Past Paper Questions on Electricity   from G491 (2009 to 2014)
Including Module 2 Fundamental Data Analysis

3.1   Current, p.d. and electrical power
3.2   Conductors and resistors
3.3   Conductivity and Resistivity
3.4   Conduction under the microscope
3.5   Potential Dividers
3.6   e.m.f. and internal resistance

charge on electron	e	-1.60×10^{-19} C

Electricity

current	$I = \dfrac{\Delta Q}{\Delta t}$
potential difference	$V = \dfrac{W}{Q}$
power and energy	$P = IV = I^2R, \quad W = VIt$
e.m.f and potential difference	$V = \varepsilon - Ir$
conductors in series and parallel	$\dfrac{1}{G} = \dfrac{1}{G_1} + \dfrac{1}{G_2} + \ldots \qquad G = G_1 + G_2 + \ldots$
resistors in series and parallel	$R = R_1 + R_2 + \ldots \qquad \dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$
potential divider	$V_{out} = \dfrac{R_2}{R_1 + R_2} V_{in}$
conductivity and resistivity	$G = \dfrac{\sigma A}{L} \qquad R = \dfrac{\rho L}{A}$

1 Here is a list of units.

$$C\,s^{-1} \qquad J\,C^{-1} \qquad J\,s^{-1} \qquad V\,A^{-1} \qquad V\,A$$

Choose the correct unit for

(a) electric current ....

(b) potential difference ....

[2]

4 A neon indicator lamp needs 90V in order to conduct. It then draws a current of 0.5 mA.

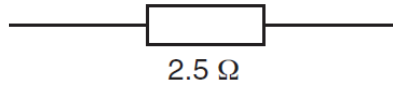**(a)** Calculate the resistance of the lamp at this voltage and current.

resistance = ... Ω [2]

(b) Calculate the number of electrons moving through of the lamp each second.
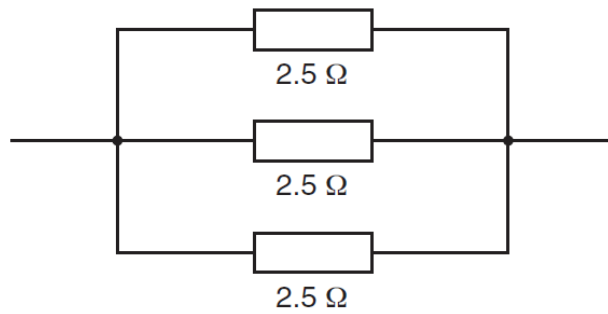
electron charge $e = 1.6 \times 10^{-19}$ C

number = ... s^{-1} [2]

6 A resistor has resistance $2.5\,\Omega$.

2.5 Ω

(a) Calculate its conductance.

conductance = ... unit .... **[2]**

(b) Calculate the conductance of three such $2.5\,\Omega$ resistors arranged in parallel.

2.5 Ω

2.5 Ω

2.5 Ω

conductance = ... unit .... **[1]**

11 This question is about a type of thermistor.

A PTC (positive temperature coefficient) thermistor increases in resistance as its temperature increases.

The circuit in Fig. 11.1 has a 6V battery connected to a PTC thermistor in series with a 500 Ω resistor.
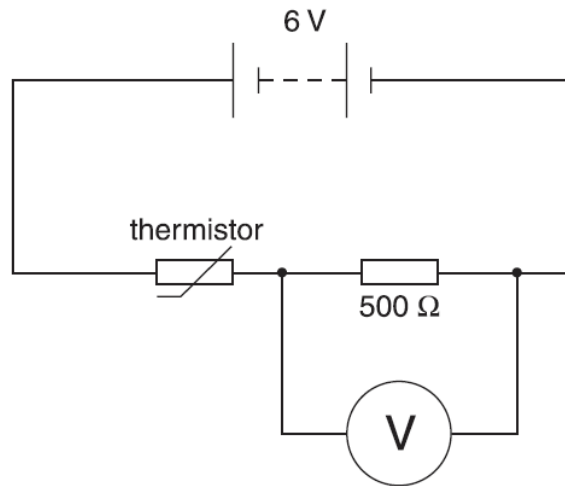

Fig. 11.1

(a) At a temperature of 20 °C, the thermistor has a resistance of 260 Ω.

    (i) Show that the p.d. across the 500 Ω resistor is about 4 V.

                                                                     [2]

    (ii) Calculate the current in the circuit.

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

(b) As the thermistor is heated to 90 °C, its resistance increases to 10 000 Ω.

State and explain what would happen to the p.d. measured by the voltmeter in Fig. 11.1 as the temperature of the thermistor increases from 20 °C to 90 °C.

You do not need to do any calculations.

[2]

(c) The variation of resistance R with temperature T for this PTC thermistor is shown in the graph of Fig. 11.2.
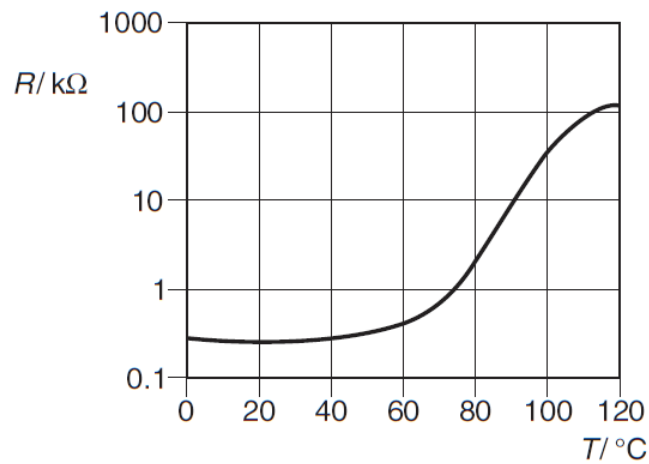

Fig. 11.2

The circuit of Fig. 11.1 can be used as a temperature sensor.

Use the graph of Fig. 11.2 to suggest why this sensor would not be very suitable for controlling the temperature of central heating but would be much more suitable for a fire alarm.

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

[3]

(d) In a different circuit, the PTC thermistor described by the graph in Fig. 11.2 is at an initial temperature of 20 °C, when it has a resistance of 260 Ω. A fault causes the current in this circuit to rise suddenly to 0.5 A.

  (i) Calculate the rate at which energy is dissipated as heat in the thermistor immediately after the fault.

  rate of dissipation of energy = ... W **[2]**

  (ii) Explain why the current in this circuit quickly falls to a much smaller value.

  [1]

Jan 2010

1 Here are equations for electrical resistivity and conductivity:

$$\rho = \frac{RA}{L} \qquad \sigma = \frac{GL}{A}$$

Write down correct units for

(a) electrical resistivity   ....

(b) electrical conductivity.   ....

  [2]

5 A mains kettle operates at 240 V and is rated at 2.2 kW.

Calculate the resistance of the kettle heating element when operating normally.

  resistance = ... Ω **[2]**

9 This question is about measuring the electrical conductivity of a semiconductor. The semiconductor is in the form of a square chip of side about 10 mm, and about 1 mm thick as shown in Fig. 9.1.

The resistance of the slice is of order of magnitude 100 Ω.
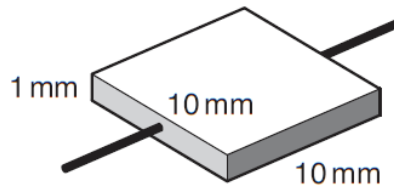Current is passed into the shaded vertical end of the slice as shown.

Fig. 9.1

(a) Draw a diagram of a circuit that could be used to obtain the electrical measurements required to determine the electrical conductivity of the semiconductor.

[2]

(b) Describe clearly how to obtain all the measurements needed to determine the conductivity.

[3]

(c) Describe how the data is used to calculate a value for the conductivity of the semiconductor.

[2]

(d) Suggest **one** way in which you could improve the measurement of the conductivity, by reducing uncertainty or systematic error in part of the measurement.

In your answer, you should clearly identify a source of uncertainty or systematic error, describe clearly the change you suggest, and explain how it would improve the measurement.

