Physics 11

Electrical Circuits Test

Student Name Solutions

Teacher _____

Time allowed for this paper

Working time for paper: 60 minutes

Part B too easy

To be provided by the supervisor:

This Question/answer booklet;
Formulae and constants sheet

To be provided by the candidate

Standard items: Pens, pencils, eraser or correction fluid, ruler, highlighter

Special items: Drawing instruments or templates.
A **scientific** (i.e. non graphics) calculator satisfying curriculum council requirements.

Structure of this paper

Section	Number of questions available	Suggested working time (minutes)	Your Mark	Marks available	Percentage of test
Section One: Short answer	9	18	15	15	30
Section Two: Extended	5	32	27	27	54
Section Three Comprehension	1	10	8	8	16
		Total	50	50	100

Important note to candidates

No other items may be used in this test. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the test room. If you have any unauthorised material with you, hand it to the supervisor before reading any further.

Instructions to candidates

1. Write answers in this Question/Answer Booklet in the spaces provided.

2. To achieve full marks, clear, logical working and diagrams MUST be shown.

3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

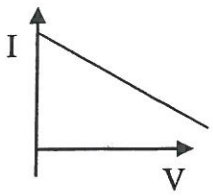
   When **estimating** numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.

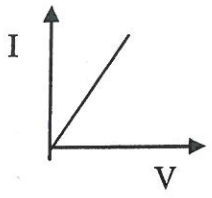
Section One: **Short answers (15 marks)**

Question 1

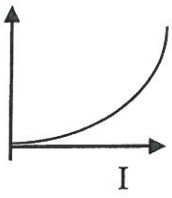
a) Which of the following graphs best represents a non-ohmic conductor? (1 mark)



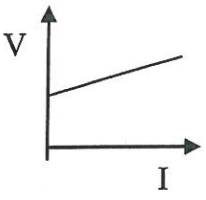
A



B



C



D

Answer: C ✓

b) Why did you select this graph? (1 mark)

It's non linear
OR/ It suggests that resistance changes as voltage changes ✓
OR/ The gradient is not constant

Question 2

Explain why the metal copper is a better electrical conductor than rubber. (2 marks)

Metals have delocalised electrons in their atomic structure ✓
These are mobile charges which are free to carry a current ✓

Question 3

When a resistor is connected to a 9 V battery, 1.57×10^{21} electrons pass through the resistor in a time of 90 seconds.

a) Calculate the current in the resistor. (2 marks)

$$I = \frac{q}{t} = \frac{1.57 \times 10^{21} \times 1.6 \times 10^{-19}}{90} = 2.79 \text{ A}$$ ✓ ✓

b) Calculate the work done on the electrons by the battery. (2 marks)

$W = qV = (1.57 \times 10^{21} \times 1.6 \times 10^{-19}) \times 9$ ✓

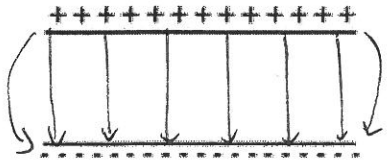
$= \cancel{27.9 \text{ J}}$ ✓

$2261 \text{ J} \ (2.26 \times 10^{3} \text{ J})$

Question 4

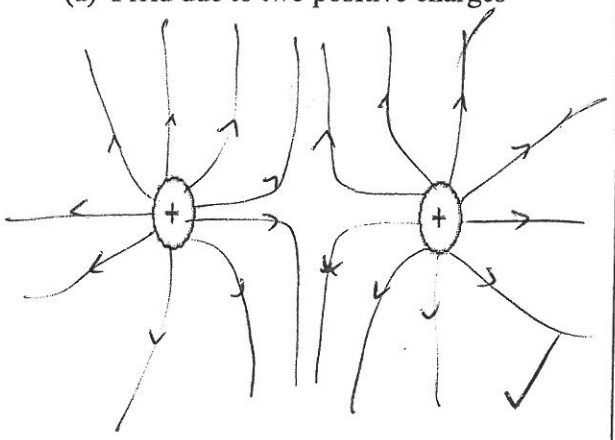
Draw the electric field around the following two different situations. (2 marks)

