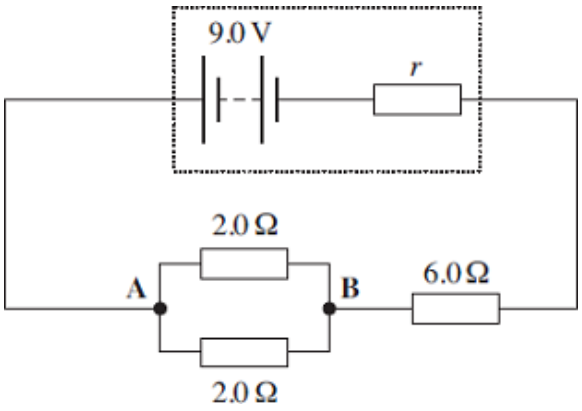
Circuit Calculations practice questions

Name _____-

57 minutes

57 marks

Q1. A battery of emf 9.0 V and internal resistance, *r*, is connected in the circuit shown in the figure below.



(a) The current in the battery is 1.0 A.

(i) Calculate the pd between points **A** and **B** in the circuit.

answer = ... V

(2)

(ii) Calculate the internal resistance, *r*.

answer = ... Ω

(2)

(iii) Calculate the **total** energy transformed by the battery in 5.0 minutes.

answer = ... J

(2)

(iv) Calculate the percentage of the energy calculated in part (iii) that is dissipated in the battery in 5.0 minutes.

answer = ...

(2)

(b) State and explain **one** reason why it is an advantage for a rechargeable battery to have a low internal resistance.

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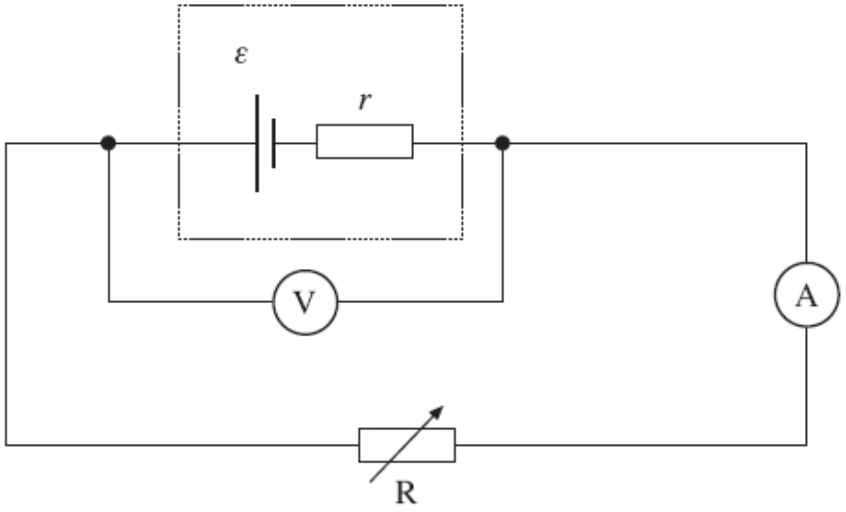
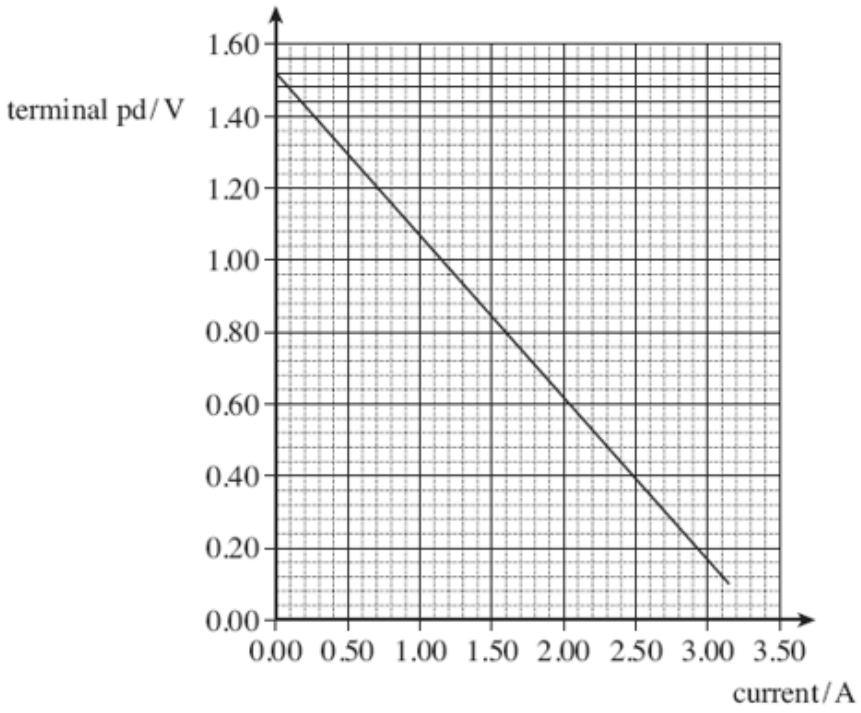
(2)