[3]

11 Fig. 11.1 shows a pressure gauge. A pressure difference curves a thin metal plate **P**. Identical strain gauge resistors **F** and **B** are glued to the front and back of plate **P**. As plate **P** curves resistor **F** is compressed and resistor **B** is stretched.
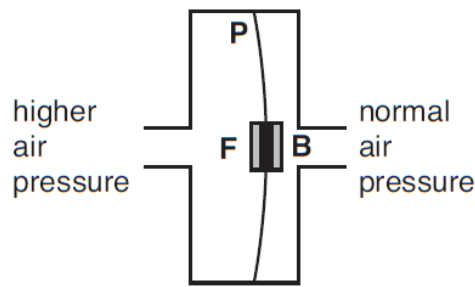

Fig. 11.1

(a) The strain gauge resistors are made of thin metal films of unstrained resistance $120\,\Omega$. The resistors are connected in series across a 6.0 V supply of negligible internal resistance as shown in Fig. 11.2. The output p.d. of the circuit is measured across the stretched resistor **B**.
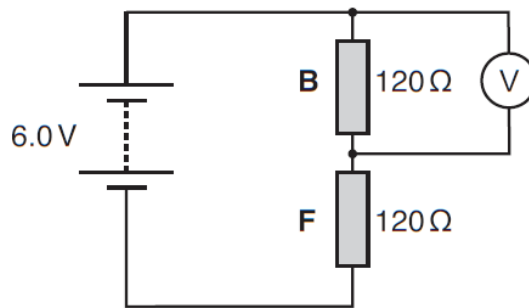
Fig. 11.2

(i) Calculate the current in the two series resistors when the plate **P** is flat.

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

(ii) A pressure difference now curves plate **P** as shown in Fig. 11.1. When the plate **P** curves, the p.d. across resistor **B** increases, but the current calculated in **(i)** remains the same.

Explain how both these effects can occur.

[3]

(b) Fig. 11.3 shows the calibration graph for the pressure sensor.
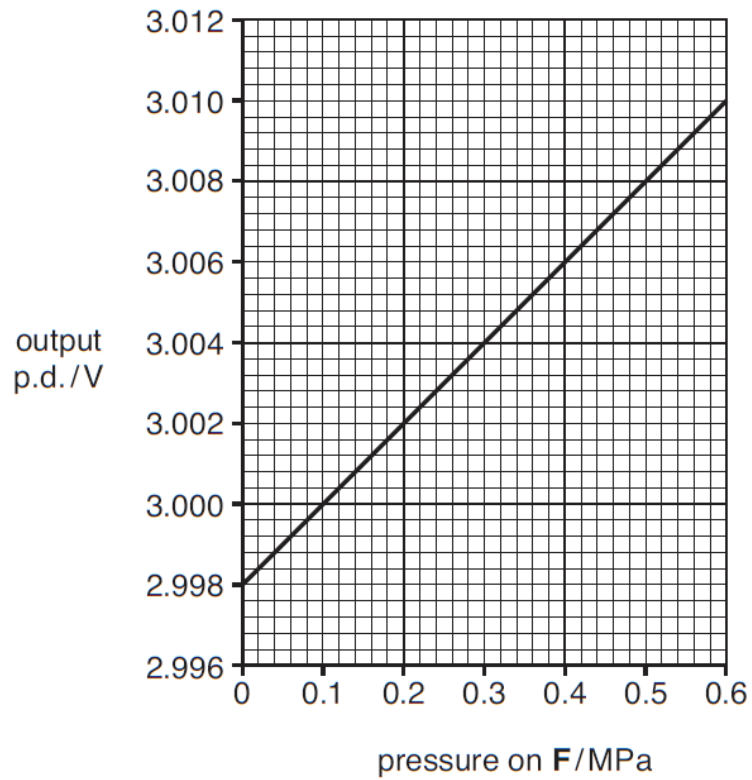
Fig. 11.3

(i) Use data from Fig. 11.3 to calculate the sensitivity of the pressure sensor.

sensitivity = ... V MPa^{-1} **[2]**

(ii) A multimeter is used to measure the output p.d. of the circuit in Fig. 11.2. The meter can record the p.d. to the nearest 1 mV.

Calculate the pressure resolution of this pressure sensor.
Make your method clear.

resolution = ... Pa **[2]**

(iii) Explain how there can be a systematic error of pressure measurement if the two resistors are not at the same temperature.

[2]

(c) The resolution of the sensor can be improved using the modified circuit shown in Fig. 11.4.
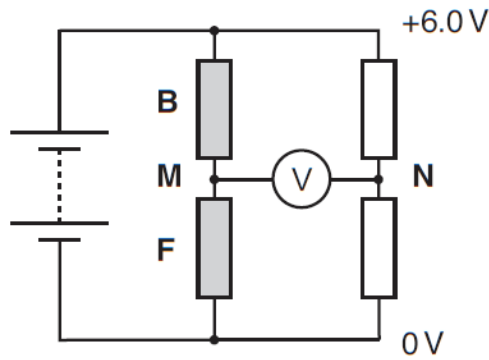
Fig. 11.4

A second pair of resistors, each having a fixed value of 120 Ω is added in parallel with **B** and **F**. The multimeter is now connected between points **M** and **N** as shown.

(i) All four resistors have the exact value 120 Ω when there is no pressure difference across plate **P**.

By considering the voltage at points **M** and **N**, explain why the p.d. across the input of the multimeter is zero when all four resistances are equal.

[1]

(ii) The multimeter can now be used on a more sensitive scale measuring to the nearest 0.01 mV.

State the improved resolution of the pressure sensor using the multimeter in this new arrangement.

pressure resolution = ... Pa **[1]**

1   Here is a list of electrical units.

                    A   **S**   **V**   **Ω**   **W**

State which of these units is correct for each of the following combinations of quantities:

(a) $\dfrac{\text{charge}}{\text{time}}$ ....

(b) $\dfrac{\text{energy}}{\text{charge}}$ ....

(c) $\dfrac{\text{current}}{\text{voltage}}$ ....   [3]

2   A student sets up a potential divider circuit with two 100Ω resistors, intending to halve a potential difference of 10V as shown in Fig. 2.1.
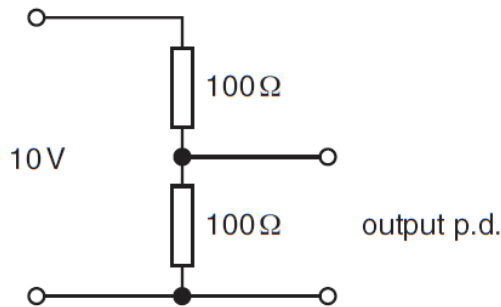
Fig. 2.1

The resistors are manufactured to a tolerance of ± 5%.

(a) State the smallest and largest possible values of each of the resistors that could be found within this tolerance.

   smallest .... Ω   largest .... Ω   [1]

(b) Calculate the smallest possible output p.d. from the circuit in Fig. 2.1.

   Make your method clear.

                                    output p.d. = ... V   [2]

11 Fig. 11.1 shows the variation of p.d. against current for two circuit components **X** and **Y**. **X** is a variable resistor set to its maximum value, **Y** is a filament lamp.

Fig. 11.1

(a) (i) Calculate the resistance of resistor **X** at this setting.