(b) Field between charged plates



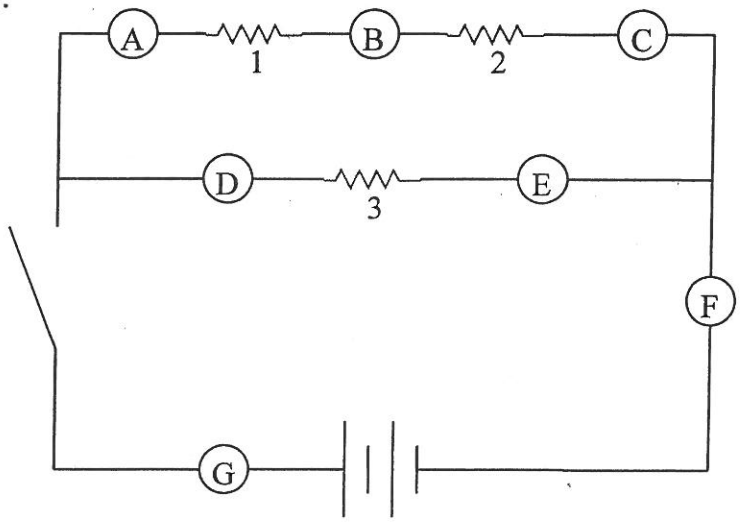
½ mark for direction
½ mark for interior shape + even spacing ✓

(a) Field due to two positive charges



½ mark direction
½ mark shape

Questions 5 to 7 uses the following circuit diagram showing the connections of three similar resistors (labelled 1, 2 and 3).



5) The direction of conventional current flow is from

Circle the correct answer: (G to A) B to A D to A

(1 mark)

6) To determine the potential difference across resistor 2, you would use the points

Circle the correct answer: A and C A and F (B and C)

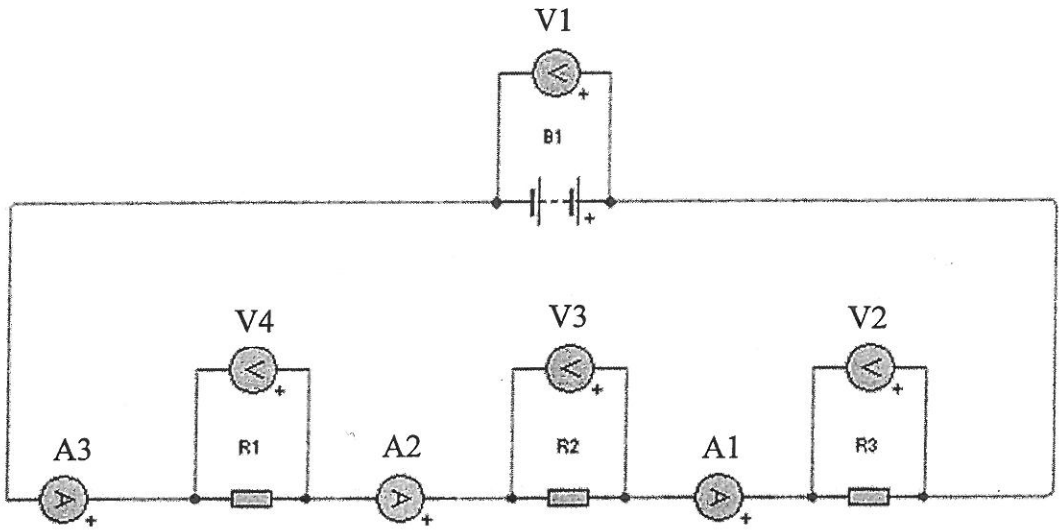
(1 mark)

7) Comparing the amount of current going through points A, D and G, the order from the greatest amount of current to the least is

Circle the correct answer: A, D then G G, A then D (G, D then A) (1 mark)

5

For questions 8 & 9 consider the following diagram



8) Make a statement which describes the relationship between V1, V2, V3 and V4? (1 mark)

written exp.

