thermistor.

R_T = ... Ω **[3]**

(ii) Calculate the current in the circuit.

current = ... A **[1]**

(c) The variation of resistance with temperature for this thermistor is shown in the graph of Fig. 3.2.

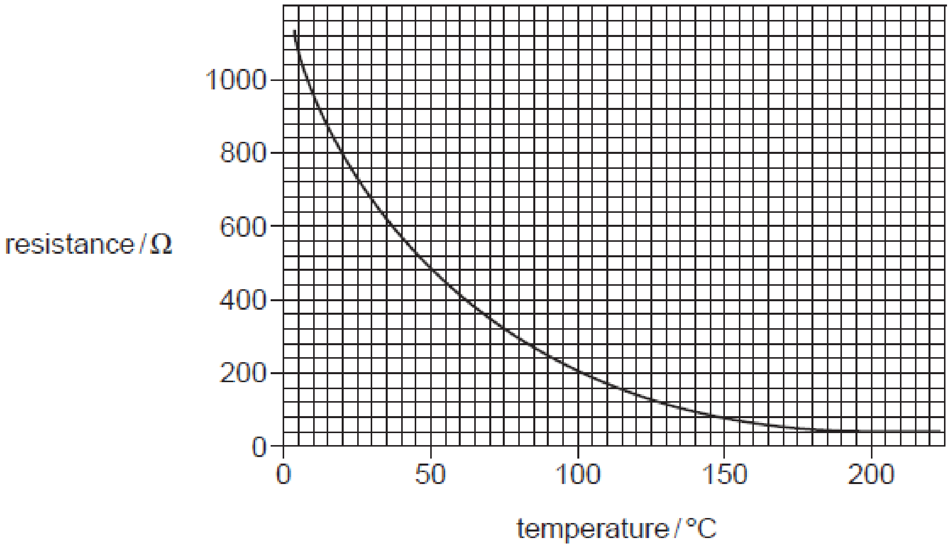


Fig. 3.2

(i) Use the graph to determine the temperature of the thermistor when its resistance is 800 Ω.

temperature = ... °C **[1]**

(ii) State and explain, without calculation, how the reading of the voltmeter in Fig. 3.1 will change as the temperature of the thermistor increases to 80 °C.

....

....

....

....

.... **[3]**

(iii) The circuit of Fig. 3.1 can be used as a temperature sensor. Temperature sensors are used in the kitchen to control the internal temperatures of ovens (typically 200 °C) and refrigerators (typically 4 °C). Use the graph of Fig. 3.2 to suggest in which device this sensor would be more suitable.

In your answer you should link the information from the graph to the working of the sensor.

....

....

....

....

.... **[3]**

[Total: 14]

Reference: OCR Physics Unit 2 January 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
3					
	a	i	V J C^{-1} R V A^{-1} P J s^{-1} I C s^{-1}.	B1 B1 B1	4 correct 3 marks; 2 correct 2 marks 1 correct 1 mark
	b	i	using $V_{out} = R_2/(R_1 + R_2)\ V_{in}$: V_{out} = 3.6 V 3.6 = R_2/(560 + R_2) 6 **alt:** 2.4 = I x 560 so I = 4.3 mA 3.6 = I R_2 R_2 = 840 (Ω)	C1 C1 A1	**accept** R_2 = (3.6/2.4) x 560 or .2.4 = 560/(560 + R_2) 6
		ii	I = 4.3 x 10^{-3} (A)	B1	**accept** 4.3 m(A) or 3/700 (A) **ecf (b)(i)** i.e. I = 6/(560 + R_2)
	c	i	20 ± 2 (°C)	B1	
		ii	R_{Th} will fall/ resistance will fall giving greater share of supply V across fixed R/AW causing the voltage across (fixed) R/voltmeter reading to rise	B1 B1 B1	**accept** explanation in terms of potential divider equation **or** current increases **or** current same in both resistors/resistors in series
		iii	ΔR is large for small ΔT at low temperatures/AW in terms of gradient so thermistor is better in circuit to control low temp, refrigerator	M2 A1	**accept** sensitivity greater at low temperature **or** vice versa **or** ΔR is small for small ΔT at high temperatures scores 1 out of 2
			Total question 3	**14**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