(Total 10 marks)

Q2. A cell of emf, ε, and internal resistance, r, is connected to a variable resistor R. The current through the cell and the terminal pd of the cell are measured as R is decreased. The circuit is shown in the figure below.



The graph below shows the results from the experiment.



(a) Explain why the terminal pd decreases as the current increases.

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(2)

(b) (i) Use the graph to find the emf, ε, of the cell.

answer = ... V

(1)

(ii) Use the graph above to find the internal resistance, *r*, of the cell.

answer = ... Ω

(3)

(c) Draw a line on the graph above that shows the results obtained from a cell with

(i) the same emf but double the internal resistance of the first cell labelling your graph **A.**

(2)

(ii) the same emf but negligible internal resistance labelling your graph **B**.

(1)

(d) In the original circuit shown in part (a), the variable resistor is set at a value such that the current through the cell is 0.89 A.

(i) Calculate the charge flowing through the cell in 15 s, stating an appropriate unit.

answer = ...

(2)

(ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = ... W

(2)

(Total 13 marks)

Q3. **X** and **Y** are two lamps. **X** is rated at 12 V 36 W and **Y** at 4.5 V 2.0 W.

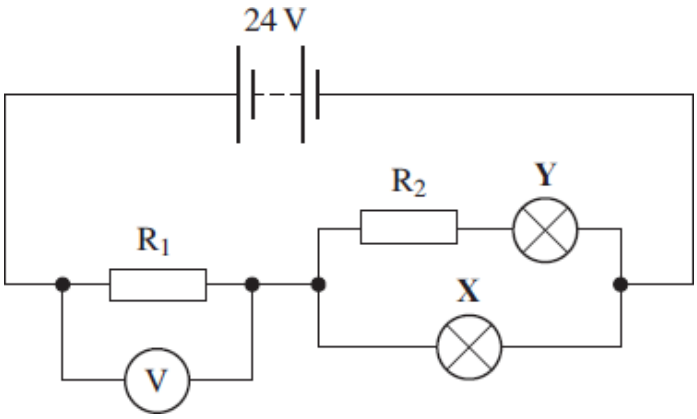
(a) Calculate the current in each lamp when it is operated at its correct working voltage.

X ..... A

Y ..... A

(2)

(b) The two lamps are connected in the circuit shown in the figure below. The battery has an emf of 24 V and negligible internal resistance. The resistors, R_1 and R_2 are chosen so that the lamps are operating at their correct working voltage.



(i) Calculate the pd across R_1.

answer V

(1)

(ii) Calculate the current in R_1.

answer ..... A

(1)

(iii) Calculate the resistance of R_1.

answer ..... Ω

(1)

(iv) Calculate the pd across R_2.

answer V

(1)

(v) Calculate the resistance of R_2.

answer ..... Ω

(1)

(c) The filament of the lamp in **X** breaks and the lamp no longer conducts. It is observed that the voltmeter reading decreases and lamp **Y** glows more brightly.

(i) Explain without calculation why the voltmeter reading decreases.

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(2)

(ii) Explain without calculation why the lamp **Y** glows more brightly.

