1. A student makes measurements to determine the total energy *W* transferred by a filament lamp.

They record the measurements shown below.

Potential difference / V	12 ± 0.20
Current / mA	80 ± 1.0
Time / s	60 ± 0.01

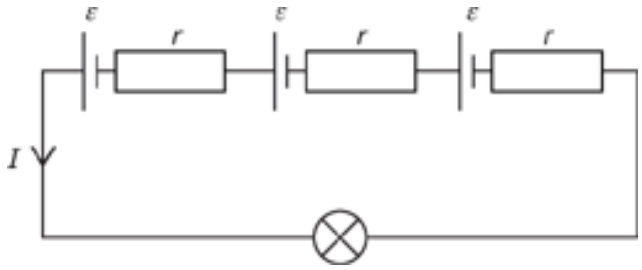
What is the percentage uncertainty in their calculated value of *W*?

A 0.2%
B 1.2%
C 2.9%
D 7.2%

Your answer ☐ **[1]**

2. A torch uses three identical cells connected in series to a bulb.

Each cell has e.m.f. ε and internal resistance *r*.



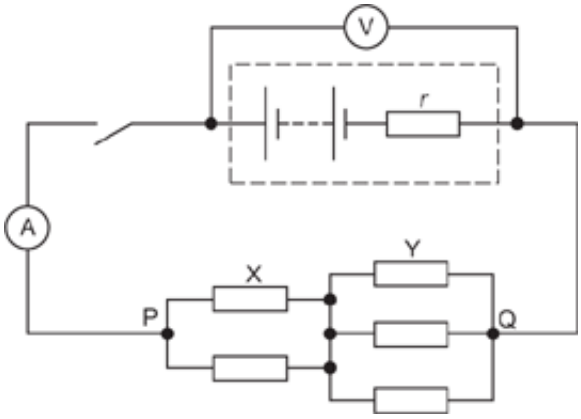
The current in the circuit is *I*.

Show that the power *P* delivered to the bulb is given by

$P = 3I(\varepsilon - Ir)$

[3]

3(a). A battery of electromotive force (e.m.f.) ε and internal resistance r is connected to five identical wire wound resistors in a circuit.



Each resistor between points P and Q has a resistance of 300Ω. Two of the resistors are labelled X and Y as shown.

The table shows the ammeter and voltmeter readings when the switch is open and when the switch is closed.

Switch position	Ammeter reading	Voltmeter reading
open	0.0 mA	4.57 V
closed	18.0 mA	4.50 V

i. Suggest why a student deduces that the e.m.f. ε of the battery has the value of 4.57 V.

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[1]

ii. Show that the resistance r is approximately 3.9 Ω.

[1]

iii. Show that the total resistance of the resistors between P and Q is 250 Ω.

[1]

(b). The switch is closed for 300 s.

Calculate:

i. the energy E dissipated in r.

E = ... J **[1]**

ii. the number of electrons N passing through r.

N = ... **[2]**

iii. the ratio

$$\frac{\text{mean drift speed of electrons in resistor X}}{\text{mean drift speed of electrons in resistor Y}}$$

ratio = ... **[2]**

(c). Resistor Y is removed from the circuit.

The switch is closed.

Complete the sentences to state the change, if any, in the meter readings.

Choose from **increases, decreases,** or **stays the same**.

i. The ammeter reading

_____ **[1]**

ii. The voltmeter reading

_____ **[1]**

4. A 3D printer can manufacture small objects.

Some 3D printers use polylactic acid (PLA). PLA is supplied in the form of long filaments. The 3D printer melts the PLA and builds up the shape of the desired object in layers.

The electrical supply to the heater in the printer has an e.m.f., ε, of 12 V. The power of the heater is 40 W.

Calculate the resistance, R, of the heater.

R = ...Ω **[2]**

5. The power dissipated across a 1 kΩ resistor is 20 W.

What is the potential difference across the resistor?

A 0.02 V
B 50 V
C 140 V
D 20 000 V

Your answer ☐ **[1]**

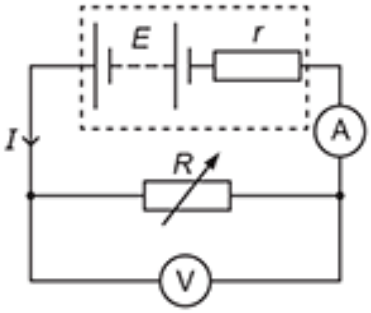
6. A 200 W heater is used for 90 minutes. The cost per kWh is 13 pence.

How much did it cost to use the heater?

A 3.9p
B 39p
C £2.34
D £23.40

Your answer ☐ **[1]**

7(a). A battery is connected to a variable resistor.



The variable resistor is made from a length of wire. The resistance of the variable resistor is *R*.
The battery has electromotive force (e.m.f.) *E* and internal resistance *r*. The current in the circuit is *I*.

Compare the e.m.f. of the battery and the potential difference (p.d.) across the variable resistor in terms of energy transfers or changes.

---

[1]

(b). State which physical quantity of the variable resistor is changed to alter its resistance.

[1]

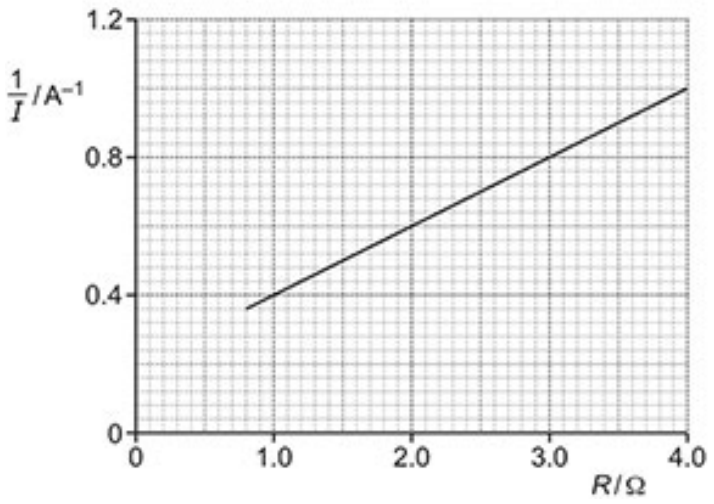
(c). A student connects up the circuit above to determine *r*.

i. Show that $\frac{1}{I} = \frac{R}{E} + \frac{r}{E}$

[2]

ii. The student varies *R* and measures the current *I*.

The student plots a graph of $\frac{1}{I}$ against *R*.



1 Use the graph to determine the power dissipated in the variable resistor when *R* = 3.0 Ω.

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

2 The e.m.f. *E* of the battery is 5.0 V.

Determine *r* from the intercept of the line with the vertical axis.

r = ... Ω **[2]**

8. An electric cooker has two independent heating rings **A** and **B** as shown in **Fig. 7.1**.

Fig. 7.1

The cooker rings **A** and **B** are connected in parallel to a 230 V power supply. At maximum power, ring **A** has a power of 1100 W and ring **B** has a power of 1700 W.

i. Show that the maximum current in the cooker is less than 13 A.

[2]

ii. The cost of 1 kW h of energy is 18p.
Calculate the cost of using the cooker at maximum power for 30 minutes.

cost = ... p **[1]**

END OF QUESTION PAPER