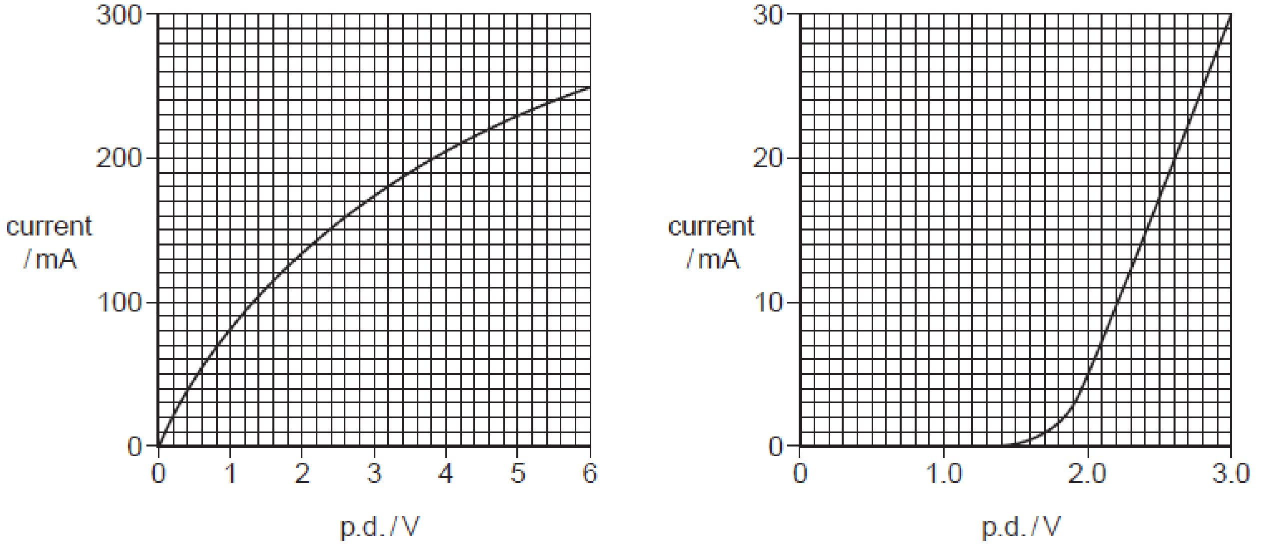
A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIFTEEN

1 Two 6.0V torches produce similar light intensities. The light source of one is a single filament lamp and of the other is a combination of four light-emitting diodes (LEDs). Fig. 1.1 shows the *I*-*V* characteristics of the filament lamp and **one** LED.



filament lamp LED

Fig. 1.1

(a) **(i)** Describe how the resistance of the filament lamp at 6.0V can be determined from its *I*-*V* characteristic.

....

.... **[2]**

(ii) State how the *I*-*V* characteristics show that the filament lamp and the LED do not obey Ohm's law.

....

.... **[1]**

(b) When at normal brightness the current in the filament lamp is 0.25A at a p.d. of 6.0V.

(i) Calculate the charge *Q* passing through the filament each second.

Q = ... C **[1]**

(ii) Calculate the energy drawn from the battery each second.

energy = ... J **[1]**

(iii) The battery is able to keep the lamp lit for 4 hours. Estimate the energy stored in the battery.

energy stored = ... J **[2]**

(c) The LEDs in the LED torch are connected in pairs across the 6.0V battery and switch so that the potential difference across each of the four LEDs is 3.0V.

(i) Define the term *potential difference*.

....

.... **[2]**

(ii) Use Fig. 1.1 to determine the current through each LED.

current = ... mA **[1]**

(iii) Show that the power drawn from the battery in the LED torch is 0.36W.

[2]

(iv) Sketch a circuit diagram showing how the battery, the four LEDs and the switch are connected in the torch.

[3]

(d) Suggest one advantage of using LEDs rather than a filament lamp in a torch.

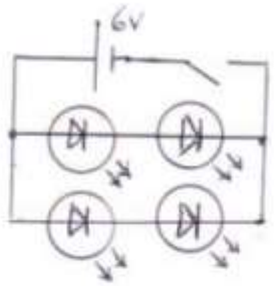
....

