1.

(a) (i) State Ohm's law. [2]

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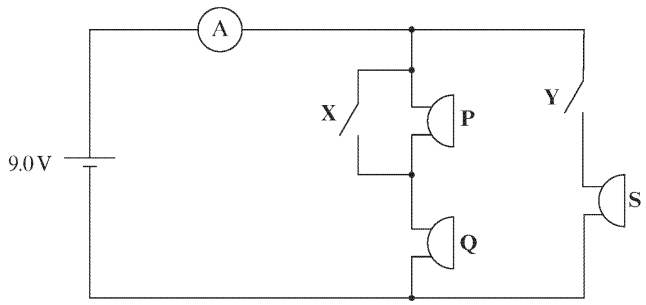
(ii) The unit of resistance is the ohm (Ω). One of the following is a correct alternative unit to the ohm. Circle the correct one. [1]

VA^{-1} AV^{-1} JC^{-1} Js^{-1}

(b)



In the above circuit, buzzers **P**, **Q** and **S** are controlled using switches **X** and **Y**. **The buzzers are identical and their resistances remain constant.**

(i) The table shows the possible combinations of open and closed switches. When a switch is closed, charge can flow through it. Complete the table. The first row has been done for you. [3]

Switch combination	**P**	**Q**	**S**
X open, **Y** open	On	On	Off
X closed, **Y** open			
X open, **Y** closed			
X closed, **Y** closed			

(ii) With **X** open and **Y** open, the ammeter reads 0.18 A. Calculate the resistance of **each** of the buzzers. [3]

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(iii) Determine the reading on the ammeter when all three buzzers are on. [2]

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(iv) When all three buzzers are on, show that

power used by **S** = 4 × power used by **Q** [3]

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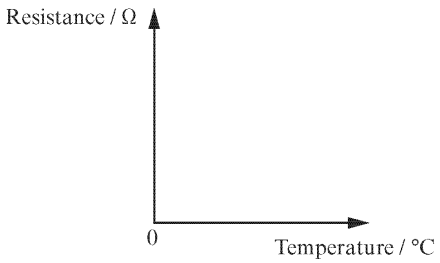
2.

(a) (i) Draw a labelled diagram of the apparatus you would use to determine the relationship between the resistance and temperature of a metal wire. [3]

(ii) Sketch, on the axis below, a graph of the results you would expect from the experiment. [2]



(b) (i) Explain in terms of particles how electrical resistance arises in metal conductors. [3]

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(ii) Hence suggest an explanation for your results to the experiment in part *(a)*. [2]

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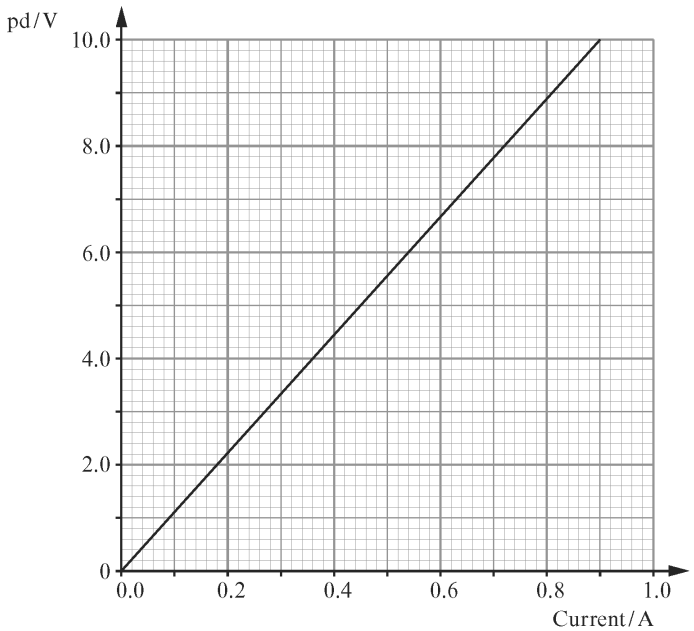
3.

Experiments are carried out to determine the material from which a metal wire is made. Initially the resistivity of the metal is found. The wire's density is then determined and the results compared with known values of resistivity and density.

(a) As a first step to finding the resistivity, an experiment investigates the relationship between pd and current for the wire. The results are shown in the graph.



(i) Draw a circuit diagram to show how the above results could be obtained. The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter. [2]

(ii) The wire has length 3.2m and **diameter** 0.20mm. Use this information and the graph to calculate the resistivity of the material in the wire. [4]

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(iii) Using the information in the table, write down **two** possible materials for the wire. [1]

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Material	**Resistivity / Ω m**	**Density / kg m^{-3}**
Iron	0.97×10^{-7}	7850
Platinum	1.06×10^{-7}	21400
Tin	1.12×10^{-7}	7300
Nichrome	1.10×10^{-6}	8400

The mass of the wire is found to be 0.74 grammes. Explaining how you obtain your answer, determine the material from which the wire is made. [3]

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4. A power cable has a resistance of 11.2Ω and is made of an alloy of aluminium of resistivity $2.8 \times 10^{-8}\,\Omega\text{m}$. It is used to link a power station to a town 160 km away.

(a) (i) Show that the cross-sectional area of the cable is $4.0 \times 10^{-4}\,\text{m}^2$. [1]

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(ii) Calculate the current in the cable given that the pd across it is 2.0 kV. [1]

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(iii) Calculate the mean drift velocity of the free electrons in the cable given that there are 6.0×10^{28} atoms per m^3 of aluminium and each atom contributes 3 free electrons. [3]

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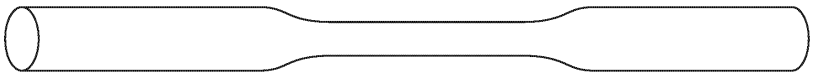
(b) A small portion of the cable is damaged. As a result its cross-sectional area is less than that of the rest of the cable, as shown in the diagram.