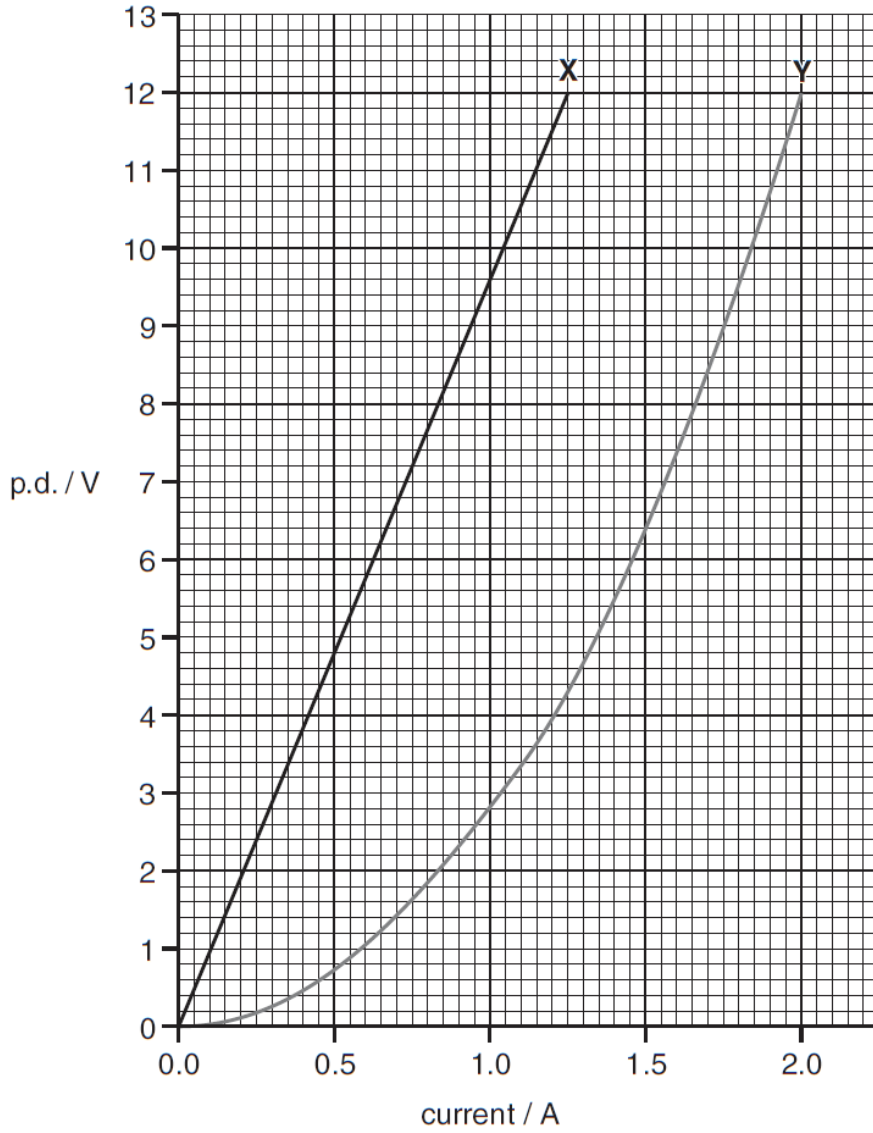resistance of **X** = ... Ω **[1]**

(ii) Describe how the graph indicates that **Y** is a filament lamp.

[1]

(b) The variable resistor **X** is used to control the power dissipated in lamp **Y**, as shown in Fig. 11.2. The power supply is 12V and has negligible internal resistance.
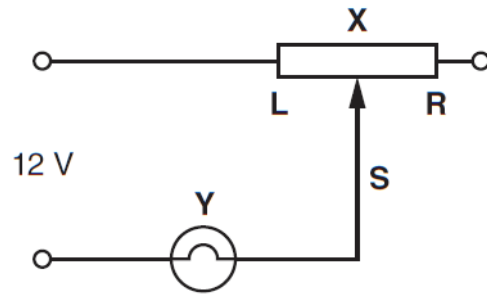
Fig. 11.2

(i) Explain how the variable resistor **X** controls the power dissipated in lamp **Y**.

[2]

(ii) Complete the following table showing the current in the circuit and the power dissipated in lamp **Y** for the positions of the variable contact **S** labelled in Fig. 11.2. You will need to use data from Fig. 11.1 to calculate the values, one value has been inserted already.

position of **S** on **X**	current / A	power in **Y** / W
at **L**		
at **R**	0.90	

[3]

(c) Another way of controlling the power dissipated in lamp **Y** is to use the variable resistor **X** as a potential divider as shown in Fig. 11.3.

Fig. 11.3

Explain clearly **one** advantage of this potential divider circuit compared to the series resistor circuit of Fig. 11.2.

[2]

4 A battery has an emf ε of 3.0 V and an internal resistance r of 0.38 Ω.

$I = 0.45$ A

$\varepsilon = 3.0$ V

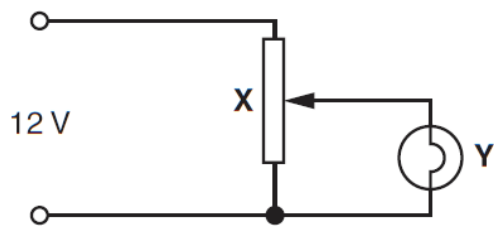$r = 0.38$ Ω

R
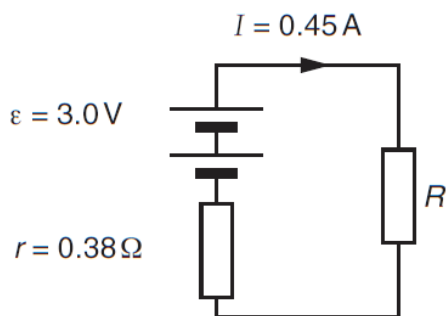
Fig. 4.1

(a) Here are five suggested statements about electro-motive force (emf).

Draw rings around **A**, **B**, **C**, **D** or **E** to indicate which **two** statements are correct.

A   It is the maximum current the battery can produce.

B   It is the maximum p.d. the battery can produce when the current delivered is negligible.

C   It is the maximum power the battery can deliver.

D   It is the force per unit charge acting on electrons that pass through the battery.

E   It is the energy transferred per unit charge by the battery to the electrons in the circuit.
[2]

(b) The battery delivers a current I of 0.45 A into a resistor R as shown in Fig. 4.1.

(i) Show that the p.d. across the resistor R is about 2.8 V.

[2]

(ii) Calculate the resistance of the resistor R.

resistance = ... Ω **[1]**

7 The following measurements of a uniform metal wire are taken so that its resistivity ρ can be calculated.

resistance $R = 118.3 \pm 0.1\,\Omega$

length $L = 2.500 \pm 0.002\,\text{m}$

diameter $D = 0.25 \pm 0.01\,\text{mm}$

The equation used to calculate the resistivity is: $\qquad \rho = \dfrac{\pi D^2 R}{4 L}$

(a) State which measurement has the greatest effect on the uncertainty in the calculated value of ρ.

measurement .... **[1]**

(b) Give a reason for your choice in **(a)**.

[1]

9 A thermistor is to be used as a temperature sensor. It is connected in series with a fixed resistor in a potential divider circuit as shown in Fig. 9.1.

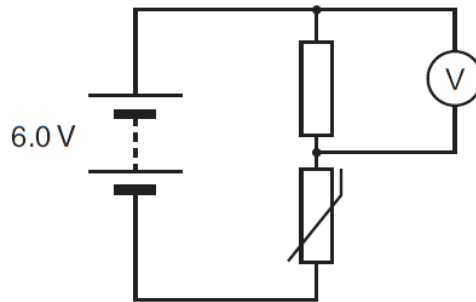**Fig. 9.1**

(a) (i) Explain why the circuit can be described as a potential divider.

[1]

(ii) The resistance of the thermistor decreases as the temperature rises.

Explain why the p.d. measured by the voltmeter across the fixed resistor increases as the temperature of the thermistor rises.

You should ensure that your spelling, punctuation and grammar are accurate.

[3]

(b) Fig. 9.2 shows how the p.d. across the fixed resistor changes with temperature in the temperature sensor circuit of Fig. 9.1.
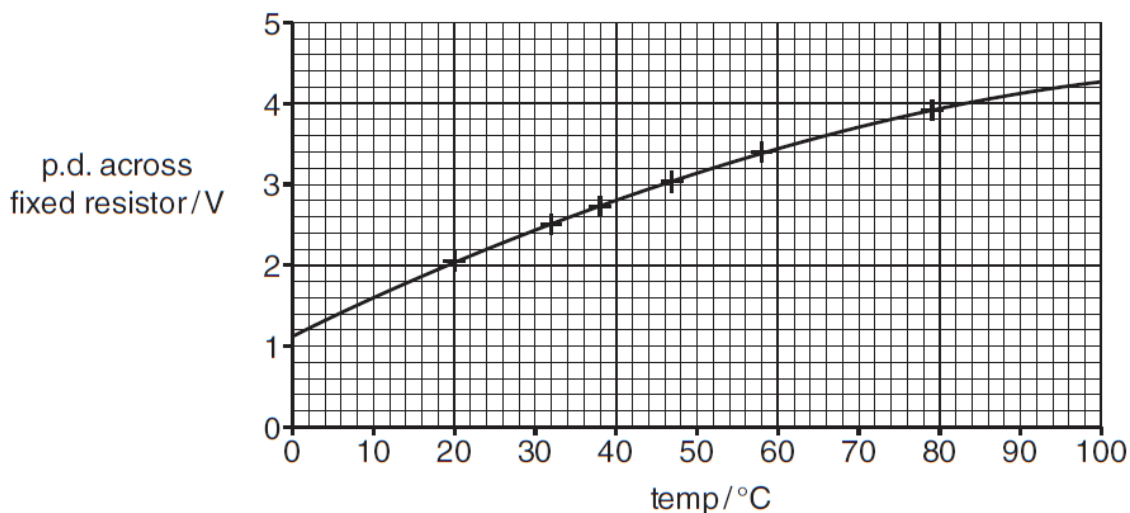
Fig. 9.2

(i) Describe how the sensitivity of the sensor changes as the temperature changes.