.... **[1]**

[Total: 16]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
1					
	a	i	read off value of current (at V = 6.0 V) calculate R using V/I	B1 B1	any reference to using gradient scores 0/2 **accept** I = 0.25 (A) or 250 (mA) **accept** R = 24 Ω
		ii	V is not proportional to I	B1	**accept** not a straight line; R is not constant
	b	i ii iii	Q = It = 0.25 x 1 = 0.25 C E = VIt or QV = 6 x 0.25 = 1.5 J E = VIt = 1.5 x 4 x 60 x 60 = 2.16 x10^4 J	B1 B1 C1 A1	 **ecf(b)(i)** **ecf b(ii)** **accept** 2.2 x 10^4 J; **allow** 360 J for 1 mark only
	c	i ii iii	energy transfer per unit charge from electrical to other forms 30 mA Use of P = VI suitable method (may be expressed purely in numerical form) = 0.36 W	B1 B1 A1 M1 A1 A0	**or** energy transfer/charge; work done /charge **or** across LED 3 x 0.030 = 0.090 W per LED so 0.090 x 4 **or** 30 mA in two branches at 6 V **or** total current is 60 mA from 6 V battery
		iv		B1 B1 B1	symbol for LED correct orientation of LED correct circuit
	d		draws a lower current/ light lasts longer (before battery discharged/)AW **or** LEDs more efficient (at converting electrical energy into light) **or** if one LED fails there are still two lit **or** more robust/longer working life	B1	 **allow** lower power consumption/AW
			Total question 1	**16**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIXTEEN

This question is about possible heating circuits used to demist the rear window of a car. The heater is made of 8 thin strips of a metal conductor fused onto the glass surface. Fig. 2.1 shows the 8 strips connected in parallel to the car battery of e.m.f. E and internal resistance r.

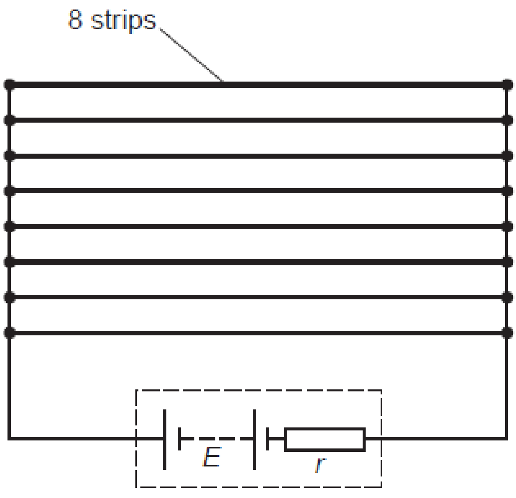


Fig. 2.1

(a) The potential difference across each strip is 12 V when a current of 2.0 A passes through it.

(i) Calculate the resistance r_p of one strip of the heater.

r_p = ... Ω **[1]**

(ii) Calculate the total resistance R_p of the heater.

R_p = ... Ω **[3]**

(iii) Show that the power P dissipated by the heater is about 200 W.

[2]

(b) Each strip is 0.90 m long, 2.4×10^{-4} m thick and 2.0×10^{-3} m wide.

Calculate the resistivity ρ of the metal of the strip. Give the unit with your answer.

ρ = ...unit .... **[4]**

(c) An alternative way of making the heater is to connect eight metal strips in **series**. The heater is to dissipate the same power as the parallel combination of **(a)** when the p.d. across it is 12V.

(i) Explain why the total resistance of the series heater must equal R_p calculated in **(a)(ii)**.

....

.... **[1]**

(ii) Calculate the resistance r_s of one strip of this series heater.

r_s = ... Ω **[1]**

(iii) Suggest, with a reason, whether you would choose the series or parallel circuit arrangement of the strips for a demister heater.

....

.... **[1]**

(d) Fig. 2.2 is a graph showing how the potential difference across the terminals of the battery varies with the current drawn from it.

