# A-Level Physics

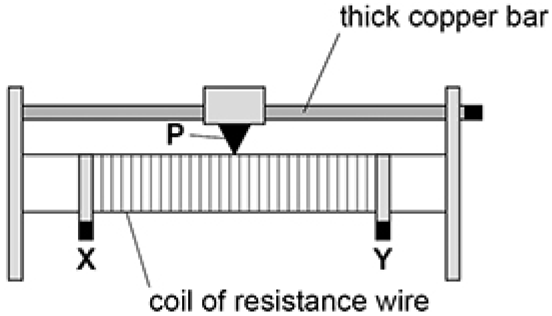
## Potential Dividers

### Question Paper

**Time available: 77 minutes**
**Marks available: 58 marks**

**1.** **Figure 1** shows a variable resistor that has a maximum resistance of 25 Ω.
A sliding contact **P** is mounted on a thick copper bar. **P** can be set to any position between **X** and **Y**.

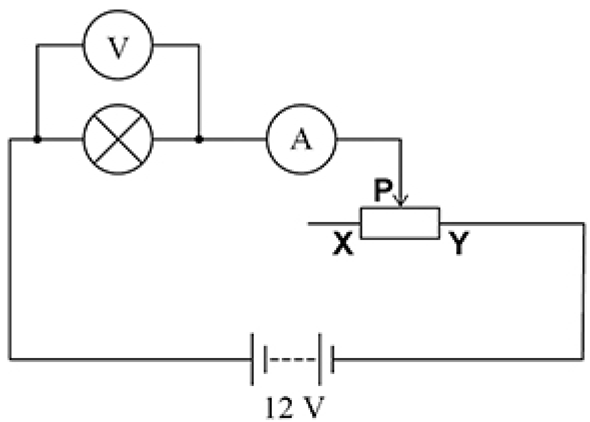
**Figure 1**




(a) **Figure 2** shows the variable resistor being used to investigate the variation of current with voltage for a filament lamp.
The normal operating voltage of the lamp is 12 V.

The 12 V battery has negligible internal resistance.

**Figure 2**




The position of **P** is adjusted so that the reading on the voltmeter is at its minimum value of 0.75 V.

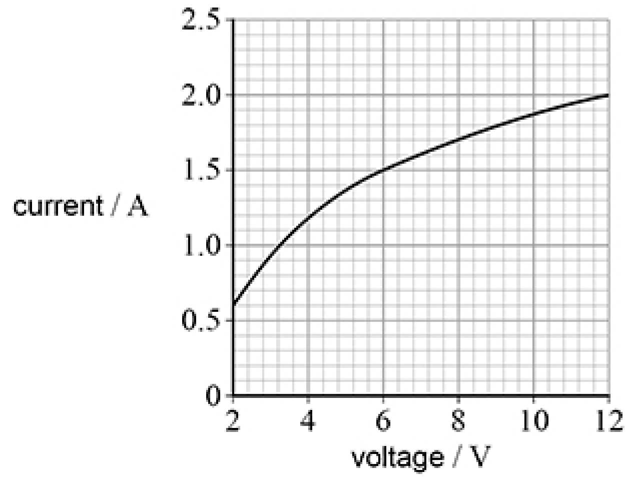
Calculate the resistance of the lamp when the voltmeter reading is 0.75 V.

resistance = _______________ Ω

**(2)**

(b) **Figure 3** shows the variation of current with voltage for the lamp between 2 V and 12 V.

**Figure 3**




Calculate the resistance of the lamp when the voltage across the lamp is 8.0 V.

resistance = _______________ Ω

**(2)**

(c) Explain, in terms of electron movement, why the resistance of the filament lamp changes as the voltage changes as shown in **Figure 3**.

___

___

___

___

___

___

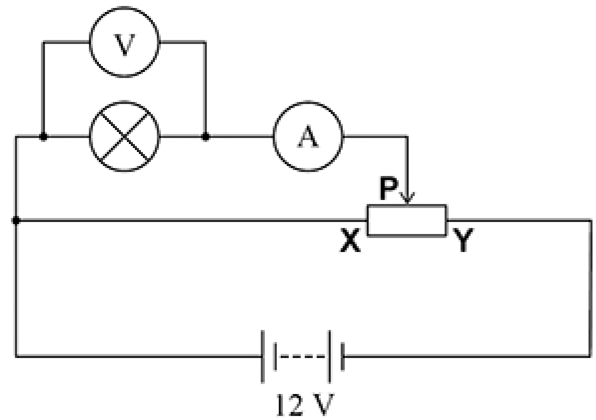
___

___

**(3)**

(d) **Figure 4** shows an alternative circuit used to investigate the variation of current with voltage for the lamp.

