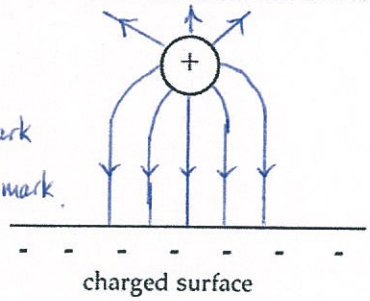
2A/B PHYSICS
ASSIGNMENT 5: ELECTRICITY

NAME: SOLUTIONS **DUE DATE:** _____ **TOTAL:** ___/45

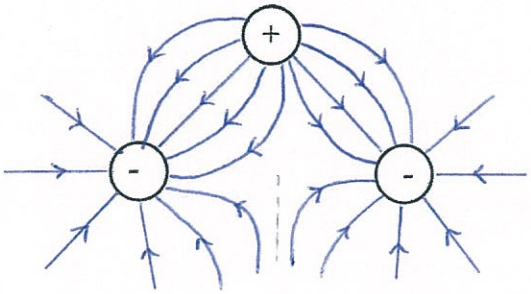
1. Draw the electric field associated with the following charged objects.

(a)



Shape - 1 mark
Direction - 1 mark

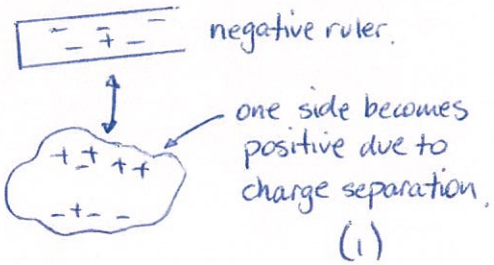
(b)



(4)

2. (a) Explain why a plastic ruler that has been rubbed on a woollen jumper can attract small pieces of paper. A diagram may help your explanation.

(HINT: Some degree of "charge separation" will occur on the paper.)



- The negative rod repels some electrons from the nearest edge of the paper. (1)
- Opposite charges then attract. (1)

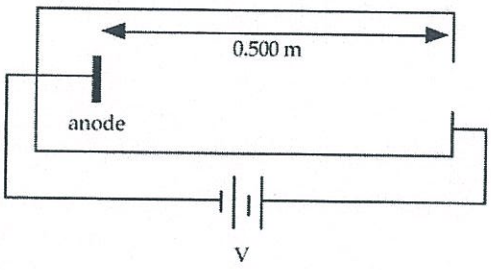
(3)

(b) Why does this not work very well if the air has high humidity?

- The water in the air is a moderate conductor. (1)
- Electrons are able to flow into the water. (1)

(2)

3. A particle accelerator has an anode and cathode separated by 0.500 m in a vacuum as shown. An ion of +2 charge and mass 6.68×10^{-27} kg is introduced near the anode and accelerated towards the cathode by a high potential difference V.



(a) Explain why the charged ion moves between the anode and the cathode.

- An electric field is set up between the anode and the cathode. (1)
- The positive charge moves away from the anode in the direction of the electric field. (1)

(2)

(b) Calculate the potential difference required to accelerate the ion to 0.750 times the speed of light.

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

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

$= \frac{(6.68\times10^{-27})(0.750\times3.00\times10^{8})^2}{2(2\times1.60\times10^{-19})}$ (1)

$= 5.284\times10^{8}\ V.$

$\therefore V = 5.28\times10^{8}\ V$ (1).

(3)

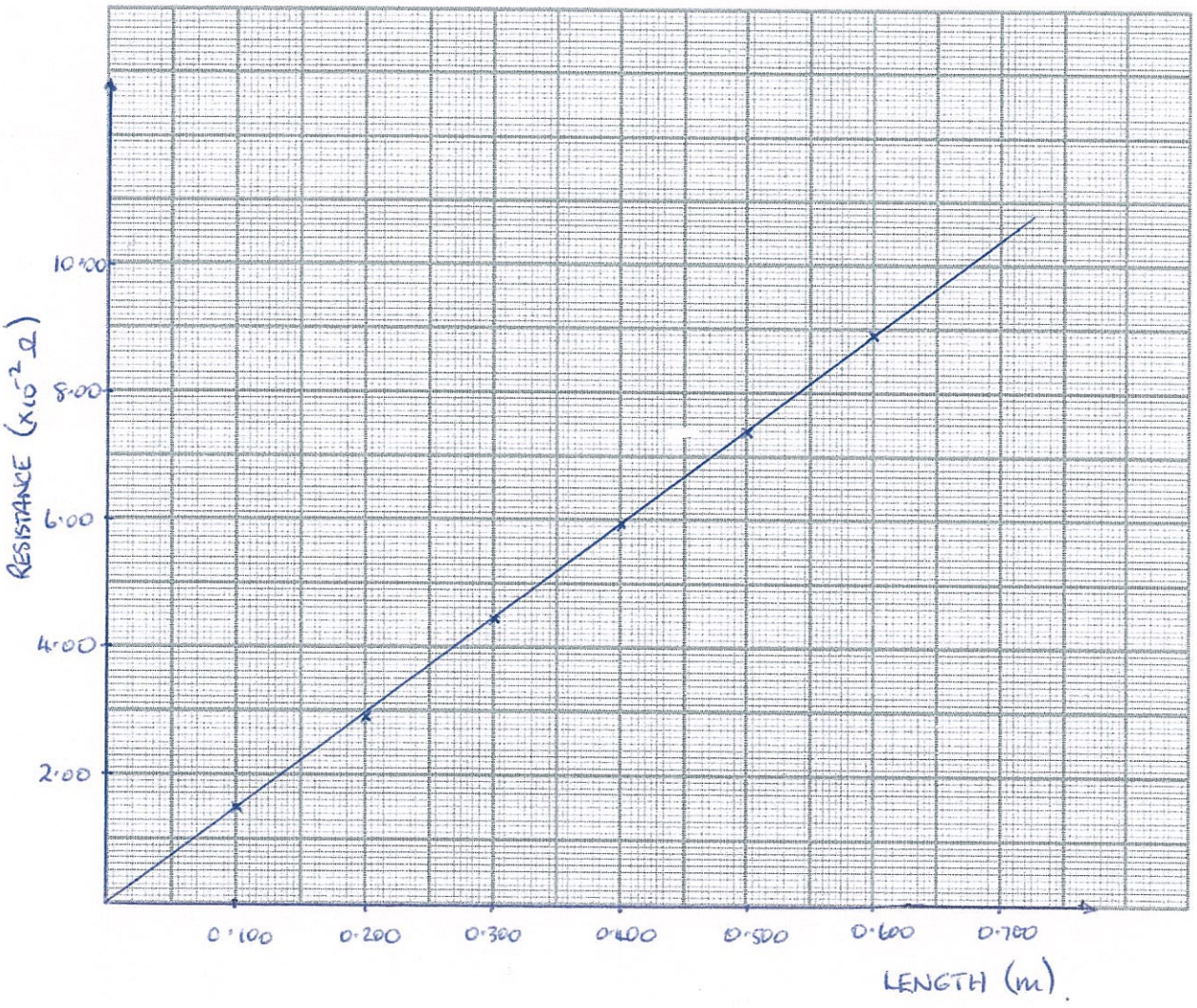
4. A group of students were given the task of identifying the metal used in a piece of wire by determining its resistivity. Using multimeters to record the voltage and current for a variety of lengths of the wire, they obtained the results show below. Ohm's Law was used to calculate the resistance R. The diameter of the wire was measured as 0.490 mm with a micrometer.