$V_1 = V_2 + V_3 + V_4$ (verbal ok) ✓

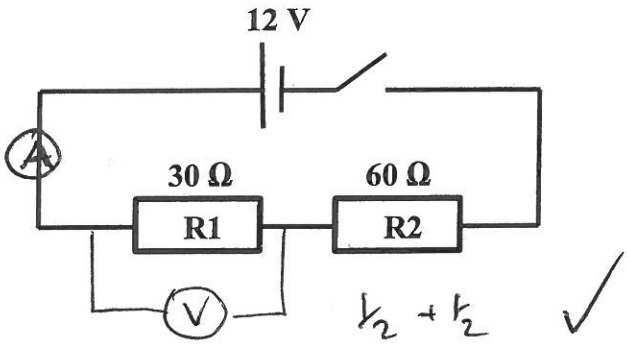
9) Make a statement which describes the relationship between A1, A2, A3. (1 mark)

$A_1 = A_2 = A_3$ (written OK) ✓

2

Section Two: **Extended answers** **(27marks)**

Question 10



½ + ½ ✓

a) On the circuit diagram above, show how you would **connect an <u>ammeter</u>** to measure the current through R1 **and a <u>voltmeter</u>** to measure the voltage across R1. (1 mark)

b) Calculate the current flowing in this circuit when the switch is closed. (2 marks)

$$I = \frac{V}{R} = \frac{12}{90} = 0.133 \text{ A}$$

✓ ✓

c) Calculate the voltage across R1. (1 mark)

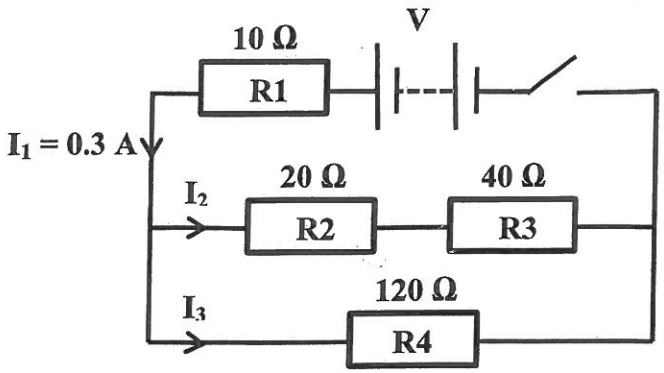
$$V = IR = 0.133 \times 30$$
$$= 4.00 \text{ V} \quad ✓$$

d) Calculate the voltage across R2. (1 mark)

$$V = IR = 0.133 \times 60$$
$$= 8.00 \text{ V} \quad ✓$$

5

Question 11



a) Calculate the total resistance of this circuit. (2 marks)

$R_{tot} = \left((R_2+R_3)^{-1}+R_4^{-1}\right)^{-1}+R_1$ ✓

$= (60^{-1}+120^{-1})+10 = 50.0\ \Omega$ ✓

b) Calculate the voltage across the parallel part of the circuit. (2 marks)

$V_{tot} = I_1 R_{tot} = 0.3\times 50 = 15$ V ✓

$V_{R1} = I_1 R_1 = 0.3\times 10 = 3$ V

$V_{11} = V_{tot} - V_{R1} = 15-3 = 12.0$ V ✓

c) Determine the current, I_3, through R4. (1 mark)

$I = V/R$

$= 12/120$

$= 0.100$ A ✓

d) Determine the current I_2. (1 mark)

$I_2 = I_1 - I_3 = 0.3 - 0.1 = 0.2$ A ✓

e) Calculate the voltage of the battery. (1 mark)

15 V ✓

7

Question 12 **(6 marks)**

Electricity supplied to your home will typically be single phase and consist of two wires – a neutral wire and an active wire. The active wire will be connected to your house via an electricity meter and a main switch. The neutral wire will be connected to earth.