**Figure 4**




The circuit components are the same as in **Figure 2**.
When the voltage across the lamp is 12 V its resistance is 6.0 Ω.

**P** is moved to position **Y**.

Calculate the total resistance of the circuit.

total resistance = _______________ Ω

**(2)**

(e) Calculate the power transferred by the battery when **P** is at position **Y**.

power = _______________ W

**(2)**

(f) A student wants to control the brightness of the lamp.

He gives two reasons why the circuit in **Figure 4** is better than the circuit in **Figure 2** for controlling the brightness. The two reasons are:

- the **Figure 4** circuit can achieve a greater range of voltages across the lamp
- the **Figure 4** circuit is more efficient at transferring energy to the lamp.

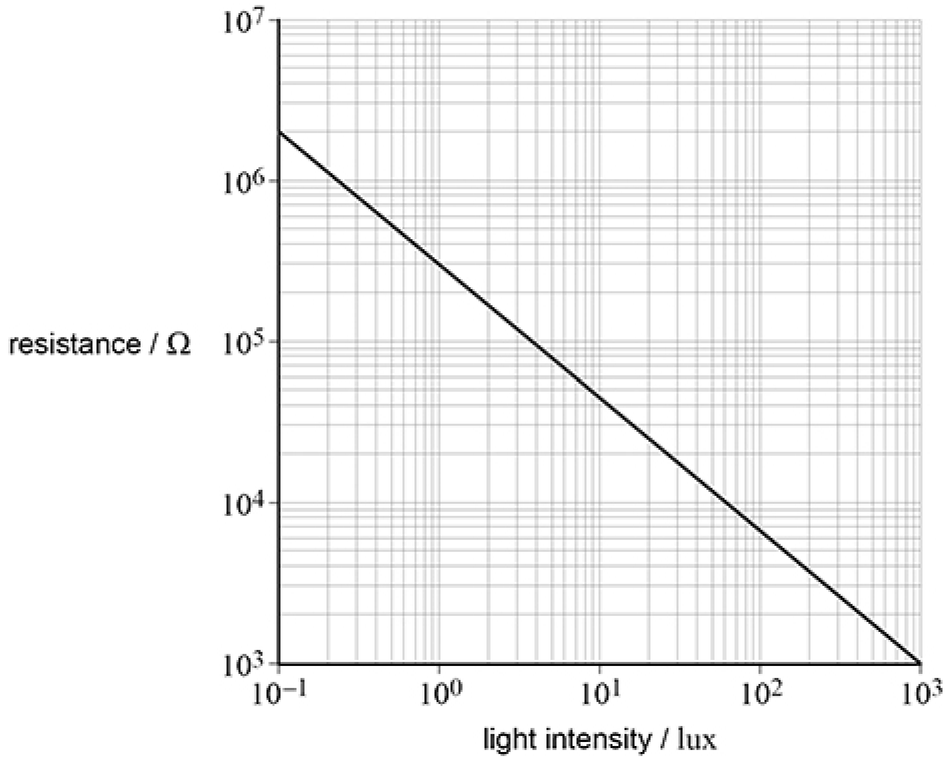
Discuss, without calculation, whether either of these two reasons is correct.

**(3)**

**(Total 14 marks)**

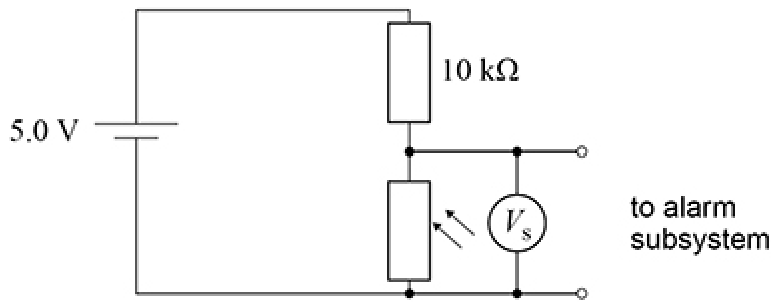
**2.** **Figure 1** shows how the resistance of an LDR varies with light intensity.

**Figure 1**




The LDR is used as part of an alarm system in a dim room. **Figure 2** shows one proposal for a sensor circuit for this system.

