Western Australian Certificate of Education
ATAR course examination, 2020

Question/Answer Booklet

11 PHYSICS

Test 4 - Electricity

Name Solutions

Student Number: In figures

Mark: $\frac{}{42}$ In words

Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: fifty minutes

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate

Standard items: pens, (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

Important note to candidates

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

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers					
Section Two: Problem-solving	8	8	50	42	100
Section Three: Comprehension					
				Total	100

Instructions to candidates

1. The rules for the conduct of examinations at Holy Cross College are detailed in the College Examination Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

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

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

6. Answers to questions involving calculations should be ***evaluated and given in decimal form.*** It is suggested that you quote all answers to ***three significant figures***, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are ***clearly and legibly set out***.

7. Questions containing the instruction "estimate" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

8. Note that when an answer is a vector quantity, it must be given with magnitude and direction.

9. In all calculations, units must be consistent throughout your working.

1. The potential difference between a cloud and the earth of 1.00 x 10^9 V results in a lightning flash during which 40.0 C of charge flows in 1.11 x 10^{-2} seconds.

(a) How many electrons were in the discharge? (2 marks)

$$n(e) = \frac{40.0}{1.60 \times 10^{-19}} \quad (1)$$

$$= \underline{2.50 \times 10^{20}} \quad (1)$$

(b) Calculate the average current that flowed. (2 marks)

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

$$= \frac{40.0}{1.11 \times 10^{-2}} \quad (1)$$

$$= \underline{3.64 \times 10^{3}\ A} \quad (1)$$

2. A proton in the Large Hadron Collider is accelerated from rest by a high voltage to 99.999% the speed of light. Determine the magnitude of the voltage required. (3 marks)

$$W = Vq = \frac{1}{2} mv^2$$

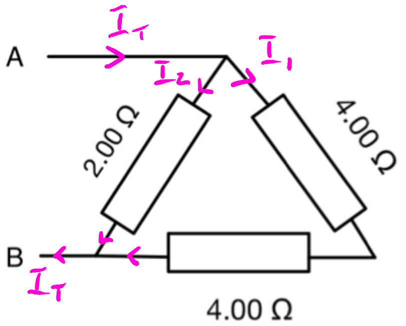
$$\Rightarrow \quad V = \frac{mv^2}{2q} \quad (1)$$

$$= \frac{(1.67 \times 10^{-27})(99.999 \times 3.00 \times 10^{8})^2}{2(1.60 \times 10^{-19})} \quad (1)$$

$$= \underline{4.70 \times 10^{12}\ V} \quad (1)$$

3. Determine the effective resistance of the following arrangement of resistors. (4 marks)

(a)

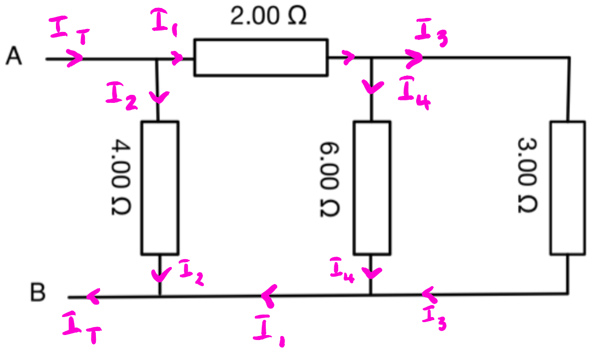


$$\frac{1}{R_T} = \frac{1}{2.00} + \frac{1}{(4.00+4.00)} \quad (1)$$

$$= 0.625$$

$$\therefore R_T = 1.60\ \Omega \quad (1)$$

(b)