....

....

[1]

(ii) Estimate the sensitivity of the sensor at 70 °C. Make your method clear.

sensitivity = ... V °C⁻¹ **[3]**

(iii) The resistance of the thermistor at 70 °C is 800 Ω.

The p.d. across the potential divider is 6.0V.

Use data from Fig. 9.2 to calculate the resistance of the fixed resistor.

resistance = ... Ω **[3]**

11 This question is about electrical light fittings and plugs and the materials used in their construction.

(a) (i) A 12V halogen lamp is rated at 25W.

Calculate the operating current for the lamp.

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

(ii) Calculate the conductance of the lamp.

conductance = ... S **[1]**

(b) Explain in terms of their microscopic structure why metals are good electrical conductors.

Your answer should be clear and well structured.

[3]

1   Here is a list of electrical units.

$$As \qquad Cs^{-1} \qquad Js^{-1} \qquad JC^{-1} \qquad AV^{-1}$$

Choose the correct unit from this list for

(a) electric charge   ....

(b) potential difference   ....

(c) conductance.   ....

[3]

6   Three resistors are connected as shown in Fig. 6.1.
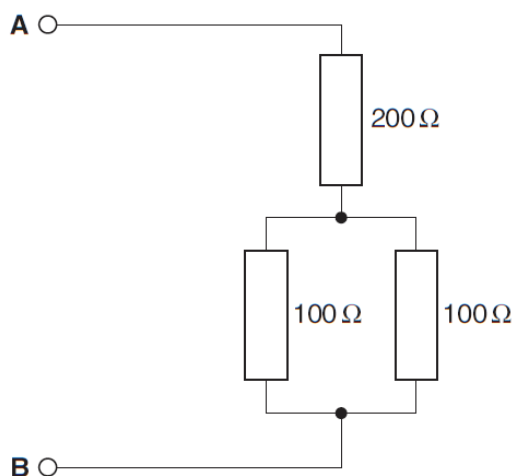
Fig. 6.1

(a) Here are four possible values for the total resistance between points **A** and **B**.

$$250\,\Omega \qquad 300\,\Omega \qquad 350\,\Omega \qquad 400\,\Omega$$

Put a ⟨ring⟩ around the correct answer.   [1]

(b) A 12V battery of negligible internal resistance is connected between **A** and **B**.

Calculate the current drawn from the battery.

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

1   Here is a list of electrical units:

   A s   **A V^{-1}**   **C s^{-1}**   **J s^{-1}**   **J C^{-1}**

   Choose the unit for

   (a) electrical power   ……………………..

   (b) electric charge   ……………………..

   (c) conductance   ……………………..   **[3]**

2   Three temperature sensors **A**, **B** and **C** were plunged into hot water at the same moment, time
     $t = 0$. The graph below shows their responses.
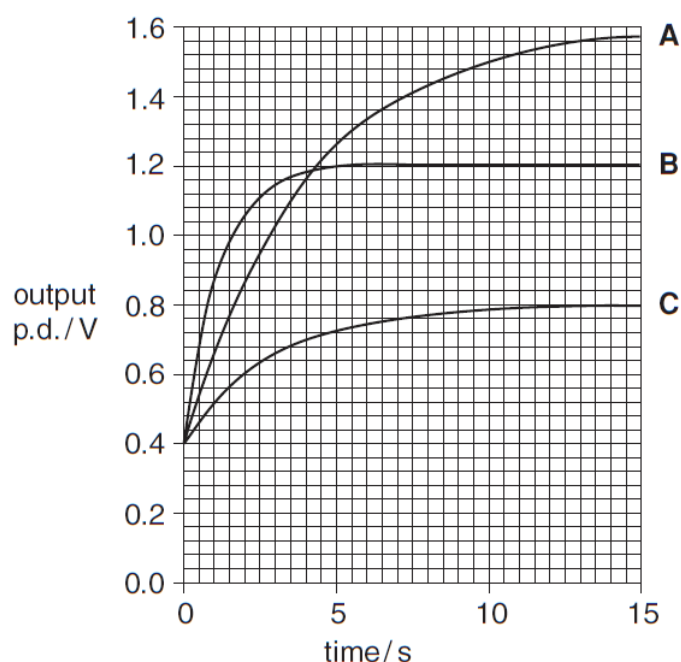
   (a) State the sensor with the **shortest** response time.   ………………………………………….**[1]**

   (b) Estimate the response time of sensor **B**.

                                          response time = ………………………………………… s **[1]**

   (c) The temperature rise of each sensor was 75 °C.

        Calculate the average sensitivity of sensor **B** in this temperature range.
        Make your method clear and give the units of sensitivity.

                                          sensitivity = ……………….. unit ……………….. **[3]**

7 The graph shows the characteristics of 3 different electrical conductors **A**, **B** and **C**.
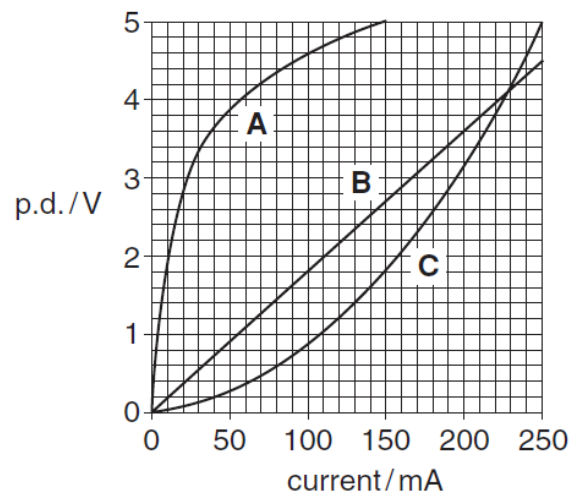
(a) State which conductor obeys Ohm's Law. .... [1]

(b) State which graph shows decreasing resistance at higher current. .... [1]

9 Fig. 9.1 shows a cell with an emf ε of 1.55 V and an internal resistance r of 0.40 Ω. The cell delivers a current I of 250 mA into a constant load resistance R of 5.8 Ω.
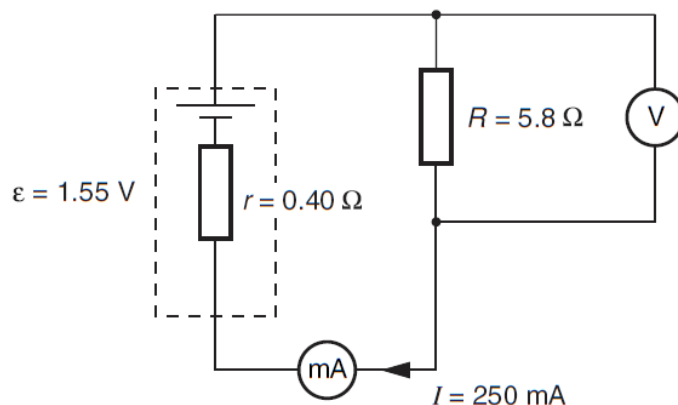
Fig. 9.1

(a) (i) Calculate the p.d. across the load resistance R.

p.d. = ... V **[2]**

(ii) Explain why the p.d. across the load resistance is less than the emf of the cell.

[1]

(b) The cell is left connected to the 5.8 Ω load resistance for several hours.
Fig. 9.2 shows how the current from the cell varies with time.

Fig. 9.2

(i) Describe how the current varies with time.

....

....

[2]

(ii) Suggest reasons why the current varies with time in this way.

....
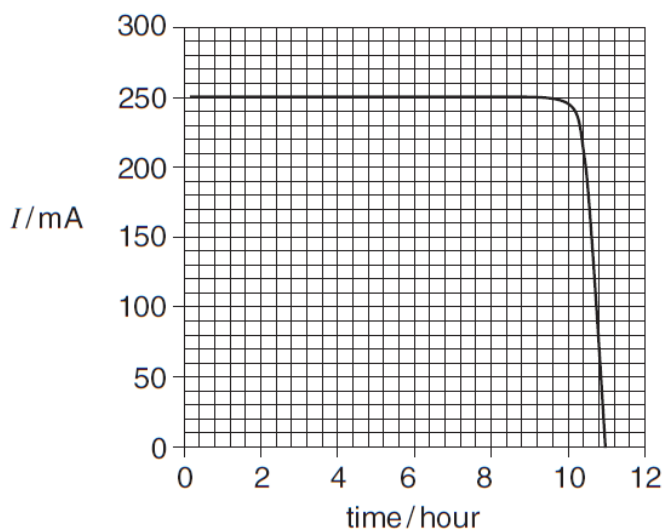
....