**Figure 2**




The power supply to the sensor has an emf of 5.0 V and a negligible internal resistance. A negligible current is drawn from the sensor circuit by the alarm subsystem.

A light beam illuminates the LDR. When the light beam is broken the LDR is not illuminated by the light beam. This causes the alarm to sound.

The table below shows how the light intensity at the LDR changes.

| | **Light intensity / lux** |
|---|---|
| LDR illuminated by light beam | 4.0 |
| LDR **not** illuminated by light beam | 1.0 |

(a) Show that the current in the sensor circuit when the LDR is **not** illuminated by the light beam is approximately 16 μA.

**(2)**

(b) The alarm sounds when the potential difference $V$s across the LDR changes by more than 25% of the power supply emf.

Discuss whether the circuit shown in **Figure 2** is suitable.
Support your answer with a calculation.

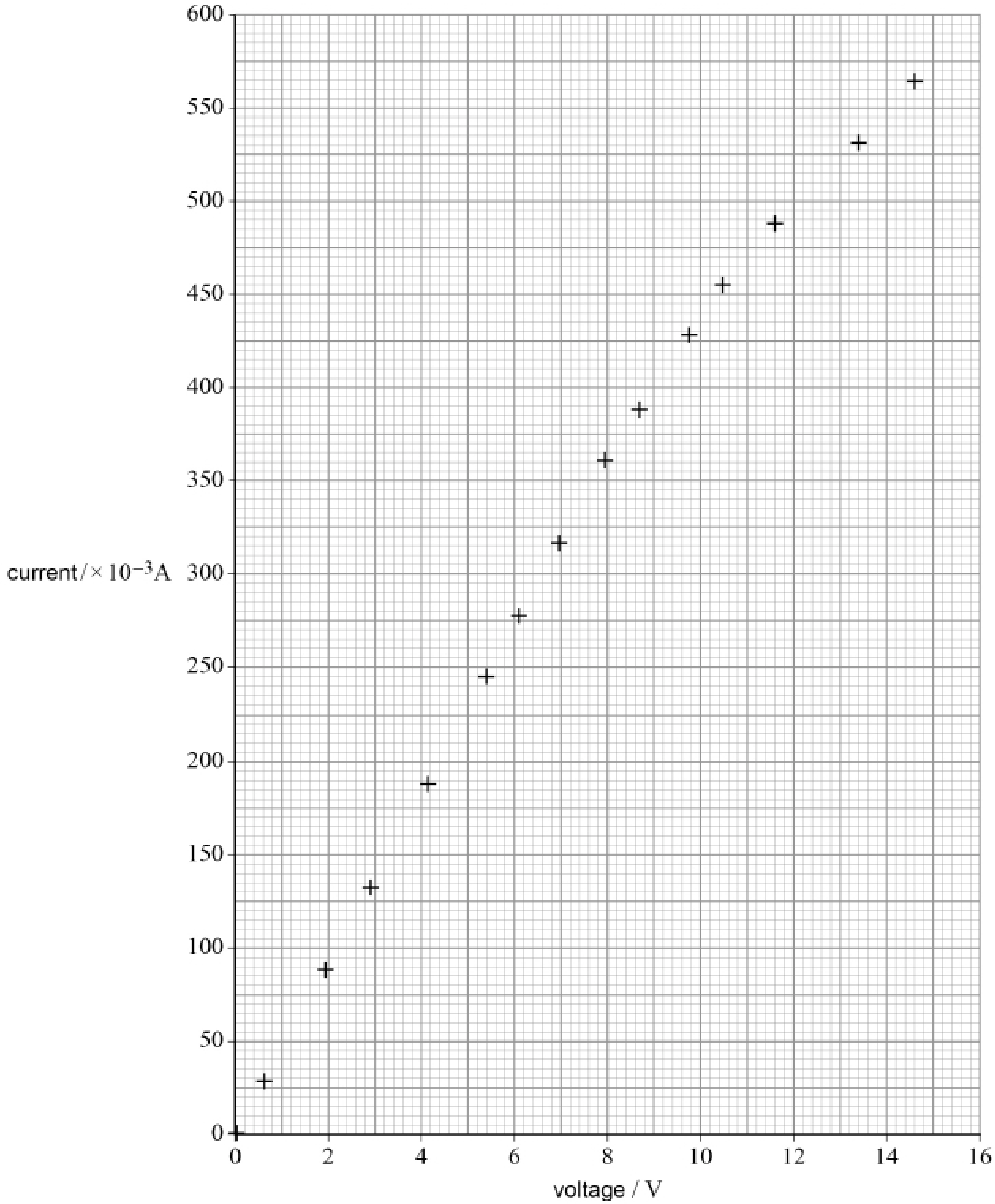
___

___

**(3)**
**(Total 5 marks)**

**3.** This question is about an experiment to obtain current–voltage data for a resistor **R**.
**Figure 1** shows a plot of current–voltage data for **R**.