$$\frac{1}{R_x} = \frac{1}{3.00} + \frac{1}{6.00}$$

$$= 0.500$$

$$\Rightarrow R_x = 2.00\ \Omega \quad (1)$$

$$\frac{1}{R_T} = \frac{1}{4.00} + \frac{1}{(2.00+2.00)}$$

$$= 0.500$$

$$\Rightarrow R_T = 2.00\ \Omega \quad (1)$$

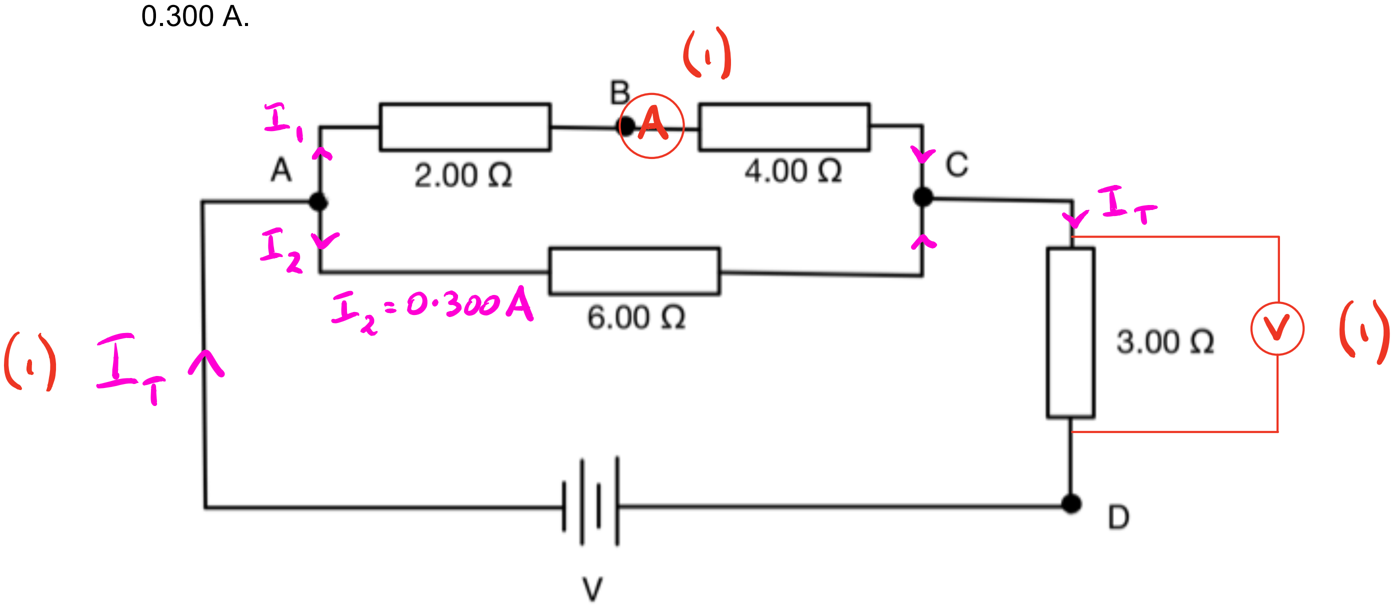
4. A 12.0-volt car battery is capable of supplying a current of 1.52 A for 30.0 hours. How much heat energy is produced in completely draining the battery? (3 marks)

$$W = Q = VIt \quad (1)$$

$$= (12.0)(1.52)(30.0 \times 24.0 \times 3.60 \times 10^3) \quad (1)$$

$$= 1.58 \times 10^6\ \text{J} \quad (1)$$

5. A student set up the following circuit and measured the current in the 6.00 Ω resistor as 0.300 A.



(a) On the diagram, draw the following: (3 marks)

- direction of electron flow
- position of the ammeter to measure the current in the 4.00 Ω resistor
- position of a voltmeter to measure the potential difference across the 3.00 Ω resistor

(b) Determine the potential difference across the 6.00 Ω resistor. (2 marks)

$$V_{AC} = I_2 R_{6\Omega}$$
$$= (0.300)(6.00) \quad (1)$$
$$= \underline{1.80\text{ V}} \quad (1)$$

(c) What current would be measured in the 4.00 Ω resistor? (2 marks)

$$V_{AC} = I_1 R_{(2+4)\Omega}$$
$$\Rightarrow \quad I_1 = \frac{1.80}{(2.00 + 4.00)} \quad (1)$$
$$= \underline{0.300\text{ A}} \quad (1)$$

Could also do this by inspection. As the resistance in both branches is the same (6.00 Ohms), the currents must be the same.