....

....

[2]

(iii) Use Fig. 9.2 to estimate the total charge delivered by the cell.

Make your method clear.

charge = ... C **[3]**

10 A red LED starts conducting when the p.d. across it is greater than 1.6 V.
Fig. 10.1 shows the circuit used to run the LED from a 9.0V battery of negligible internal resistance.
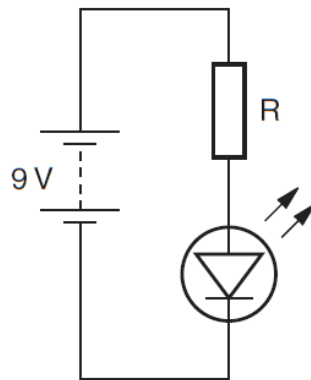

Fig. 10.1

(a) **(i)** State the purpose of the resistor R in this circuit.

[1]

(ii) When operating at its normal current of 25 mA the p.d. across the LED is 2.1 V.

Calculate the value of the resistor R for operation of the LED at 25 mA from the 9.0V battery. Make your method clear.

resistance = ... Ω **[2]**

(iii) Calculate the power dissipated in the resistor R in this circuit.

power = ... W **[2]**

(b) Fig. 10.2 shows how the p.d. across LEDs varies with current for a red and a green LED.

key:

--------- green LED

————— red LED
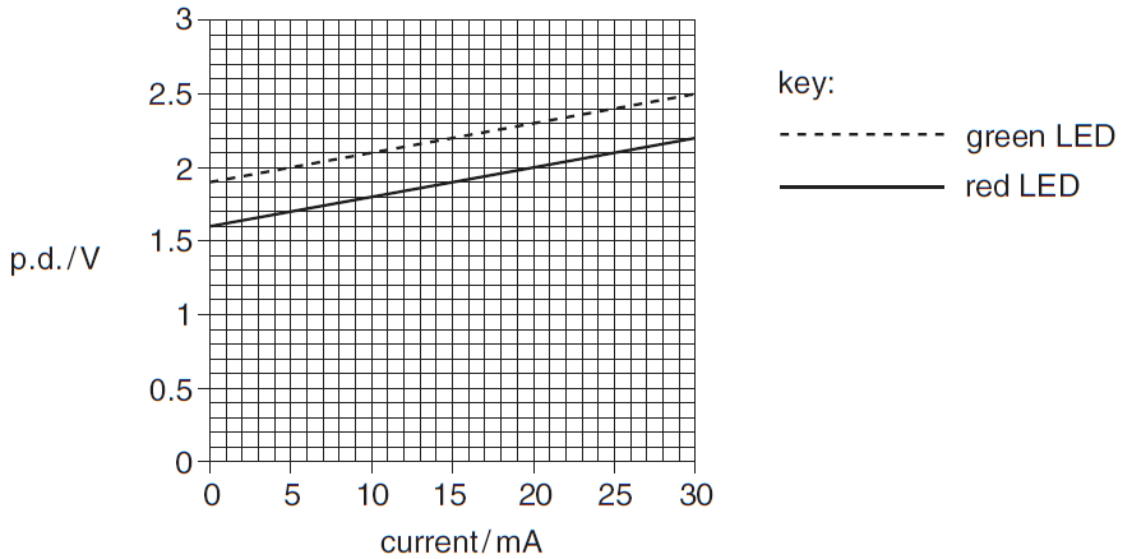
Fig. 10.2

(i) Describe a difference shown in the graphs between the behaviour of the red and green LEDs.

....

.... **[1]**

(ii) A red and a green LED are connected in parallel with a suitable series resistor to a supply of variable p.d. as in Fig. 10.3.
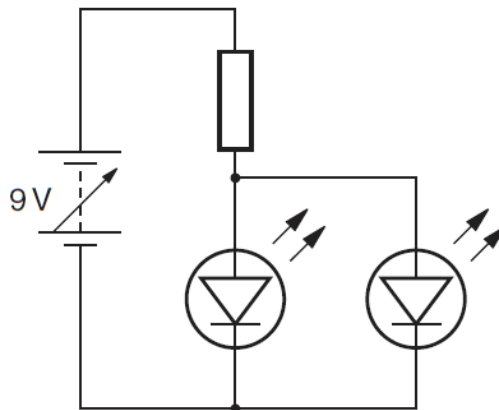

Fig. 10.3

State and explain what happens in the circuit when the p.d. across the diodes is gradually increased from 0 V to over 2.1 V.

....

.... **[2]**

(iii) The output of the variable supply is set to 7.0V.
This makes a p.d. of 2.0 V across both LEDs. Use data from Fig. 10.2 to find the total conductance of the circuit at this setting.

Assume the variable supply has negligible internal resistance.

conductance = ... S **[2]**

1 Here is a list of four units for physical quantities.

$$C\,s \qquad C\,s^{-1} \qquad J\,s^{-1} \qquad V\,C$$

From the list write down the unit for

(a) power ....

(b) current. ....

[2]

5   Fig. 5.1 shows graphs of current against p.d. for a semiconductor diode maintained at three different temperatures: 100 °C, 25 °C and −40 °C.
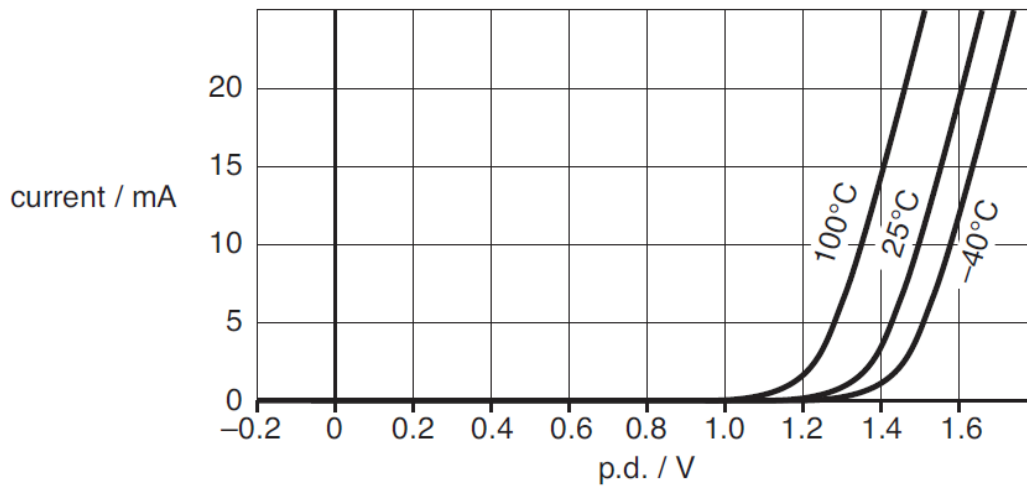

Fig. 5.1

(a) Describe **two** features of the graph for the diode at 25 °C.

1.

2.

[2]

(b) Describe how the graphs vary with increasing temperature.

[1]

6 A battery in a digital camera is supplying a constant current of 0.29 A.

(a) Calculate the charge supplied during 5 seconds.

charge = ... C **[1]**

(b) Calculate the number of electrons that flow from the negative terminal of the battery in this time.

Show your reasoning clearly.

