5.2 Heating Effect of Electric Currents

Question Paper

Course	DP IB Physics
Section	5. Electricity & Magnetism
Topic	5.2 Heating Effect of Electric Currents
Difficulty	Hard

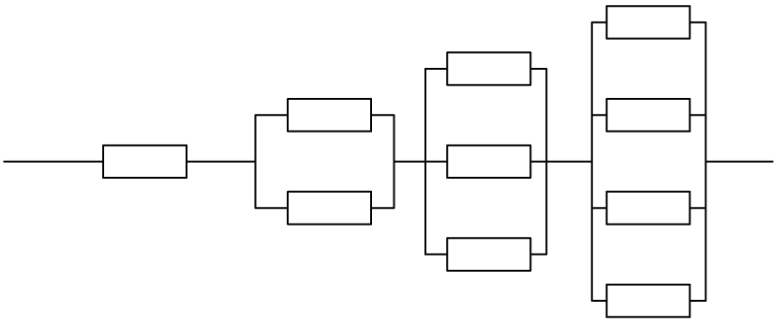
Time allowed: 40

Score: /33

Percentage: /100

Question 1a

A combination of identical resistors each with resistance *R* has a total resistance of 250 Ω.



(a)

Show, without the use of a calculator, how to find the value of resistance of each resistor and hence determine the value of *R*.

[2]

[2 marks]

Question 1b

A student is provided with four fixed resistors of the following sizes:

1 × 5.0 Ω

1 × 10.0 Ω

2 × 20.0 Ω

(b)

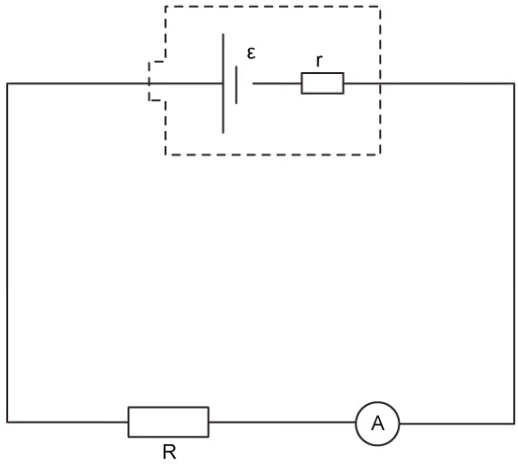
Calculate the maximum power which can be drawn from a circuit which uses all four resistors connected to a variable power supply with terminal voltage ranging from 2–12 V. Include a sketch of the circuit you have outlined in your answer.

[4]

[4 marks]

Question 1c

A physics class planned an investigation into electromotive force (emf) and internal resistance. When the students arrived the equipment had not been set out as they expected. They were provided with the circuit diagram shown, and a set of ten fixed resistors, ranging from 10–200 Ω in regular increments which could be used in place of the resistor, *R*.



(c)
Comment on how the students can use their results to find both the emf and the internal resistance of the cell and hence suggest the outcome of this investigation.

[3]

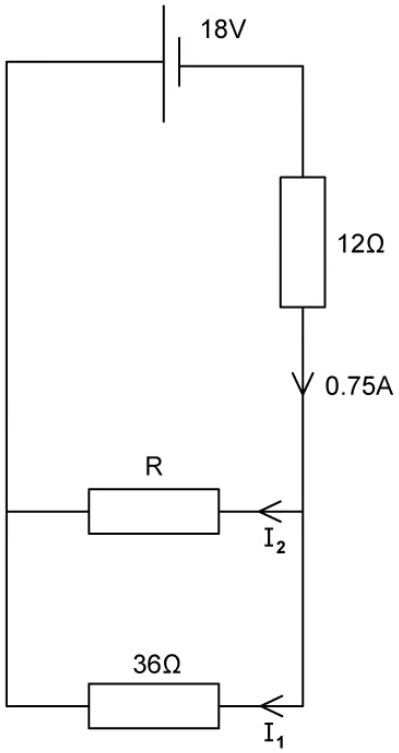
Assume that the ammeter is suitable to measure all the currents which this circuit may produce. No additional equipment may be used.

