11 ATAR Physics

Electrical Physics Unit Test 2016

Name: SOLUTIONS

Mark: / 61

= %

Time Allowed: 50 minutes

Notes to Students:

- You must include **all** working to be awarded full marks for a question.
- Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
- **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(10 marks)**

A calculator has a rated operating current of 5.00 mA and a voltage of 1.50 V

(a) Calculate the number of electrons that flow through a point in the calculator every minute.

(4 marks)

I = 5.00 x 10^3 A

e- = 1.60 x 10^{-19} C

q = ?

t = 60 s

q = I t (1)

= 5 x 10^3 x 60

= 0.300 C (½)

$n = \frac{0.300}{1.60\times10^{-19}}$ (1)

= 1.88 x 10^{18} electrons (1)

(b) The battery in the calculator can supply a constant charge of 4.86 x 10^3 C at the rated current. Calculate the operating time, in hours, the calculator can be used for.

(3 marks)

q = 4.86 x 10^3 C

I = 5.00 x 10^3 A

t = ?

q = I t (1)

$t = \frac{q}{I}$

$= \frac{4.86\times10^{3}}{5.00\times10^{-3}}$ (½)

= 972,000 s $= \frac{972000}{60\times60} = 270$ hours (½) (1)

(c) Calculate the amount of energy each electron transfers as it passes through the calculator.

(3 marks)

q = 1.60 x 10^{-19} C

V = 1.50 V

W = qV (1)

= 1.60 x 10^{-19} x1.50 (1)

= 2.40 x 10^{-19} J (1)

Question 2 **(9 marks)**

An air-conditioning unit of a house has a power rating of 2.50 kW at 240 V. It is turned on in the middle of summer at 3:00 pm and runs continuously until 10:00 pm. The cost of electricity at this time is 28.0 cents per kWh.

(a) Calculate the amount of energy, in MJ, the air-conditioner uses in this time period.

(3 marks)

t = 7 hours x 60 x 60 ½

= 2.52 x 10^4 s

P = 2.50 x 10^3 W

E = P t 1

= 2.52 x 10^4 x 2.50 x 10^3 ½

= 63.0 MJ 1

(b) Calculate the cost of running the air-conditioner for this time period.

(3 marks)

Cost = Power x time x Rate

= 2.50 x 10^3 x 7 x 28.0 2

= 490 c 1

= $4.90

-1 if not in hours
-1 if not in kW

(c) The air-conditioner has a 'power saving mode' which reduces the power rating to 1.60 kW at 240 V. Calculate how much money would be saved in this time period if the power saving mode was used.

(3 marks)