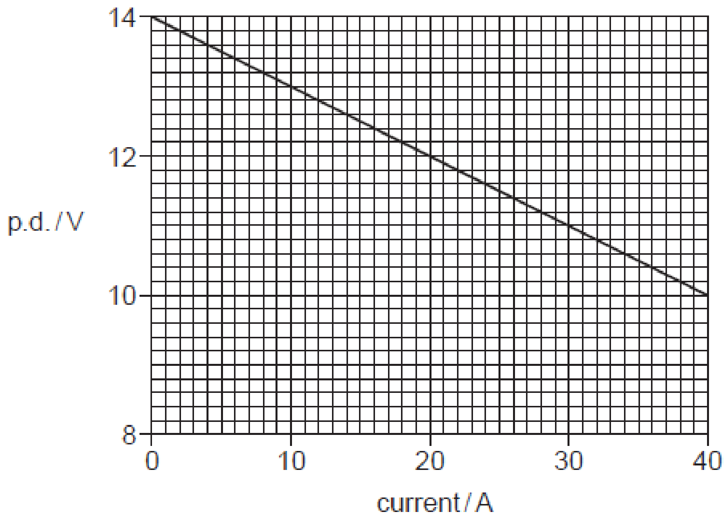


Fig. 2.2

(i) From the graph find the e.m.f. E of the battery.

E = ... V **[1]**

(ii) Use data from the graph to calculate the internal resistance r of the battery.

r = ... Ω **[3]**

[Total: 17]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
2					
	a	**i**	12/2.0 = 6.0 (Ω)	B1	**allow** 6; do not apply the SF penalty (N.B. applied only once per paper) for any answer where the second SF is 0
		ii	attempt to use resistors in parallel formula 1/R = 8/6 R = 0.75 (Ω)	C1 C1 A1	no mark for just quoting formula **ecf (a)(i)** **allow** ¾ (Ω)
		iii	$P = V^2/R = 12^2/0.75$ **or** 8VI = 8 x 12 x 2 **or** $I^2R = 16^2 \times 0.75$ = 192 W	C1 A1	**ecf (a)(ii)**
	b		ρ = RA/l $= 6.0 \times 0.24 \times 2.0 \times 10^{-6}/0.9$ $= 3.2 \times 10^{-6}$ Ω m	C1 C1 A1 B1	correct rearrangement of formula **ecf (a)(i);** substitution into a correct formula 2/3 marks for one or more POT errors **accept** 3.2 Ω μm; 4×10^{-7} scores 2/3
	c	**i**	(As V is the same) then R must be the same to give same P	B1	**accept** alternative wording producing same argument, e.g. same I, same V so same R
		ii	0.75/8 = 0.094 (Ω)	B1	**ecf (a)(ii)**/8; **accept** 3/32 but NOT 0.09
		iii	for parallel circuit with break in one wire rest still work **or** series strips very wide (if use material of same resistivity as such low resistance/ giving poor visibility))	B1	any sensible statement
	d	**i**	14 V	B1	
		ii	e.g. V = 12 V; I = 20 A substitution into E = V + Ir, e.g. 14 = 12 + 20 r r = 0.1 Ω	C1 C1 A1	**or** any suitable pair of readings from graph **ecf(d)(i); accept** r = gradient; = (14 – 10)/40 or similar ; = 0.1 Ω
			Total question 2	**17**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SEVENTEEN

This question is about the use of a light-dependent resistor (LDR) as a light sensor in a potential divider circuit. Fig. 3.1 shows how the resistance of a particular LDR varies with light intensity.

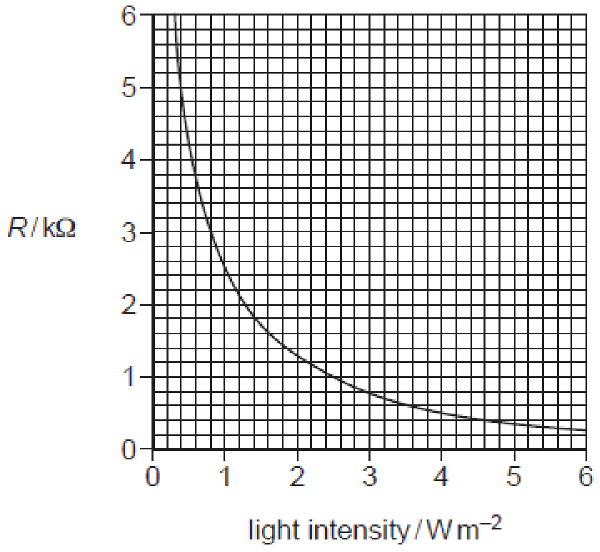


Fig. 3.1

(a) Explain the term *intensity*.

....