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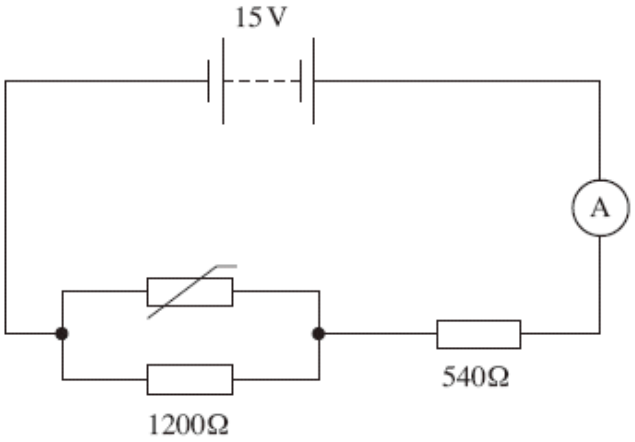
(2)
(Total 11 marks)

Q4. The circuit shown below shows a thermistor connected in a circuit with two resistors, an ammeter and a battery of emf 15V and negligible internal resistance.



(a) When the thermistor is at a certain temperature the current through the ammeter is 10.0 mA.

(i) Calculate the pd across the 540 Ω resistor.

answer = ... V

(1)

(ii) Calculate the pd across the 1200 Ω resistor.

answer = ... V

(1)

(iii) Calculate the resistance of the parallel combination of the resistor and the thermistor.

answer = ... Ω

(2)

(iv) Calculate the resistance of the thermistor.

answer = ... Ω

(2)

(b) The temperature of the thermistor is increased so that its resistance decreases. State and explain what happens to the pd across the 1200 Ω resistor.

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(3)

(Total 9 marks)

Q5. (a) A student wishes to investigate how the resistance of a thermistor changes with temperature.

(i) Draw a labelled diagram of a suitable circuit that would enable the student to measure the resistance of the thermistor.

(2)

(ii) Describe the procedure the student would follow in order to obtain accurate and reliable measurements of the resistance of the thermistor at different temperatures.

The quality of your written communication will be assessed in this question.

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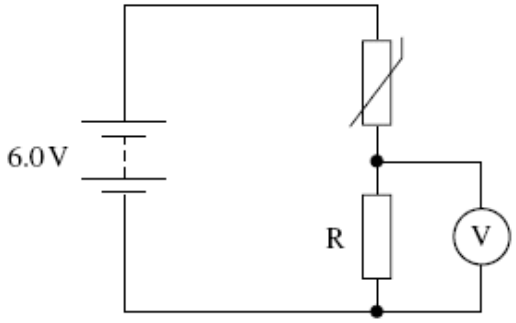
(6)

(b) The diagram below shows a thermistor connected in series with a resistor, R, and battery of emf 6.0 V and negligible internal resistance.



When the temperature is 50 °C the resistance of the thermistor is 1.2 kΩ. The voltmeter connected across *R* reads 1.6V.

(i) Calculate the pd across the thermistor.

answer = ... V

(1)

(ii) Calculate the current in the circuit.

answer = ... A

(1)

(iii) Calculate the resistance of R quoting your answer to an appropriate number of significant figures.

answer = ... Ω

(2)

(c) State and explain the effect on the voltmeter reading if the internal resistance of the battery in the circuit in part (b) was not negligible.

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.....

.....

(2)
(Total 14 marks)

M1. (a) (i) (use of $V = IR$)

$R_{total} = 1$ (ohm) ✓

$V = 1 \times 1 = 1.0$ V ✓

2

(ii) (use of $V = IR$)

$R = 9.0/1.0 = 9.0\ \Omega$ ✓

$r = 9.0 - 1.0 - 6.0 = 2.0\ \Omega$ ✓

or use of ($E = I(R + r)$)

$9.0 = 1(7 + r)$ ✓

$r = 9.0 - 7.0 = 2.0\ \Omega$ ✓

2

(iii) (use of $W = VIt$)

$W = 9.0 \times 1.0 \times 5 \times 60$ ✓

$W = 2700$ J ✓

2

(iv) energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600$ (J) ✓

percentage = $100 \times 600/2700 = 22\%$ ✓ CE from part aii

2

(b) internal resistance limits current ✓

hence can provide higher current ✓

or energy wasted in internal resistance/battery ✓

less energy wasted (with lower internal resistance) ✓

or charges quicker ✓

as current higher or less energy wasted ✓

or (lower internal resistance) means higher terminal pd/voltage ✓

as less pd across internal resistance or mention of lost volts ✓

2

[10]