**Figure 1**




(a) Draw a best-fit line for the data on **Figure 1**.

**(1)**

(b) Identify the data point with the greatest value of current and voltage at which **R** obeys Ohm's law.

Draw a circle around this data point on **Figure 1**.

**(1)**

(c) When **R** obeys Ohm's law it has a resistance of 22.2 Ω.

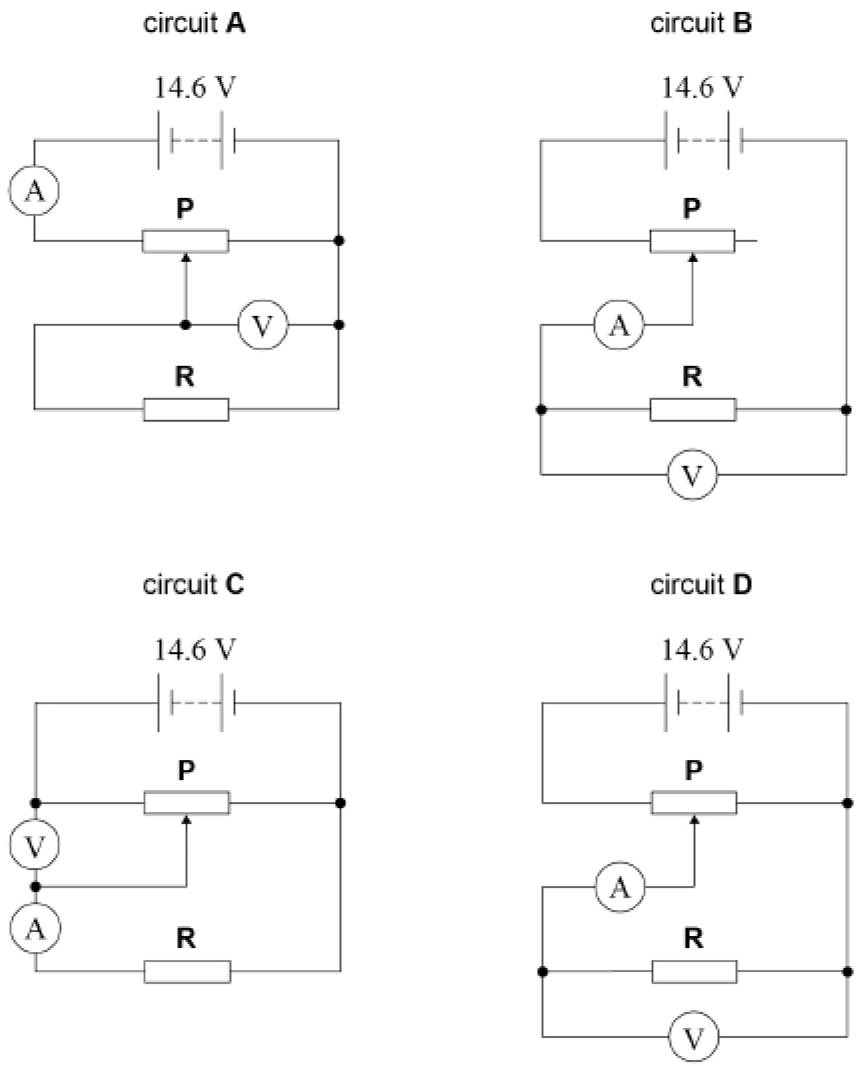
Determine the percentage increase in the resistance of **R** from its 22.2 Ω value to its value when the current is $550 \times 10^{-3}$ A.

percentage increase = ____________________

**(2)**

(d) One of the circuits **A** to **D** shown in **Figure 2** was used to obtain the current–voltage data in **Figure 1**. The maximum resistance of resistor **P** is twice the resistance of **R**.
The battery has an emf of 14.6 V and negligible internal resistance.