.... **[1]**

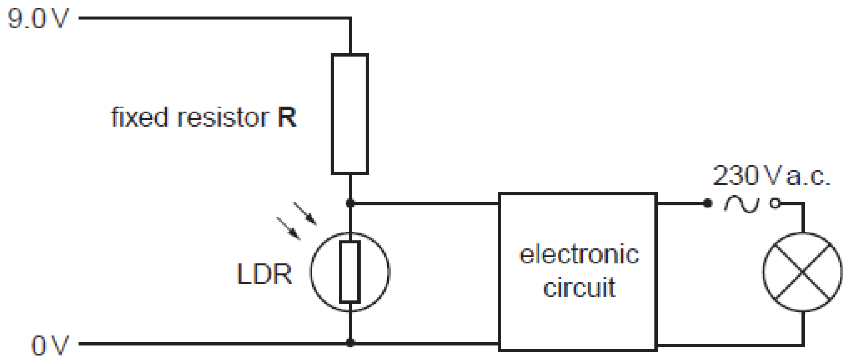
(b) The intensity of daylight is about 10 W m^{-2} and at night time is about 0.1 W m^{-2}. Describe how the resistance of the LDR changes during the day compared with how it changes at night.

....

....

.... **[2]**

(c) Fig. 3.2 shows a light-sensing potential divider circuit where the LDR is connected in parallel to the input of an electronic circuit that operates a 230 V mains lamp.



The electronic circuit draws a negligible current. The potential difference across the LDR must be at least 5.0 V to activate the circuit and switch on the lamp. The lamp is switched on when the light intensity falls to 1.0 W m^{-2}.

(i) Use Fig. 3.1 to determine the resistance of the LDR at a light intensity of 1.0 W m^{-2}.

resistance = ... kΩ **[1]**

(ii) Calculate the current in the LDR in Fig. 3.2 for the p.d. across it to be 5.0 V.

current = ... A **[2]**

(iii) Show that the resistance of the fixed resistor **R** in Fig. 3.2 is 2.0 kΩ.

[1]

(d) The lamp switches off when the light intensity reaches 2.5 W m^{-2}. Calculate the p.d. across the LDR when this happens.

potential difference = ... V **[3]**

(e) Explain why the LDR must be shielded or be at some distance from the lamp when it switches on.

....

....

....

.... **[2]**

[Total: 12]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
3					
	a		energy per unit area per unit time	B1	**accept** power per unit area; **allow** second for unit time
	b		Small changes in R for high light intensities/daylight conditions Large changes in R for low light intensities/dim light/night time conditions to change circuit state need a significant change in R to be useful/reliable	B1 B1 B1	**accept** low R by day, high R by night for 1 mark **NOT** comparison e.g. R by day smaller than R at night **max 2 marks** from 3 marking points
	c	i ii iii	2.5 (kΩ) 5.0 = I x 2.5 kΩ giving I = 2.0×10^{-3} A 4.0 = 2.0×10^{-3} x R **or** potential divider argument giving R = 2.0×10^{3} Ω	A1 C1 A1 M1 A0	**allow** 2.4 to 2.6 **ecf (c)(i)** **accept** 2.0 mA **ecf (c)(ii) or ecf (c)(i)** **accept** 2.0 kΩ
	d		R (of LDR) = 1(.0 kΩ) potential divider of 1.0 kΩ and 2.0 kΩ giving 3.0 V across LDR	B1 C1 A1	 **accept** I = 3.0 (mA) so V = 3.0 (mA) x 1.0 (kΩ) = 3.0 V
	e		light shining on the LDR will cause it to switch the illumination off causing an ON/OFF oscillation/AW	B1 B1	two suitable qualifying statements for the 2 marks
			Total question 3	**12**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

DATASHEET

DATA - FUNDAMENTAL CONSTANTS AND VALUES

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\,s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\,m^{-1}}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	$\mathrm{J\,s}$
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\,m^{2}\,kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\,K^{-1}\,mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\,K^{-1}}$
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{W\,m^{-2}\,K^{-4}}$
the Wien constant	α	2.90×10^{-3}	$\mathrm{m\,K}$
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	$\frac{e}{m_e}$	1.76×10^{11}	$\mathrm{C\,kg^{-1}}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	9.58×10^{7}	$\mathrm{C\,kg^{-1}}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$\mathrm{N\,kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\,s^{-2}}$
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661×10^{-27}	kg

ALGEBRAIC EQUATION

quadratic equation $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

ASTRONOMICAL DATA

Body	Mass/kg	Mean radius/m
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.97×10^{24}	6.37×10^{6}