$\$4.90 \times \frac{1.60}{2.50} = \$3.14$ 1

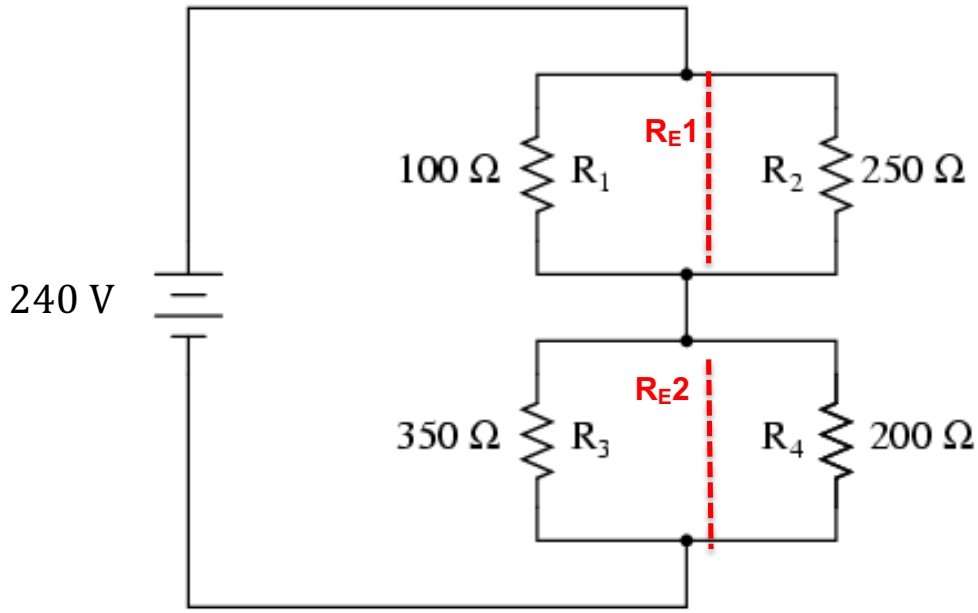
Or a similar ratio method used

$4.90 – 3.14 = $1.76 savings 1

1

Question 3 **(8 marks)**

Consider the following circuit:



(a) Calculate the total resistance of the circuit. [3 marks]

$\frac{1}{RE1} = \frac{1}{100} + \frac{1}{250} = \frac{7}{500}$ $\therefore R_E1 = \frac{500}{7} = 71.4\ \Omega$ (1)

$\frac{1}{RE2} = \frac{1}{350} + \frac{1}{200} = \frac{11}{1400}$ $\therefore R_E2 = \frac{1400}{11} = 127\ \Omega$ (1)

$R_T = 71.4 + 127$

$= 198\ \Omega$ (1)

(b) Calculate the current that flows through R_1 [3 marks]

$V = I R$ (1)

$I = \frac{240}{198}$

$= 1.21$ A (½)

$V_{drop} = IR_E$

$= 1.21 \times 71.4$

$= 86.4$ V (½)

$I_{R1} = \frac{V}{R}$

$= \frac{86.4}{100} = 0.864$ A (1)

(c) Calculate the voltage across R_4

[2 marks]

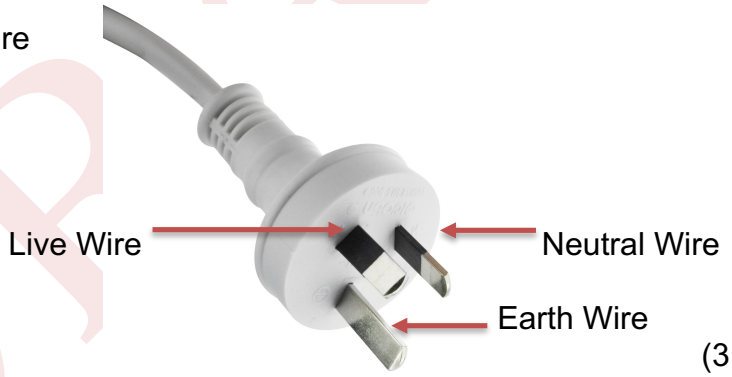
$V = I_T . R_{E2}$ (1) OR $V = \mathcal{E} - V_{RE2}$ (1)

$= 1.21 \times 127 = 154$ V (1) $= 240 - 86.4 = 154$ V (1)

Question 4 **(6 marks)**

There are many safety features incorporated into household electrical circuits to protect the occupants of the house. Explain how the following safety features operate.

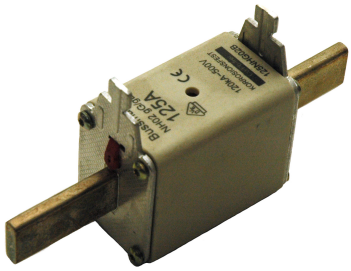
Safety Feature 1: Earth Wire



(3 marks)

- Earth wire is connected to the external metal casing of the appliance.
- In the event of the live wire coming in contact with the metal casing, the earth wire provides a neutral path of very low resistance to earth.
- Ensuring the majority of the current flows through the earth wire to earth and not the consumer

Safety Feature 2: Fuse



(3 marks)

- As the current in the wire of the fuse increases, so does the temperature (as $P = I^2 R$.
- Which melts and creates an open circuit if the current exceeds a rated value
- Preventing fire/thermal hazards in the circuit.

Question 5 **(5 marks)**

A student wishes to determine the electrical resistivity of a steel rod. The length is measured as 43.5 cm and the diameter is measured as 1.80 cm. The student places the rod in a circuit and measures the voltage across the rod as 4.50 V and the current passing through the rod as 2.20 Amps

Calculate the resistivity of the steel used to manufacture the rod.