[3 marks]

Question 1d

(d)

The circuit diagram shows a battery which has negligible internal resistance connected to three resistors which have different values of resistance.



(i)

Calculate current I_1.

[1]

(ii)

Calculate resistance, R.

[1]

[2 marks]

Question 2a

A current of 2.0 mA flows in an ammeter for 90 minutes.

(a)
Calculate the approximate number of electrons which pass through the ammeter in this time.

[1]

[1 mark]

Question 2b

Human skin tissue has much higher resistivity than muscle tissue. Typical values for the resistivity of particular tissue types vary. For this question use the data in the table below.

Tissue	Resistivity / Ω m
Muscle	8.3
Dry skin	3.0×10^4

A person grasps a wire which has a diameter of 0.5 cm at a potential of 12 V. The wire is not insulated and the person is well earthed. The skin of the hand is 1.0 mm thick and is in contact with the whole wire for a distance of 10 cm.

(b)

(i)
Calculate the current in mA which passes through the person as a result of this accident.

[2]

(ii)
Comment on the change as the current passes through the skin and into the muscle tissue.

[2]

[1 mark]

Question 2c

Following the accident in part (b) the teacher sets a research homework, where students are asked to discuss electrical safety.

(c)
By comparing the factors given in the question

(i)
Suggest how the magnitude of the current passing into the body could have been affected.

[2]

(ii)
Outline safety precautions which the student should have taken before handling the wire.

[3]

[1 mark]

Question 2d

High voltage electrical accidents can cause deep burns throughout the body, which often require major surgery and can lead to permanent disability or death.

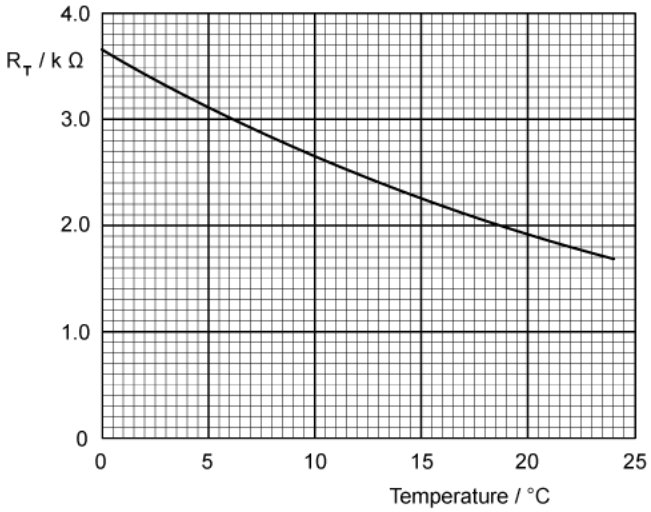
(d)
Outline the reasons for this level of injury, stating two assumptions that you have made in your explanation.

[4]

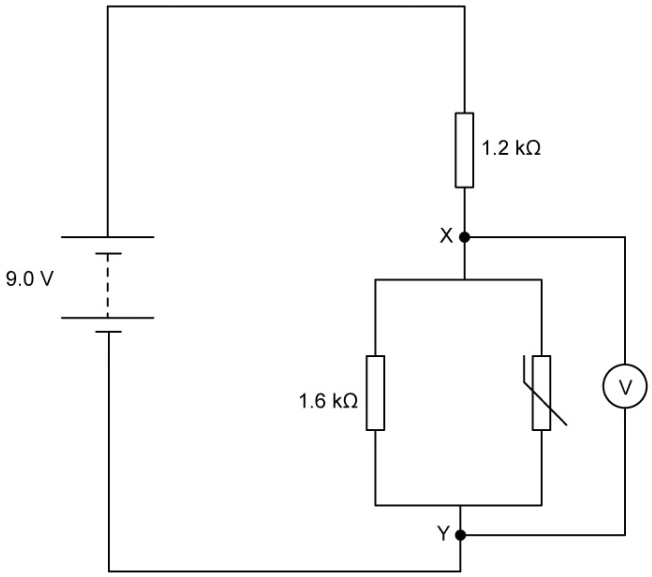
[4 marks]

Question 3a

The variation with temperature of the resistance, R_T of a thermistor with temperature is shown.