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
curved surface area of cylinder	$= 2\pi rh$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

Particle Physics

Class	Name	Symbol	Rest energy/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^\pm$	0.510999
	muon	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^0	134.972
	K meson	$K^\pm$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	−1

Properties of Leptons

		Lepton number
Particles:	$e^-, \nu_e; \mu^-, \nu_\mu$	+1
Antiparticles:	$e^+, \overline{\nu_e}, \mu^+, \overline{\nu_\mu}$	−1

Photons and energy levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{k\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$

first harmonic $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 *and* n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

force $F = \frac{\Delta(mv)}{\Delta t}$

impulse $F\,\Delta t = \Delta(mv)$

work, energy and power $W = F s \cos\theta$

$E_k = \frac{1}{2} m v^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

$efficiency = \frac{useful\ output\ power}{input\ power}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k\,\Delta L$

Young modulus $= \frac{tensile\ stress}{tensile\ strain}$ *tensile stress* $= \frac{F}{A}$ *tensile strain* $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

Electricity

current and pd $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

resistivity $\rho = \frac{RA}{L}$

resistors in series $R_T = R_1 + R_2 + R_3 + \ldots$

resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

power $P = VI = I^2R = \frac{V^2}{R}$

emf $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

Circular motion

magnitude of angular speed $\omega = \frac{v}{r}$

$\omega = 2\pi f$

centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

centripetal force $F = \frac{mv^2}{r} = m\omega^2 r$

Simple harmonic motion

acceleration $a = -\omega^2 x$

displacement $x = A\cos(\omega t)$

speed $v = \pm\omega\sqrt{(A^2 - x^2)}$

maximum speed $v_{max} = \omega A$

maximum acceleration $a_{max} = \omega^2 A$

for a mass-spring system $T = 2\pi\sqrt{\frac{m}{k}}$

for a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

Thermal physics

energy to change temperature $Q = mc\Delta\theta$

energy to change state $Q = ml$

gas law $pV = nRT$

$pV = NkT$

kinetic theory model $pV = \frac{1}{3}Nm(c_{rms})^2$

kinetic energy of gas molecule $\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

Gravitational fields

force between two masses $F = \frac{Gm_1m_2}{r^2}$

gravitational field strength $g = \frac{F}{m}$

magnitude of gravitational field strength in a radial field $g = \frac{GM}{r^2}$

work done $\Delta W = m\Delta V$

gravitational potential $V = -\frac{GM}{r}$

$g = -\frac{\Delta V}{\Delta r}$

Electric fields and capacitors

force between two point charges $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$

force on a charge $F = EQ$

field strength for a uniform field $E = \frac{V}{d}$

work done $\Delta W = Q\Delta V$

field strength for a radial field $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

electric potential $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

$E = \frac{\Delta V}{\Delta r}$

capacitance $C = \frac{Q}{V}$

$C = \frac{A\varepsilon_0\varepsilon_r}{d}$

capacitor energy stored $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

capacitor charging $Q = Q_0(1 - e^{-t/RC})$

decay of charge $Q = Q_0 e^{-t/RC}$

time constant RC

Magnetic fields

force on a current $F = BIl$

force on a moving charge $F = BQv$

magnetic flux $\Phi = BA$

magnetic flux linkage $N\Phi = BAN\cos\theta$

magnitude of induced emf $\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$

$N\Phi = BAN\cos\theta$

emf induced in a rotating coil $\varepsilon = BAN\omega\sin\omega t$

alternating current $I_{rms} = \dfrac{I_0}{\sqrt{2}}$ $V_{rms} = \dfrac{V_0}{\sqrt{2}}$

transformer equations $\dfrac{N_s}{N_p} = \dfrac{V_s}{V_p}$

$efficiency = \dfrac{I_s V_s}{I_p V_p}$

Nuclear physics

the inverse square law for γ radiation $I = \dfrac{k}{x^2}$

radioactive decay $\dfrac{\Delta N}{\Delta t} = -\lambda N$, $N = N_0 e^{-\lambda t}$