(a) Explain why the active wire, rather than the neutral wire, is connected to the main switch. (2 marks)

- When working with electrical circuit in the house, or in the case of a fault, the main switch is used to isolate the house from supplied electrical potential. ✓
- Placing the switch on the active line ensures the house is at zero potential and no wires or appliances could be energised. ✓

(b) Some electrical appliances in the home do not have an earth pin on their electrical plug. Suggest a reason as to why an electrical appliance, for example a hair dryer, may not have an earth pin. (2 marks)

- An earth pin is not needed for appliances with double insulation ✓
- Appliances with plastic (or other electrically insulating) cases typically have two insulating barriers between the electrical mechanism/wires & the user. ✓

(c) What is the purpose of the earth wire? (2 marks)

- The earth wire is present as a safety mechanism in the advent of a malfunction or damage to an appliance.
- If an appliance becomes energised due to a fault, it is potentially a safety hazard.
- The earth wire provides a low-resistance path for electric current to flow, which protects users from electrocution. ✓✓

any 2.

6

Question 13 **(4 marks)**

(a) Describe the purpose of a residual current device (RCD) and explain how it functions. (2 marks)

- Purpose: to protect against electric shock (or other earth leakage) ✓
- Function: it detects any imbalance between the current in and out of the active & neutral wire & quickly breaks the circuit. ✓

(b) Explain the difference between a fuse and a circuit breaker. (2 marks)

(Both have the same function – to break the circuit if current exceeds design limit).

Differences: + a fuse is expendable & must be replaced when it fails. ✓

+ a circuit breaker has a switch and can be easily reset. ✓

4

Question 14 **(5 marks)**

A garden lighting system consists of 4(four), 13 Ω lights, connected in parallel. The system is driven by a 12 V solar panel. A safety feature of the circuit is a trip switch, which is designed to cut the power if the current in the circuit exceeds 8.00 A.
Not happy with number of lights, a home handyman wanted to connect extra lights to the system
How many lights can he have in the system without tripping the safety switch? Show all calculations required.

Minimum resistance $\Rightarrow$ $R_{tot} = \frac{V}{I}$

$= \frac{12}{8}$

$= 1.5\,\Omega$ ✓

OR $I_{Lamp} = \frac{V}{R} = \frac{12}{13} = 0.923A$

no. of lamps $= \frac{\text{Total Current}}{\text{Current for one lamp}}$

$= \frac{8}{0.923} = 8.67$

$\therefore$ 8 Lamps is max.

|| resistors $R_{tot}^{-1} = R_1^{-1} + R_2^{-1} + \dots R_n^{-1}$

but $R_1 = R_2 = R_3 \dots$ ie

ie $R_{tot}^{-1} = R^{-1} + R^{-1} + \dots R_n^{-1}$ ✓

$= nR^{-1}$

$n = \frac{R_{tot}^{-1}}{R^{-1}}$

$= \frac{1.5^{-1}}{13^{-1}}$ ✓

$= \frac{13}{1.5} = \underline{8.67}$ ✓

ie max $= \underline{8}$ ✓

(or use trial & error, but must clearly show that 8 is OK, 9 is not for full marks)

10

5

Section Three: Comprehension and Interpretation (8 marks)