**Figure 2**

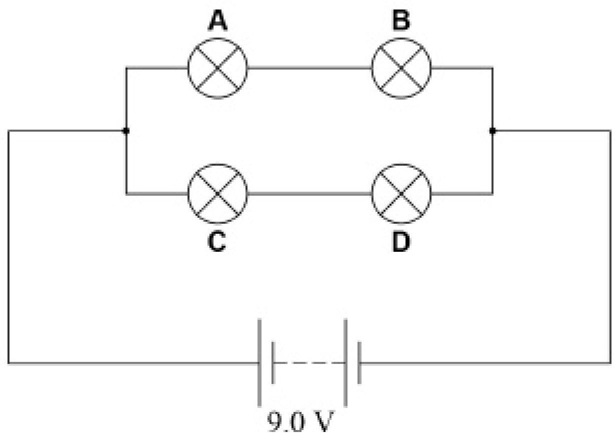


Deduce which **one** of these circuits was used to directly obtain the current–voltage data in **Figure 1**.
You should include in your answer an explanation of why each of the other circuits is **not** suitable to obtain the data directly from the voltmeter and ammeter readings.

**(4)**
**(Total 8 marks)**

**4.** A student connects four lamps **A**, **B**, **C** and **D** in the circuit shown in **Figure 1**.
The battery has an emf of 9.0 V and negligible internal resistance.

**Figure 1**




(a) The table shows the operating conditions for the lamps when they are at normal brightness.

| Lamps | Operating voltage / V | Power / W |
|---|---|---|
| **A** and **C** | 6.0 | 6.0 |
| **B** and **D** | 3.5 | 4.1 |

The student observes that **two** of the lamps are at their normal brightness.
Assume that any changes in resistance of the lamps are negligible.

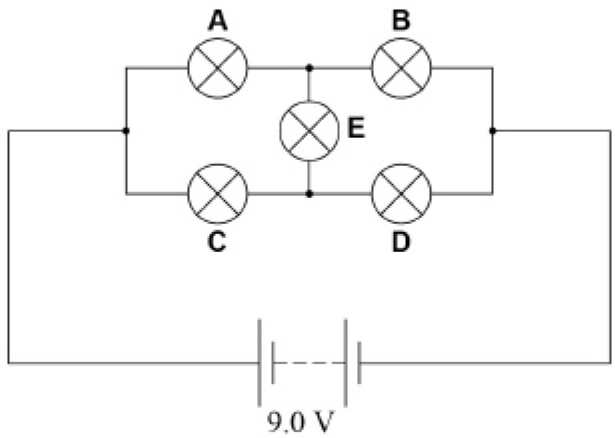
Determine which **two** lamps are at their normal brightness.

Use calculations to support your answer.

**(4)**

(b) The student connects another lamp **E** in the circuit as shown in **Figure 2**.
Lamp **E** is identical to lamps **A** and **C**.

**Figure 2**




Explain what the student would observe regarding the brightness of the lamps.

Refer to potential differences across lamp **E** in your answer.

**(3)**

(c) Lamp **B** in **Figure 2** fails so that it no longer conducts. This change does not affect the resistance of the other lamps.

Deduce the effect on the current in the battery.

Use calculations to support your answer.

___

___

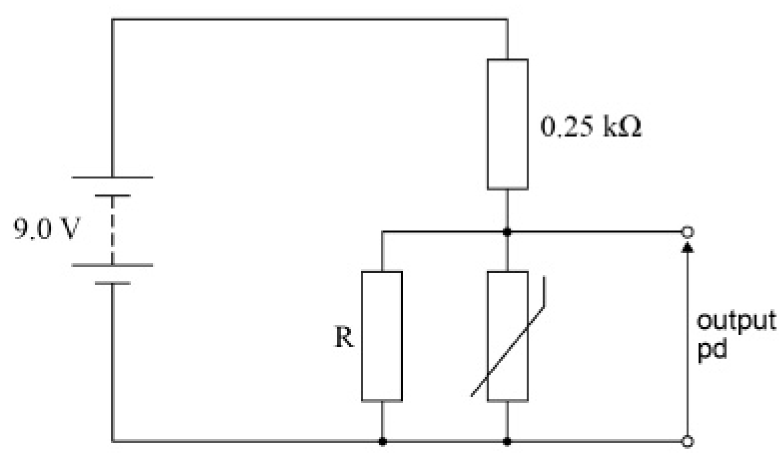
___

___

**(3)**

**(Total 10 marks)**

**5.** The diagram shows a circuit designed by a student to monitor temperature changes.




The supply has negligible internal resistance and the thermistor has a resistance of 750 Ω at room temperature. The student wants the output potential difference (pd) at room temperature to be 5.0 V

(a) The 0.25 kΩ resistor is made of 50 turns of wire that is wound around a non-conducting cylinder of diameter 8.0 mm

Resistivity of the wire = $4.2 \times 10^{-7}$ Ω m

Determine the area of cross-section of the wire that has been used for the resistor.

area of cross-section = ____________________ $m^2$

**(3)**

(b) The student selects a resistor rated at 0.36 W for the 0.25 kΩ resistor in the diagram.