activity $A = \lambda N$

half-life $T_{½} = \dfrac{\ln 2}{\lambda}$

nuclear radius $R = R_0 A^{1/3}$

energy-mass equation $E = mc^2$

OPTIONS

Astrophysics

1 astronomical unit = 1.50×10^{11} m

1 light year = 9.46×10^{15} m

1 parsec = 206265 AU = 3.08×10^{16} m

= 3.26 light year

Hubble constant, H = 65 km s^{-1} Mpc^{-1}

$M = \dfrac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$

in normal adjustment $M = \dfrac{f_o}{f_e}$

Rayleigh criterion $\theta \approx \dfrac{\lambda}{D}$

magnitude equation $m - M = 5\log\dfrac{d}{10}$

Wien's law $\lambda_{max} T = 2.9 \times 10^{-3}$ m K

Stefan's law $P = \sigma A T^4$

Schwarzschild radius $R_s \approx \dfrac{2GM}{c^2}$

Doppler shift for v << c $\dfrac{\Delta f}{f} = -\dfrac{\Delta\lambda}{\lambda} = \dfrac{v}{c}$

red shift $z = -\dfrac{v}{c}$

Hubble's law $v = Hd$

Medical physics

lens equations $P = \dfrac{1}{f}$

$m = \dfrac{v}{u}$

$\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$

threshold of hearing $I_0 = 1.0 \times 10^{-12}$ W m^{-2}

intensity level $intensity\ level = 10\log\dfrac{I}{I_0}$

absorption $I = I_0 e^{-\mu x}$

$\mu_m = \dfrac{\mu}{\rho}$

ultrasound imaging $Z = \rho c$

$\dfrac{I_r}{I_i} = \left(\dfrac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$

half-lives $\dfrac{1}{T_E} = \dfrac{1}{T_B} + \dfrac{1}{T_P}$

Engineering physics

moment of inertia $I = \Sigma m r^2$

angular kinetic energy $E_k = \frac{1}{2} I \omega^2$

equations of angular motion

$\omega_2 = \omega_1 + \alpha t$

${\omega_2}^2 = {\omega_1}^2 + 2\alpha\theta$

$\theta = \omega_1 t + \frac{\alpha t^2}{2}$

$\theta = \frac{(\omega_1 + \omega_2)\, t}{2}$

torque $T = I\,\alpha$

$T = F\,r$

angular momentum $\text{angular momentum} = I\omega$

angular impulse $T\Delta t = \Delta(I\omega)$

work done $W = T\theta$

power $P = T\omega$

thermodynamics $Q = \Delta U + W$

$W = p\Delta V$

adiabatic change $pV^{\gamma} = \text{constant}$

isothermal change $pV = \text{constant}$

heat engines

efficiency $= \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H}$

maximum theoretical efficiency $= \frac{T_H - T_C}{T_H}$

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power $= (\text{area of } p - V \text{ loop}) \times (\text{number of cycles per second}) \times (\text{number of cylinders})$

output or brake power $P = T\omega$

friction power = indicated power – brake power

heat pumps and refrigerators

refrigerator: $COP_{\text{ref}} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}$

heat pump: $COP_{\text{hp}} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C}$

Turning points in physics

electrons in fields $F = \frac{eV}{d}$

$F = Bev$

$r = \frac{mv}{Be}$

$\frac{1}{2} mv^2 = eV$

Millikan's experiment $\frac{QV}{d} = mg$

$F = 6\pi\eta r v$

Maxwell's formula $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

special relativity $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

$l = l_0 \sqrt{1 - \frac{v^2}{c^2}}$

$E = m c^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$

Electronics

resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Q-factor $Q = \frac{f_0}{f_B}$

operational amplifiers: open loop $V_{\text{out}} = A_{\text{OL}}(V_+ - V_-)$

inverting amplifier $\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_f}{R_{\text{in}}}$

non-inverting amplifier $\frac{V_{\text{out}}}{V_{\text{in}}} = 1 + \frac{R_f}{R_1}$

summing amplifier $V_{\text{out}} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \cdots\right)$

difference amplifier $V_{\text{out}} = (V_+ - V_-)\frac{R_f}{R_1}$

Bandwidth requirement:

for AM $\text{bandwidth} = 2f_M$

for FM $\text{bandwidth} = 2(\Delta f + f_M)$

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This document has been produced for educational purposes only.

This document has been produced for the AQA A Level Physics Specification.

Student Voice

If you when using this document, you believe there is an improvement to made, please state this in the space below….

Only constructive and reasoned feedback will be considered.