M2. (a) mention of pd across internal resistance **or** energy loss in internal resistance **or** emf > V ✓

pd across internal resistance/lost volts increases with current **or** correct use of equation to demonstrate ✓

2

(b) (i) *y – intercept* 1.52 V (± 0.01 V) ✓

1

(ii) identifies gradient as *r* **or** use of equation ✓

substitution to find gradient **or** substitution in equation ✓

r = 0.45 ± 0.02 Ω ✓

3

(c) (i) same intercept ✓

double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✓

2

(ii) same intercept horizontal line ✓

1

(d) (i) (use of $Q = It$)

$Q = 0.89 \times 15 = 13$ ✓ C ✓

2

(ii) use of $P = I^2r$ ✓

$P = 0.89^2 \times 0.45$

$P = 0.36$ W ✓

2

[13]

M3. (a) (use of $P = V/I$)

$I = 36/12 = 3.0$ A ✓

$I = 2.0/4.5 = 0.44$ A ✓

2

(b) (i) pd = 24 − 12 = 12 V ✓

1

(ii) current = 3.0 + 0.44 = 3.44 A ✓

1

(iii) $R_1 = 12/3.44 = 3.5\ \Omega$ ✓

1

(iv) pd = 12 − 4.5 − 7.5 V ✓

1

(v) $R_2 = 7.5/0.44 = 17\ \Omega$ ✓

1

(c) (i) (circuit) resistance increases ✓

current is lower (reducing voltmeter reading) ✓

or correct potential divider argument

2

(ii) pd across Y **or** current through Y increases ✓

hence power/rate of energy dissipation greater **or** temperature of lamp increases ✓

2

[11]

M4. (a) (i) voltage = 0.01 × 540 = 5.4 V **(1)**

1

(ii) voltage = 15 – 5.4 = 9.6 V **(1)**

1

(iii) (use of resistance = voltage/current)

resistance = 9.6/0.01 **(1)** = 960 Ω **(1)**

or R_T = 15/0.01 = 1500 Ω **(1)**

R = 150 – 590 = 960 Ω **(1)**

or potential divider ratio **(1)(1)**

2

(iv) (use of $1/R = 1/R_1 + 1/R_2$)

$1/960 = 1/200 + 1/R_2$ **(1)**

$1/R_2 = 1/960 – 1/1200$

R_2 = 4800 Ω **(1)**

2

(b) (voltage of supply constant)

(circuit resistance decreases)

(supply) current increases or potential divider argument **(1)**

hence pd across 540 Ω resistor increases **(1)**

hence pd across 1200 Ω decreases **(1)**

or resistance in parallel combination decreases **(1)**

pd across parallel resistors decreases **(1)**

pd across 1200 Ω decreases **(1)**

3

[9]

M5. (a) (i) **working** circuit including power supply and thermistor (correct symbol) **(1)**

voltmeter and ammeter or ohm meter **(1)**

2

(ii) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.
The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter.
The candidate gives details of how the thermistor is heated in a beaker of water **or** a water bath and a thermometer is used to measure the temperature at small regular intervals.
The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. The candidate may mention that the water must be stirred to ensure that the thermistor is at the temperature measured by the thermometer.
The candidate may give some indication of the range of temperatures to be used.
The candidate may refer to repetition of whole experiment.
The candidate may plot a graph of resistance against temperature.
The candidate may use a digital thermometer.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter.
The candidate gives details of how the thermistor is heated in a beaker of water and a thermometer is used to measure the temperature.
The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary.
The form and style of writing may be only partly appropriate.

The candidate changes temperature at least once and measures V and I or R.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

Max 6

(b) (i) pd = 6.0 – 1.6 = 4.4 (V) **(1)**

1

(ii) current = 4.4/1200 = 3.7×10^{-3} (A) **(1)** (not 3.6)

1

(iii) resistance = $1.6/3.7 \times 10^{-3} = 440$ **or** 430 (Ω) **(1)**

2 sfs **(1)**

2

(c) less current now flows **or terminal pd/voltage** lower **(1)**
(or voltage across cell/external circuit is lower)

(hence) pd/voltage across resistor will decrease **(1)**

2

[14]