Determine whether this resistor is suitable.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

**(2)**

(c) Determine the value of R that the student should select.

Give your answer to an appropriate number of significant figures.

value of R = ____________________ Ω

**(5)**

(d) State and explain the effect on the output pd of increasing the temperature of the thermistor.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

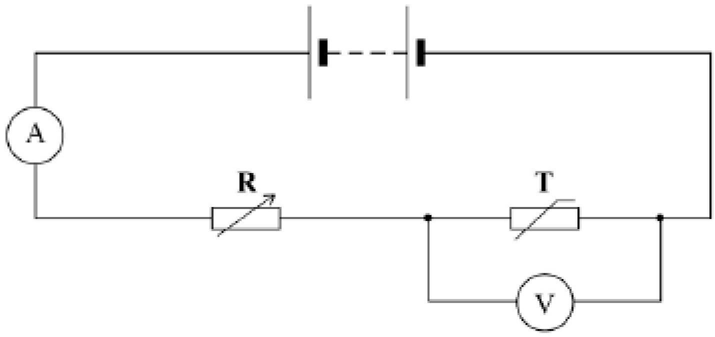
___________________________________________________________________

**(2)**

**(Total 12 marks)**

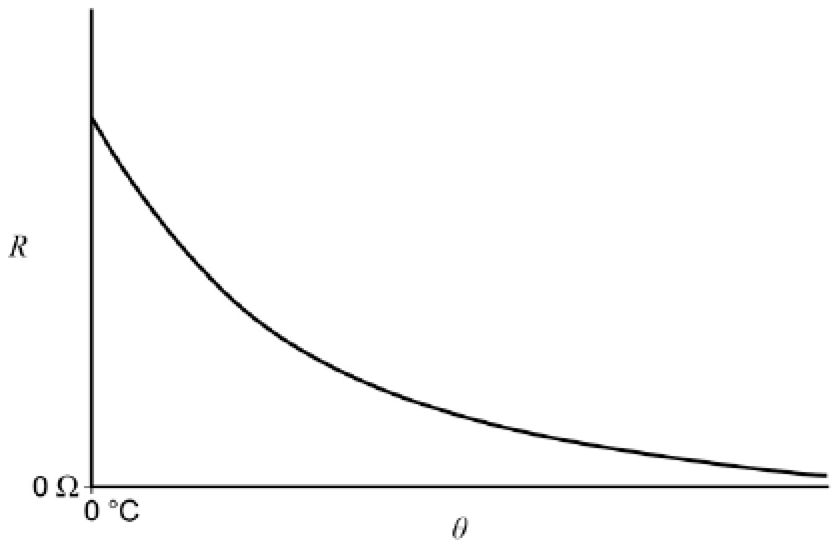
**6.** **Figure 1** shows a circuit including a thermistor **T** in series with a variable resistor **R**. The battery has negligible internal resistance.

**Figure 1**




The resistance–temperature ($R$–$\theta$) characteristic for **T** is shown in **Figure 2**.

**Figure 2**




(a) The resistor and thermistor in **Figure 1** make up a potential divider.

Explain what is meant by a potential divider.

______________________________________________________________

______________________________________________________________

______________________________________________________________

**(1)**

(b) State and explain what happens to the voltmeter reading when the resistance of **R** is increased while the temperature is kept constant.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**(3)**

(c) State and explain what happens to the ammeter reading when the temperature of the thermistor increases.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**(2)**

(d) The battery has an emf of 12.0 V. At a temperature of 0 °C the resistance of the thermistor is $2.5 \times 10^3$ Ω.

The voltmeter is replaced by an alarm that sounds when the voltage across it exceeds 3.0 V.

Calculate the resistance of R that would cause the alarm to sound when the temperature of the thermistor is lowered to 0 °C.

resistance = ____________________ Ω

**(2)**

(e) State **one** change that you would make to the circuit so that instead of the alarm coming on when the temperature falls, it comes on when the temperature rises above a certain value.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**(1)**

**(Total 9 marks)**