(i) State how the current in the thinner portion compares with the current in the rest of the cable. [1]

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(ii) State how the mean drift velocity of free electrons in the thinner portion compares with that in the rest of the cable. Justify your answer. [2]

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(iii) Hence suggest, in terms of particles, why the damaged part of the cable will be prone to overheating. [2]

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5.

(a) (i) Draw a labelled diagram of a suitable arrangement that would enable a student to investigate how the resistance of a metal wire changes between a temperature of **0 °C** and **100 °C**. [3]

(ii) Describe how the student would:

- obtain measurements of resistance across the full temperature range;
- ensure accurate results;
- analyse the data obtained. [5]

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(b) (i) A certain metal alloy has a *superconducting transition temperature* of –163 °C. Explain what is meant by the words in italics. [2]

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(ii) State how this alloy can be kept below its superconducting transition temperature. [1]

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6. (a) (i) Draw a labelled diagram of the apparatus you would use to determine the relationship between the resistance and length of a metal wire.

[3]

(ii) Sketch a graph of your expected results.

[1]

(iii) Explain how you would use an accurately drawn graph of resistance against length, as well as any other measurements, to obtain a value for the resistivity of the metal in the wire.

[3]

(b) (i) A simple heater is made of a metallic wire of resistivity 48 × 10-8 Ω m and crosssectional area 4.0 × 10-8 m2. When it is in use the potential difference across the heater is 12.0 V and its power is 32 W. Calculate the length of the wire in the heater.

[3]

(ii) Calculate the drift velocity of the electrons in the wire when the heater is in use.
[The number of free electrons per unit volume is 3.4 × 1028 m-3 for the material in the wire.]

[3]

7.

(a) What is a *superconductor*? [1]

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(b) A metal conductor is placed in liquid helium. It is noted that at a certain temperature, as the metal cools, its resistance changes suddenly, dropping rapidly to zero.

(i) What name is given to the temperature at which this sudden change occurs? [1]

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(ii) Sketch a graph of resistance against temperature for the above conductor, labelling any key features of your graph. [2]

(iii) What potential difference would be needed to maintain a current in the conductor when it has been immersed in the liquid helium for some time? [1]

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(c) Conducting electrons in a superconductor do not cause a heating effect. Explain why conducting electrons **do** produce a heating effect in wires at room temperature. [2]

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8.

1. *(a)* (i) State Ohm's law. [1]

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(ii) What can be said about the *resistance* of a conductor that obeys Ohm's law? [1]

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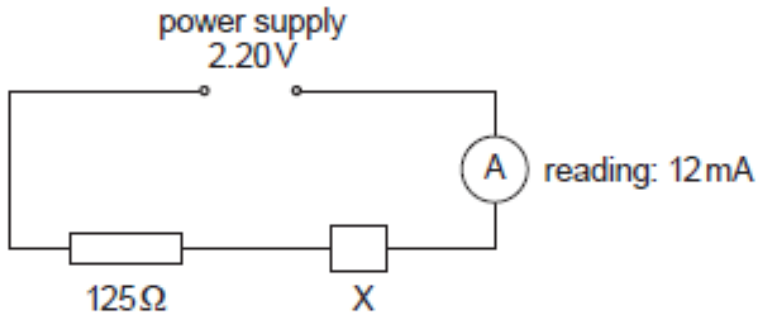
(b) (i) An electrical component, X, is included in the circuit shown. The internal resistance of the power supply is negligible.



Show that the resistance of X in this circuit is approximately 60 Ω. [2]

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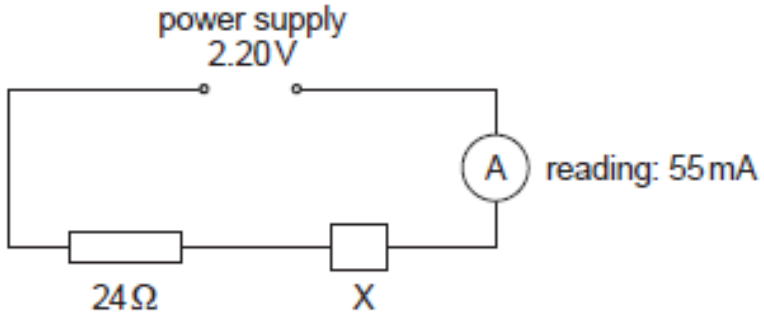
(ii) When the 125 Ω resistor in *(b)*(i) is replaced by a 24 Ω resistor, the reading on the ammeter increases, as shown below.



Evaluate whether or not X obeys Ohm's law, presenting your argument clearly. [2]

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(iii) State, giving a reason, whether or not X could be a filament lamp. [1]

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(c) A certain high temperature superconductor has a transition temperature of –188 °C. The boiling point of liquid nitrogen is –196 °C.

(i) State what is meant by the *transition temperature* of a superconductor. [1]

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(ii) Give one possible use for a high temperature superconductor and state why it would be an advantage for the transition temperature to be above the boiling point of liquid nitrogen. [2]

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9.

4. *(a)* **Describe** how the resistance of a metal varies between 0K and 1000K.
[Assume that the metal is superconducting below a certain temperature.]
Account for this variation in resistance at higher temperatures. [6 QER]

(b) Superconductors are used in MRI scanners and particle accelerators. Consider which of these two applications has been of greater benefit to society. [3]

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