$R = \frac{V}{I}$ (1)

$= \frac{4.50}{2.20}$ (½)

= 2.05 Ω (½)

$A = \pi \left(\frac{1.80 \times 10^{-2}}{2}\right)^2$ (½)

= 2.54 x 10^{-4} m^2

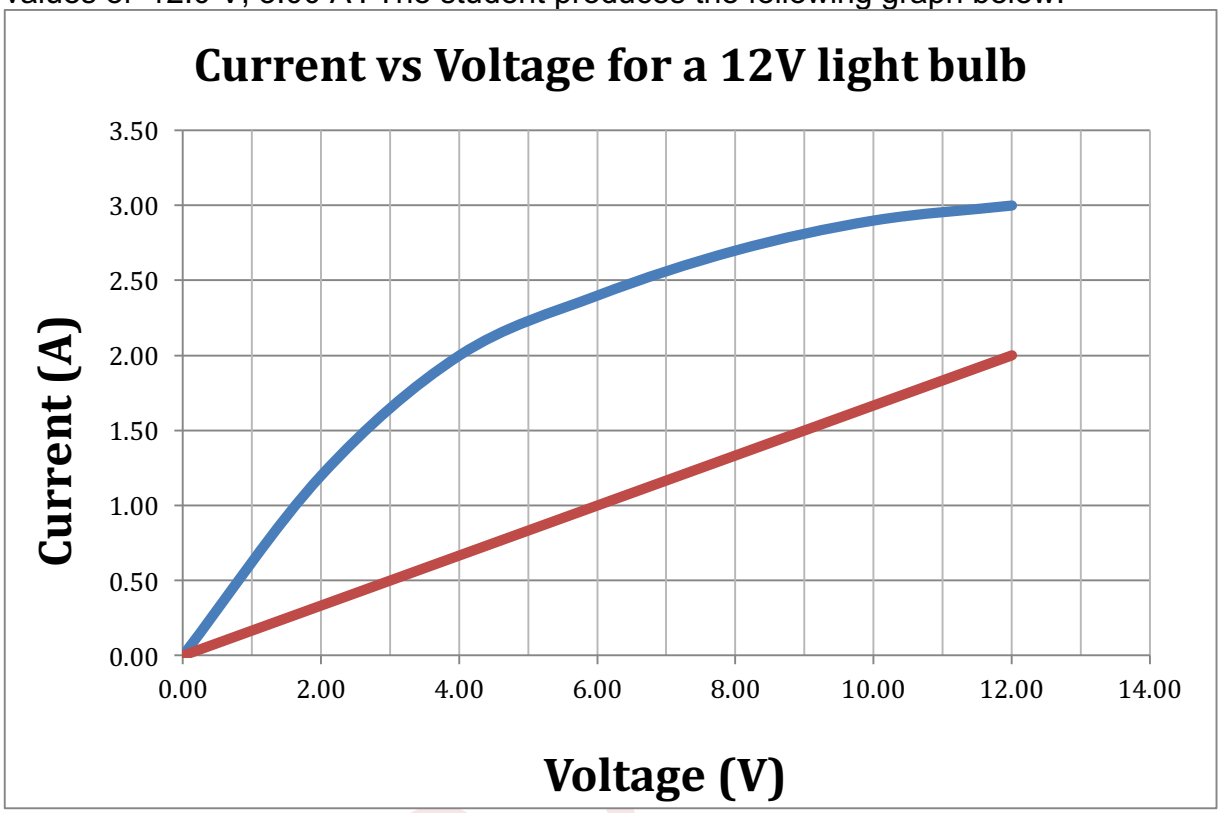
$R = \frac{\rho L}{A}$ (1) $\therefore \rho = \frac{RA}{L}$

$= \frac{2.05\ (2.54 \times 10^{-4})}{0.435}$ (½)

= 1.20 x 10^{-3} Ω.m (1)

Question 6 **(7 marks)**

A student varies the potential difference across a lamp bulb and records the current running through it. On the side of the lamp bulb is stamped the intended operating values of '12.0 V, 3.00 A'. The student produces the following graph below:



(a) Calculate the resistance of the light bulb at the intended operating voltage of 12.0 V.