$e = 1.6 \times 10^{-19} C$

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

8 Fig. 8.1 shows a graph of how the resistance R of a light dependent resistor (LDR) varies with light intensity, up to a value of 2000 lux.
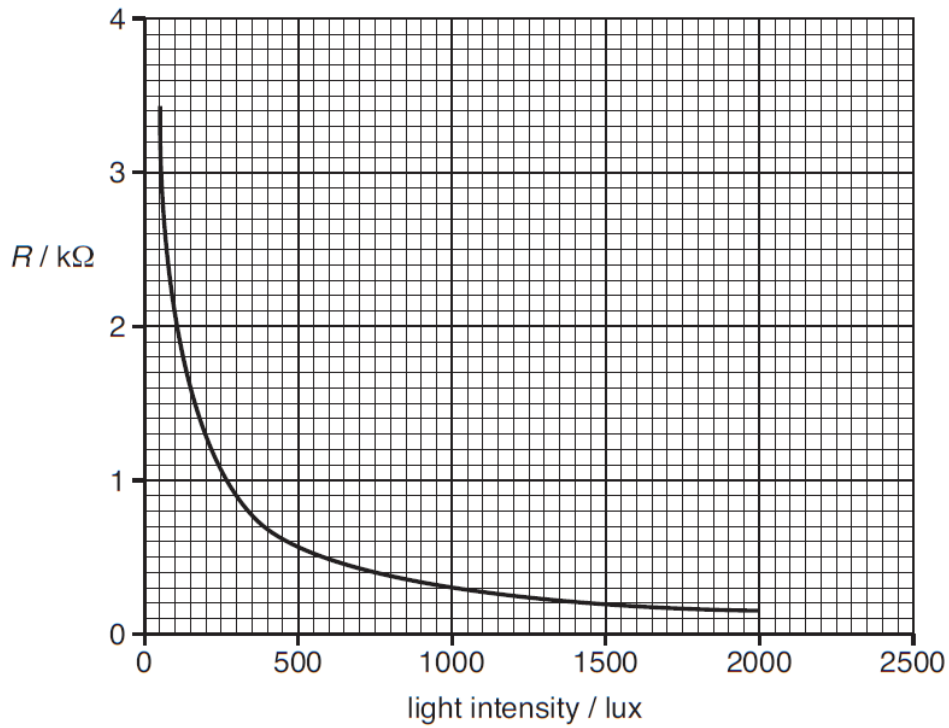

Fig. 8.1

(a) (i) Use the graph to find the resistance of the LDR at light intensities of

    1   500 lux   resistance of LDR = ... Ω

    2   2500 lux.   resistance of LDR = ... Ω **[1]**

   (ii) State which of the two values that you have recorded in **(a)(i)** you have more confidence in. Give reasons for your decision.

[2]

(b) The LDR is to be used (as a light sensor) as one component of a potential divider in a circuit with three further components:

- fixed resistor
- 6.0 V battery
- voltmeter to measure the output p.d.

The circuit is to be constructed so that the output p.d. **increases** as the light intensity on the LDR increases.

Draw the circuit diagram.

[3]

(c) It is required that the output p.d. of the circuit should be 1.6 V at a light intensity of 500 lux.

Calculate the value of the fixed resistor to achieve this. Make your method clear.

resistance = ... Ω [3]

9 Fig. 9.1 shows a graph of p.d. against current for a 12V filament lamp.

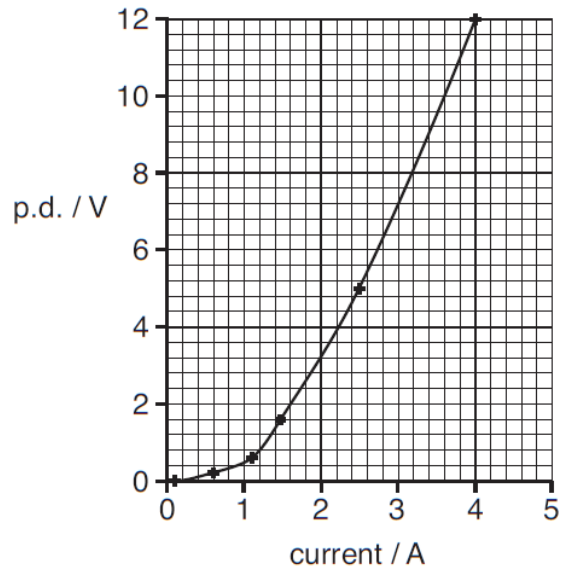**Fig. 9.1**

(a) Calculate the power of the lamp when operating at 6.0V.

Show clearly how you obtain your answer.

power = ... W **[2]**

(b) Fig. 9.2 shows the data table for the graph of Fig. 9.1.

current/A	p.d./V	R/Ω
0.10	0.03	0.30
0.60	0.21	
1.05	0.65	
1.45	1.58	1.09
2.54	4.98	1.96
4.01	12.00	2.99

Fig. 9.2

(i) Complete the third column of Fig. 9.2 for the resistance R of the filament. **[1]**

(ii) Complete the graph in Fig. 9.3 of the filament resistance against current by plotting the two missing resistance values **and** drawing the curve of best fit. **[2]**
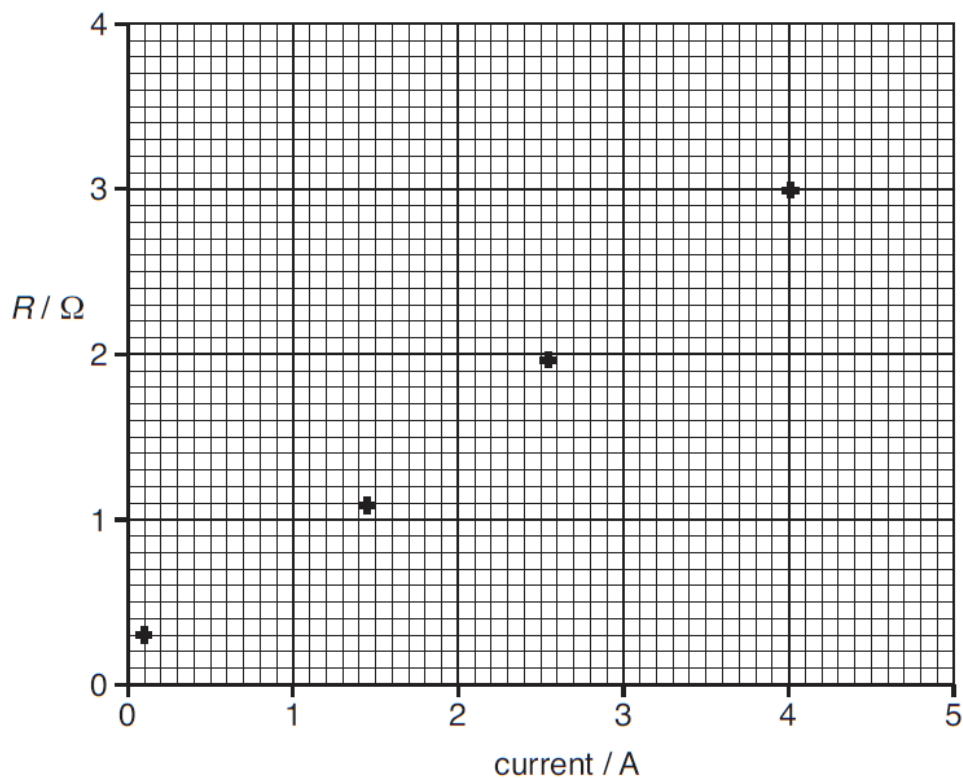

Fig. 9.3

(iii) Use the graph in Fig. 9.3 to explain how the conductivity of the filament material changes with temperature.

[2]

(c) Fig. 9.4 shows the current in the same filament lamp plotted against time, as recorded by a data-logger. The lamp is connected to a source of emf 12 V at time 0.05 s.
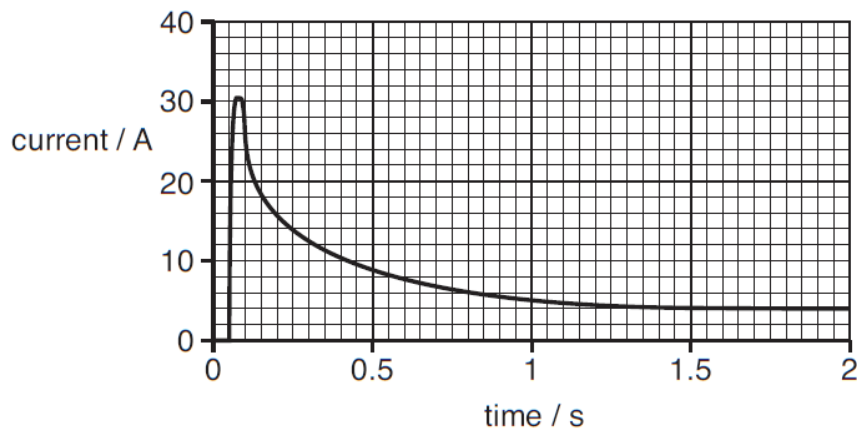

Fig. 9.4

(i) Show that the data in the table of Fig. 9.2 indicate that the initial current could be as high as 40 A, when first connected to a source of emf 12 V.

[1]

(ii) Suggest a reason why it only reaches about 30 A as shown in Fig. 9.4.

[1]

(iii) Give an explanation for **one other** quantitative feature of the graph after the peak current.

[1]

1 Here is a list of electrical units.

<div align="center">

C   **S**   **V**   **Ω**   **W**

</div>

State which of these units is correct for each of the following combinations of quantities:

$\dfrac{\text{voltage}}{\text{current}}$ ....