The thermistor is connected into a circuit using a power source with negligible internal resistance. The temperature is 22.5 °C.



(a)
Show, without the use of a calculator, how to determine the reading on the voltmeter, giving the answer to two significant figures.

[1]

[1 mark]

Question 3b

The temperature is changed so that the voltmeter reads 4.0 V.

(b)
Determine the new temperature.

[2]

[2 marks]

Question 4a

(a)
Show that $I^2R = \frac{V^2}{R}$ and hence express the unit represented by these equations in S.I. units.

[2]

[2 marks]

Question 4b

A family on a tight budget needs to buy a new electric heater. The retailer's website, written (it claims) by electrical engineers, suggests that the best value-for-money heater has very high resistance because $P = I^2R$.

The family, who all study physics, think that a low resistance heater would be better, because $P = \frac{V^2}{R}$.

(b)
Explain who is correct.

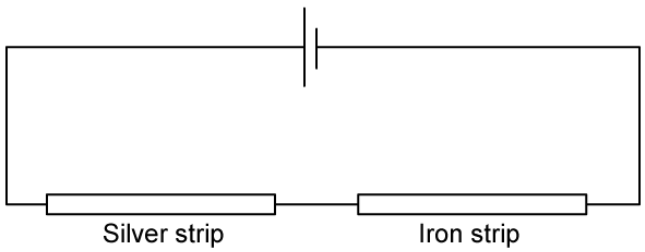
[2]

[2 marks]

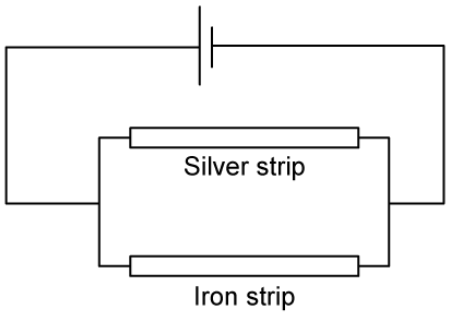
Question 4c

Two thin strips of silver and of iron have the same dimensions. The strips are connected to a circuit, first in series and then in parallel. A potential difference is applied in the positions shown, and the voltage increased incrementally until one of the two wires begins to glow.

(i)



(ii)



(c)
Explain which metal strip will glow first

(i)
For the series arrangement.

[2]

(ii)
For the parallel arrangement.

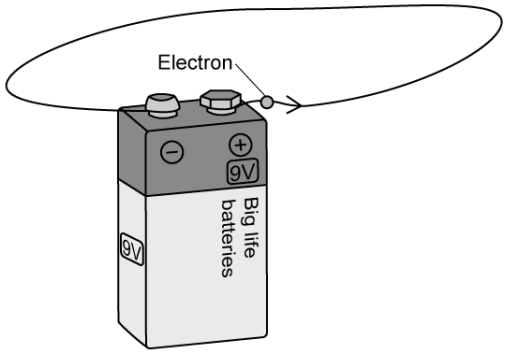
[2]

[4 marks]

Question 5a

In a thought experiment a teacher asks students to imagine an electron passing through a cell with a terminal voltage of 9 V.

The electron passes along a wire until it reaches the positive terminal of the cell. In the thought experiment, students are asked to assume that there is no obstruction to the movement of the electron within the wire.



a)
Using energy considerations, calculate the final speed of the electron.

[2]

[2 marks]

Question 5b

The teacher points out that the thought experiment is fundamentally flawed, since it breaks a certain law of physics.

(b)
Explain the teacher's comment, and hence use a simple observation from daily experience to prove that the teacher is correct.

[2]

[2 marks]