(d) Calculate the potential difference V supplied by the battery. (3 marks)

$$I_T = I_1 + I_2$$
$$= 0.300 + 0.300$$
$$= 0.600\ A \quad (1)$$

$$V_{CD} = I_T R_{3\Omega}$$
$$= (0.600)(3.00)$$
$$= 1.80\ V \quad (1)$$

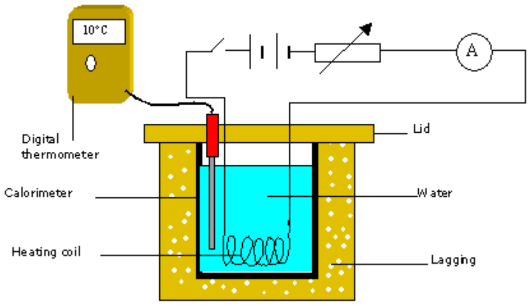
$$V_T = V_{AC} + V_{CD}$$
$$= 1.80 + 1.80$$
$$= \underline{3.60\ V} \quad (1)$$

Could also work out the total resistance (6.00 Ohms) and multiply by the total current.

(e) What power is generated in the 3.00 Ω resistor? (3 marks)

$$P_{3\Omega} = I_T^2 R_{3\Omega} \quad (1)$$
$$= (0.600)^2(3.00) \quad (1)$$
$$= \underline{1.08\ W} \quad (1)$$

6. A well-insulated copper calorimeter of mass 95.0 g contains 195 g of water at 10.0 °C. A heating coil is placed in the water and connected to a power source as shown. The temperature of the water rises to 25.0 °C in 7.50 minutes while the ammeter reads 2.75 A. Assume 100% of the heat generated by the heating coil is absorbed by the copper and water. (c_{Cu} = 3.90 x 10^2 $Jkg^{-1}K^{-1}$)



(a) Calculate the amount of electrical energy converted into heat energy. (3 marks)

$$W = Q = m_w c_w \Delta T + m_{Cu} c_{Cu} \Delta T \quad (1)$$
$$= (0.195)(4.18 \times 10^3)(15.0) + (0.0950)(3.90 \times 10^2)(15.0) \quad (1)$$
$$= \underline{1.28 \times 10^4\ J} \quad (1)$$

(b) Determine the power generated in the heating coil. (3 marks)

$$P = \frac{W}{t} \quad (1)$$

$$= \frac{1.28 \times 10^4}{(7.50 \times 60.0)} \quad (1)$$

$$= \underline{28.4\ W} \quad (1)$$

(c) What is the potential difference across the heating coil? (2 marks)

$$P = \frac{W}{t} = VI$$

$$\Rightarrow \quad V = \frac{P}{I} \quad (1)$$

$$= \frac{28.4}{2.75} \quad (1)$$

$$= \underline{10.3\ V} \quad (1)$$

7. A 17.9 kW reverse-cycle air conditioner is used to cool a home. It operates on 415 V supply and is used by the family over five months of warm to hot weather for an average of 3.5 hours per day. If the cost of electricity is 28.8 cents per unit (kWh), ***ESTIMATE*** the cost of running the machine. (1.00 unit = 1.00 kWh = 3.60 x 10^6 J) (4 marks)

ESTIMATE: 150 days in 5 months (1)

$$\text{Cost} = P(\text{kW}) \times t(\text{h}) \times r \quad (1)$$

$$= (17.9)(150 \times 3.50) \times 28.8$$

$$= 2.7 \times 10^5 \text{ cents} \quad (1)$$

$$= \underline{\$2700}$$

(1-2 sig fig only - 1 mark)

8. A household electrical circuit includes components that protect people when using electrical devices. The fuse has been replaced by circuit breakers and residual current devices in new homes.

Choose either a 'circuit breaker' or a 'residual current device' and describe how it protects people from electric shock and why it is better than a fuse. (3 marks)

Circuit breaker: detects if the current exceeds the maximum.

RCD: detects change in current in active and neutral.

(Either - 1 mark)

Both shut off very quickly (< 30 ms). (1)

Fuse takes much longer to melt - person may feel a shock. (1)