$\dfrac{\text{energy}}{\text{time}}$ ....

current × time   ....   **[3]**

10 This question is about a copper conducting bar which must carry a large current from a generator to a transformer in a power station.

(a) The bar loses 2.0 kW of power P to the surroundings when it carries a current I of 8 000 A.

   (i) Using $P = I^2 R$, show that the resistance R of the bar must be about $3 \times 10^{-5}\,\Omega$.

[2]

   (ii) Calculate the p.d. across the length of the bar.

p.d. = ... V [2]

(b) **(i)** Using $G = \sigma A / L$, show that the uniform cross-sectional area A of a conductor of length L, of material of conductivity σ and resistance R is given by the equation

$$A = \frac{L}{\sigma R}.$$

[2]

   (ii) The bar in **(a)** is 10 m long.
   Calculate its cross-sectional area.

   conductivity of copper $= 5.9 \times 10^7\,\text{Sm}^{-1}$

cross-sectional area = ... m^2 [2]

11 Fig. 11.1 shows how the emf ε across a temperature sensor depends on temperature.
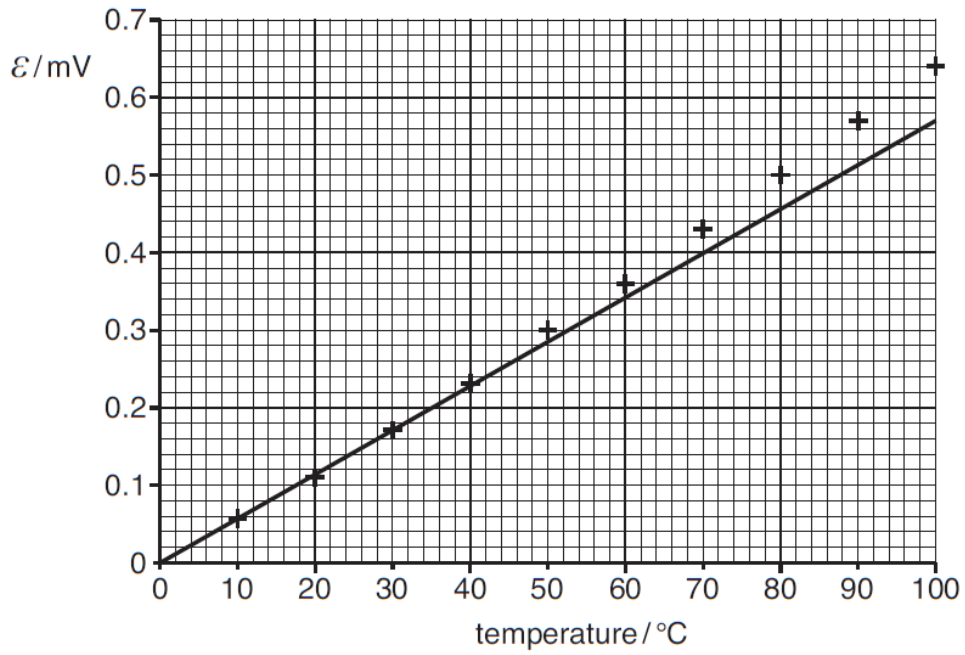

Fig. 11.1

(a) (i) A straight line that fits the data **up to 40 °C** has been added to the graph. Describe the relationship between the emf ε and the temperature in the range 0°C to 100°C shown by **all** the data in Fig. 11.1.

[2]

(ii) Estimate the **sensitivity** of the temperature sensor in the range 0°C to 40°C. Make your method of estimating the sensitivity clear.

sensitivity = ... V°C^{-1} **[2]**

(b) Fig. 11.2 shows the circuit diagram of the temperature sensor connected to an external resistance **R**.
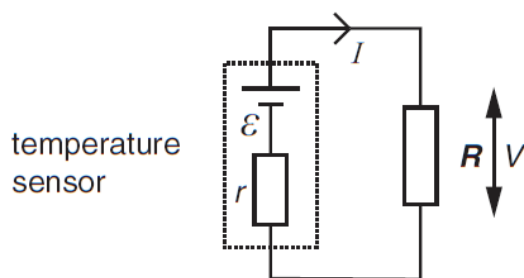

Fig. 11.2

The sensor behaves like a supply of variable emf $\mathcal{E}$ and constant internal resistance r.

(i) Explain why this circuit can be described as a potential divider circuit.

[1]

(ii) The p.d. V across the sensor, and the current I in the circuit are given by the equations:

$$V = \mathcal{E} - I r \qquad \text{and} \qquad I = \frac{\mathcal{E}}{(R + r)}$$

Combine the equations to show that $V = \dfrac{\mathcal{E} R}{(R + r)}$.

[2]

(iii) The resistor **R** is replaced by a meter to measure the p.d. across the sensor. This meter has a resistance R of $15\,\Omega$.

Use the equation $V = \dfrac{\mathcal{E}\,R}{(R + r)}$ to show that the meter will display a voltage about 2% lower than the true emf $\mathcal{E}$.

internal resistance of sensor $r = 0.30\,\Omega$

[2]

(c) The meter used to measure the p.d. across the temperature sensor in **(b)(iii)** is the **moving coil galvanometer**, listed in the table below. Two other instruments which can be used to measure voltage are also shown.

instrument	full scale deflection (maximum reading)	sensitivity
moving coil galvanometer	300 mm	$10\,\mu\text{V mm}^{-1}$
cathode ray oscilloscope	100 mm	$1.0\,\text{mV mm}^{-1}$
digital voltmeter	$200.0\,\mu\text{V}$	$0.1\,\mu\text{V}$ steps

Give **one** reason why each of these other instruments is **not** suitable.
Use data from the table **and** the graph of Fig. 11.1.

not the cathode ray oscilloscope because:

not the digital voltmeter because:

[2]

1 The two columns below list the usual units of four electrical quantities and a set of equivalent alternative units.

units
A
V
W
Ω

equivalents
J s^{-1}
V A^{-1}
C s^{-1}
J C^{-1}

Draw a straight line from each **unit** box to the corresponding **equivalent** box. **[3]**

3 Two resistors are connected in series to a 6.0V supply of negligible internal resistance as shown in Fig. 3.1.
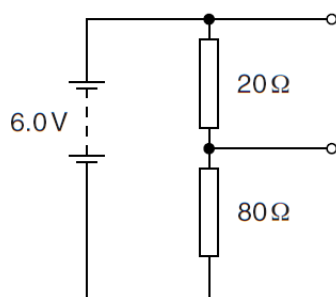

Fig. 3.1

(a) Show that the p.d. across the 20Ω resistor is greater than 1V.

[2]

(b) Calculate the power dissipated in the 20Ω resistor.

power = ... W **[2]**

4 A resistance thermometer uses changes in resistance with temperature to measure temperature. Fig. 4.1 is the calibration graph of its resistance against temperature.
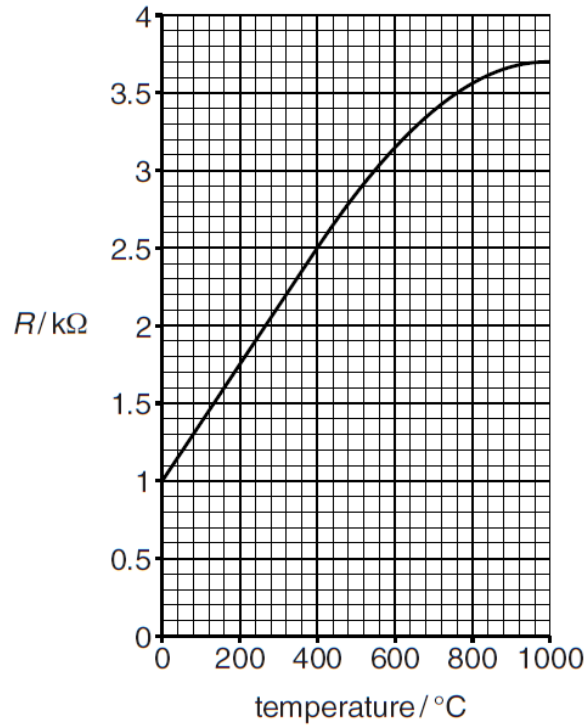
Fig. 4.1

(a) Calculate the sensitivity of the thermometer at 200 °C.

sensitivity = ... $\Omega\,°C^{-1}$ **[2]**

(b) Describe what happens to the sensitivity of the thermometer as the temperature increases from 0 °C to 1000 °C.