(2 marks)

I = 3.00 A V = I R $R = \frac{V}{I}$ ½

V = 12.0 V $= \frac{12}{3}$ ½

= 4.00 Ω 1

(b) State if the light bulb ohmic or non-ohmic. Provide an explanation for your answer.

(2 marks)

Non-Ohmic 1

Non linear V-I Characteristic 1 OR Resistance changes over a range of voltages 1

(c) A student then obtains a 6.00 Ω resistor and varies the voltage from 0.00 to 12.0 V. Sketch the I-V Characteristic curve for the resistor on the graph above for this voltage range. Include any calculations you require in the space below.

(3 marks)

1 mark for working out

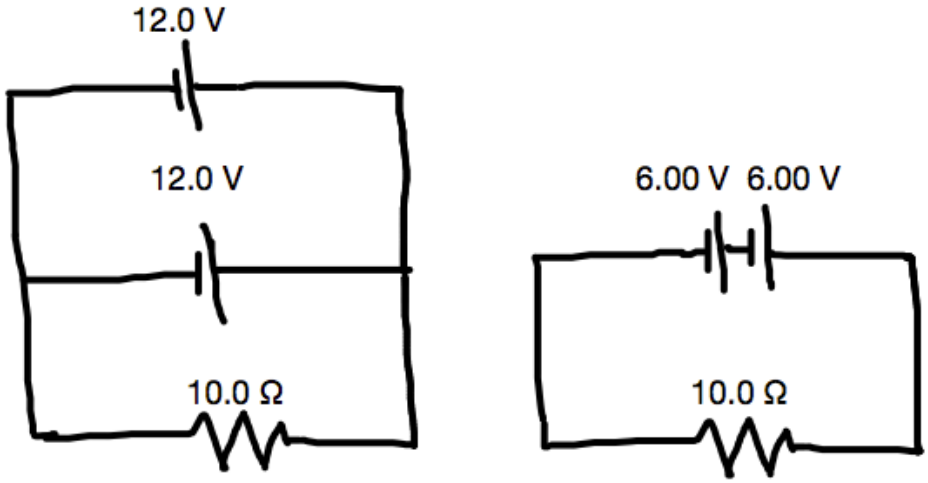
1 mark for Ohmic (linear plotting) 1 mark for ending at (12.00, 2.00)

Question 7 **(7 marks)**

A student has a 10.0 Ω electrical component that requires a voltage of 12.0 V. He has two 6.00 V cells and two 12.0 V cells.

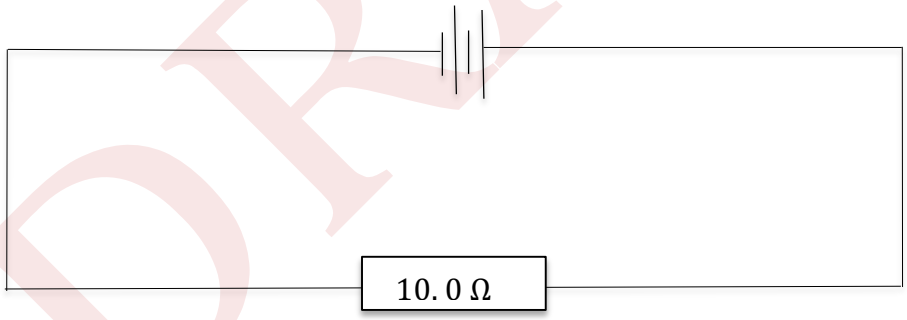
(a) Draw two circuit diagrams showing the different ways the student could arrange **only two** cells in a circuit in order for the electrical component to operate at 12.0 V

(4 marks)



- -1 mark if polarity of cells are opposed.
- -1 mark for messy diagrams

The student places a 6.00 V cell in series with a 12.0 V cell in a circuit as shown in the diagram below.



(b) Determine the current that would flow through both of the cells in this arrangement.