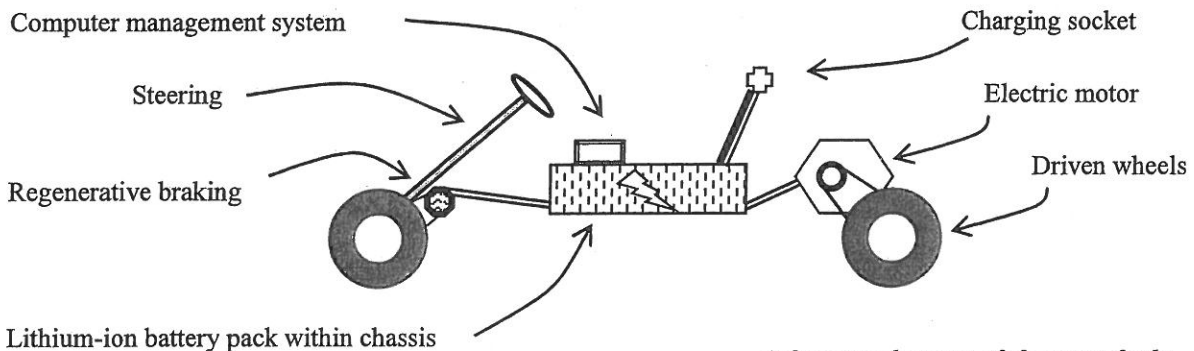
Question 15 Full Battery Electric Vehicles

Vehicles powered by the internal combustion engine (ICE) have been in use for over a century. The operating principles of the engine are practically unchanged and they are still very inefficient. Alternative forms of propulsion are now receiving serious consideration.

Earth's finite energy resources are being used unsustainably and urban transport plays a major role in energy wastage and pollution that contributes to climate change. The unremitting increase in oil costs and the dramatic improvement in the performance, price and lifecycle of batteries are making a compelling case for Electric Vehicles.

Hybrid vehicles recently entered the Australian market. They have both a fuel burning engine and an electric motor with a small battery that is recharged by the engine. A full battery Electric Vehicle (EV) has an electric drive system only and is powered by batteries.

The comparatively affordable technology required for Electric Vehicles is ready now. It is a solution that produces zero emissions, has the highest motor-to-wheel efficiency and requires minimal support infrastructure.



Schematic diagram of electric vehicle

The main components of an Electric Vehicle are as follows

Battery - lithium-ion technology as used in mobile telephones and laptop computers which can provide a typical range of up to 300 km.

Electric Motor – drives the wheels with high torque, giving sports car like performance, but with a very low noise level and smooth delivery.

Regenerative Braking System - energy recovered recharges the battery.

Computerised Management System - controls all electrical systems to ensure optimal performance and durability of the battery. Also allows charging to be synchronised with off-peak electricity.

Charging socket – can be connected to a normal 240 V AC household outlet to recharge the battery in typically six to eight hours. Many councils are considering providing charging stations within cities.

Until the production volume of EVs rises significantly they will be more expensive to manufacture compared to similar sized petrol cars. Electric vehicles allow savings of up to 90% on fuel expenses and 50% on maintenance costs which makes them viable when all costs are considered.

A perceived financial risk is the lifetime and expense of the battery so some manufacturers will opt for leasing of the vehicle rather than outright purchase or leasing of the battery pack alone.

The main drawback of an EV over conventional ICE vehicles is the limited range and the time taken to recharge the battery. However, studies have shown that 99% of urban users do less than 150 km per day.

So when used as an urban vehicle that can be charged overnight, drivers should be able to adapt quickly and enjoy the benefits of this mode of transport. The EV may be the car of the future for many Australian families.

Questions

a. State 4 advantages of an EV over an ICE vehicle. (2 marks)

zero emission
high efficiency (motor-to-wheel) ✓
minimal support infrastructure
more sustainable in terms of limited energy resources ✓
quiet
etc any 4 for ½ mark each

b. Why is an EV more suited to urban driving rather than cross-country trips? (2 marks)

- limited range ✓
- takes time to charge battery ✓

c. Explain why braking is more efficient on an EV compared to a conventional ICE car by describing the energy transformations in each case. (2 marks)

Traditional : x braking converts KE of the car into heat (in the brake pads) which is wasted to the atmosphere ✓

EV x braking converts KE of the car into electric current which charges the battery – ie. not wasted ✓

d. The computer management system controls a component in the vehicle called an inverter. This enables household electricity to be used to charge the battery and is needed because of fundamental difference between the electricity from a household socket and the electricity in a battery. What is this fundamental difference? (2 marks)

household – AC ✓

batteries – DC ✓

(must be clear which is which for 2 marks)