[2]

9 One method of calibrating a voltmeter is to measure the known p.d. across a standard cell. A standard cell is one whose emf is stable and accurately known.

One such standard cell has an emf ε of 1.019 V at room temperature.

(a) State the number of significant figures in this emf value.

number of significant figures = ... **[1]**

(b) The uncertainty in the emf is given as 1.019 ± 0.001 V.

Calculate the % uncertainty implied by this data.

% uncertainty = ... % **[1]**

(c) The p.d. across the cell may change if the current exceeds 2.8 µA or if more than 10 µC of charge are drawn in any measurement.
The internal resistance of the standard cell is 350 Ω.

(i) In a particular voltmeter calibration by a student the current drawn is 1.1 µA.

Show that the maximum time the student has to complete the measurement is less than 10 s.

[2]

(ii) Calculate the resistance of the voltmeter being calibrated.

Make your method clear.

resistance of voltmeter = ... Ω **[3]**

(iii) Calculate the voltage drop across the internal resistance of the standard cell during the calibration.

voltage drop = ... V **[2]**

(d) Suggest and explain a problem that would arise in an attempt to calibrate a voltmeter of much lower internal resistance using this standard cell.

[2]

June 2013

1   Fig. 1.1 shows the *I-V* characteristics for three electric circuit components:

a fixed resistor **R**

a filament lamp **L**

a light emitting diode (LED) **D**.

....

Fig. 1.1

Write the correct component labels **R**, **L** or **D** on the line under each graph.   **[2]**

5   A rechargeable battery for a toy helicopter delivers a charge of 2900 C at a p.d. of 3.7 V.

(a) Calculate the energy delivered by the battery.

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

(b) The energy is delivered in 9.0 minutes.

Calculate the mean power output of the battery.

power = ... W **[2]**

6 **(a)** A circuit of total conductance 45 mS is connected to a 3.0 V battery of negligible internal resistance.

Calculate the current in the circuit.

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

(b) Three conductors are connected as shown in Fig. 6.1.
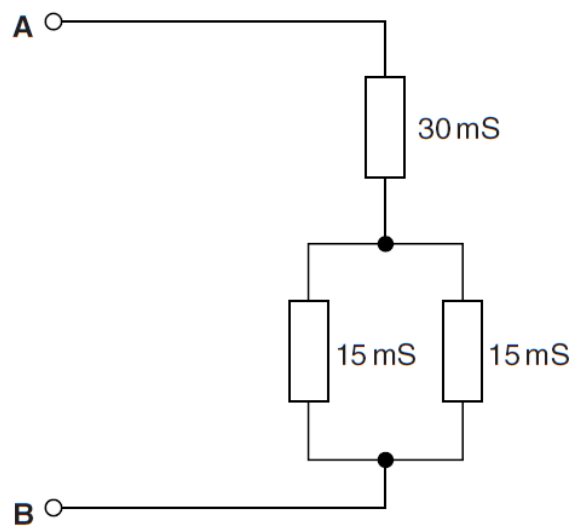Their conductance values are shown on the diagram.

Fig. 6.1

Here are four possible values for the total conductance between points **A** and **B**.

15 mS   30 mS   37.5 mS   60 mS

Put a (ring) around the correct answer. **[1]**

5   An electron beam carries a current of 8.0pA.

Calculate how many electrons pass a point in the beam per second.

$e = 1.6 \times 10^{-19}\,C$

electrons per second = ... s^{-1} **[2]**

6   A resistor has a resistance of 4.7 Ω and a maximum operating voltage of 12V.

(a) Calculate the maximum power that the resistor can dissipate.

power = ... W **[2]**

(b) The resistor is made of a wire of resistivity 4.5 × 10^{-7} Ω m.

The cross-sectional area of the wire is 1.8 × 10^{-8} m^2.

Calculate the length of wire needed to make the 4.7 Ω resistor.

length = ... m **[2]**

8 This question is about a light dependent resistor (LDR) in a light sensing circuit.

(a) (i) An LDR and a fixed resistor R are connected as a potential divider to the 6.0V battery shown in Fig. 8.1 to make a sensing circuit.

Draw the potential divider on Fig. 8.1 to complete the circuit.
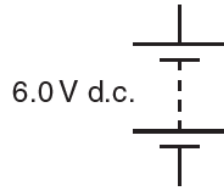Label the components R and LDR on the diagram. **[1]**

6.0 V d.c.

Fig. 8.1

(ii) A voltmeter is to be connected to the circuit to indicate an **increasing** output p.d. when the sensor detects an **increasing** light intensity.

The resistance of the LDR **decreases** when the light intensity incident upon it increases.

Explain clearly why the voltmeter should be connected across the fixed resistor.

Make the steps in your reasoning clear.

[3]

(b) Fig. 8.2 shows how the output p.d. of this sensing circuit varies with the light intensity measured in lux incident upon the LDR.
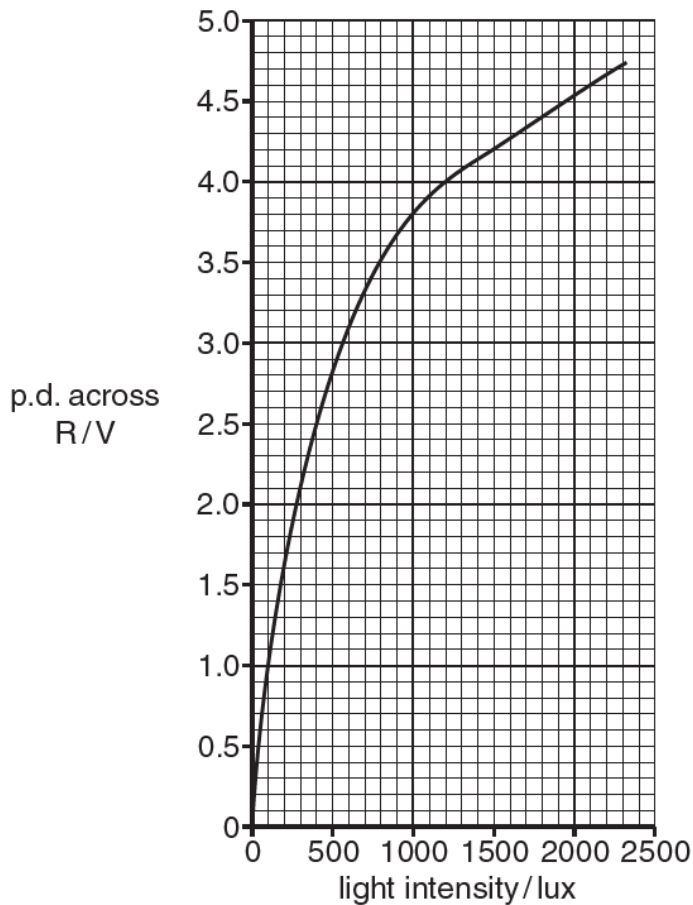

Fig. 8.2

(i) State what you understand by the sensitivity of the sensing circuit.

[1]

(ii) Calculate the sensitivity for the sensor at an intensity of 1000 lux.

You may find it helpful to draw a construction line on Fig. 8.2.

sensitivity = ... V lux^{-1} [3]

(iii) The resistance of the fixed resistor R is 800 Ω.

The light intensity on the LDR is 1000 lux. Use Fig. 8.2 to find the p.d. across the fixed resistor at this light intensity.

Use this to calculate the resistance of the LDR.

resistance = ... Ω **[4]**

(b) The electrical properties of graphene are unusual. Within the layer it conducts like a metal, but perpendicular to the layer it conducts like a semiconductor.

Fig. 9.3 illustrates a conductivity measurement of a square layer of graphene of side 200 nm.
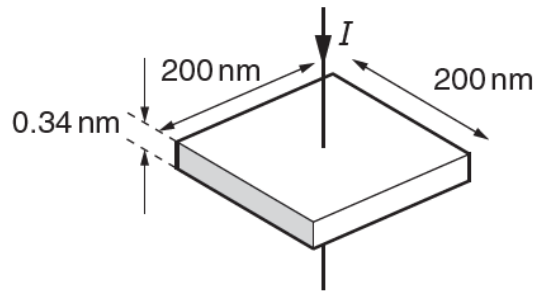

Fig. 9.3

It carries a current of 6.7×10^{-15} A when a p.d. of 0.15 mV is applied across its thickness of 0.34 nm.

Calculate the conductivity of graphene perpendicular to the layer.

conductivity = ... Sm^{-1} **[3]**