(3 marks)

$\mathcal{E} = 6.00 + 12.0$ (½)

= 18.0 V

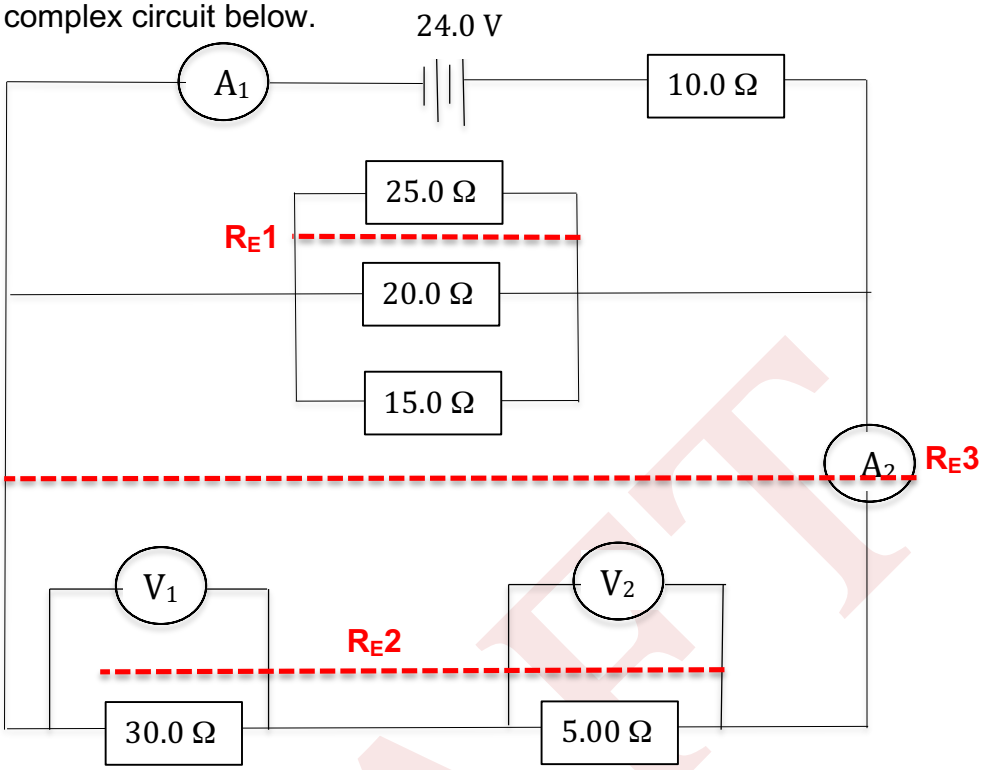
I = $\frac{V}{R}$ (1)

= $\frac{18}{10}$ (½)

= 1.80 A (1)

Question 8 **(9 marks)**

Consider the complex circuit below.



(a) Calculate the total resistance of the circuit. (4 marks)

$\frac{1}{RE1} = \frac{1}{25} + \frac{1}{20} + \frac{1}{15} = \frac{47}{300}$ $\therefore R_E1 = \frac{300}{47} = 6.38\ \Omega$ (1)

$R_E2 = 30.0 + 5.00 = 35.0\ \Omega$ (½)

$\frac{1}{RE3} = \frac{1}{6.38} + \frac{1}{35} = \frac{2069}{11165}$ $\therefore R_E3 = \frac{11165}{2069} = 5.40\ \Omega$ (1)

(½)

$R_T = 5.40 + 10.0$
$= 15.4\ \Omega$ (1)

(b) Calculate the total current the flows in the circuit. (2 marks)

$I_T = \frac{\mathcal{E}}{R_T}$ (½)

$= \frac{24.0}{15.4} = 1.56$ A (1) (½)

(c) Determine the current that flows through A_2 (3 marks)

$V_P = I_T R_{E3}$ (½)

$= 1.56 \times 5.40$
$= 8.42$ V (1)

$I_2 = \frac{V_P}{RE2}$ (½)

$= \frac{8.42}{35.0} = 0.241$ A (1)

End of Test