$$R = \frac{\rho l}{A}$$

Scales - 1 mark
Labels - 1 mark
Plotting - 1 mark.

Length (l) (m)	Resistance (R) (x 10^{-2} Ω)
0.100	1.51
0.200	2.92
0.300	4.44
0.400	5.94
0.500	7.38
0.600	8.90

(a) Graph these results, with R on the vertical axis. (3)



(b) Use the graph to determine the resistivity of the metal in the wire, and hence name the metal.

gradient $= \frac{R}{\ell} = \frac{(10.4 \times 10^{-2} - 0)}{(0.700 - 0)}$

$= 0.149\ \Omega m^{-1}$. (1)

$\rho = \frac{RA}{\ell}$

$= (\text{gradient})\pi r^2$ (1)

$= (0.149)\pi (0.245 \times 10^{-3})^2$

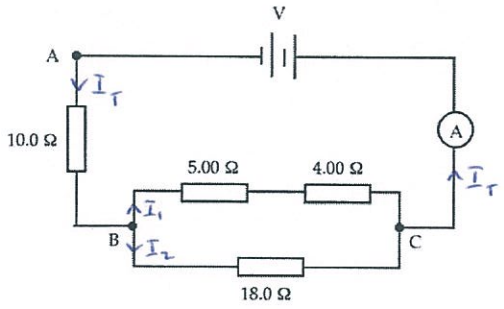
$= 2.81 \times 10^{-8}\ \Omega m$. (1)

∴ Metal is aluminium. (1)

* must use the gradient.

(4)

5. A compound circuit is set up as follows. The current through the 18.0 Ω resistor is 0.333 A.



(a) Calculate the potential drop across the 18.0 Ω resistor.

$V_{BC} = I_2 R_{18\Omega}$

$= (0.333)(18.0)$ (1)

$= 5.994\ V$

∴ $V_{BC} = 5.99\ V$. (1)

(2)

(b) What current is measured on the ammeter?

$V_{BC} = I_1 R_{9.00\Omega}$

$\Rightarrow I_1 = \frac{5.994}{9.00}$ (1)

$= 0.666\ A.$ (1)

$I_T = I_1 + I_2$

$= 0.333 + 0.666$

$= \underline{0.999\ A.}$ (1)

(3)

(c) Determine the potential difference across the electricity source.

$\frac{1}{R_{BC}} = \frac{1}{18.0} + \frac{1}{9.00}$

$= \frac{1.00 + 2.00}{18.0}$

$\Rightarrow R_{BC} = \frac{18.0}{3.00}$

$= 6.00\Omega.$ (1)

$R_T = R_{AB} + R_{BC}$

$= 10.0 + 6.00$

$= 16.0\Omega.$ (1)

$V_T = I_T R_T$

$= (0.999)(16.0)$

$= 15.98\ V$

$\therefore V_T = \underline{16.0\ V.}$ (1)

(3)

(d) What power is consumed within this circuit?

$P = V_T I_T$

$= (15.98)(0.999)$ (1)

$= 15.96\ W$

$\therefore P = \underline{16.0\ W}$ (1)

(2)

6. A solar hot water system has a 3.60 kW heater that is used to heat water overnight if needed. It operates at 2.40×10^2 V. The water is heated from 15.0 °C to 70.0 °C overnight, using 6.86×10^7 J of energy. Assume 100% of the electrical energy is used to heat the tank.

(a) Calculate the time taken to heat the water.

$$P = \frac{E}{t}$$

$$\Rightarrow t = \frac{E}{P}$$

$$= \frac{6.86 \times 10^7}{3.60 \times 10^3} \quad (1)$$

$$= 1.906 \times 10^4 \text{ s}$$

$$\therefore t = 1.91 \times 10^4 \text{ s} \quad (1)$$

(2)

(b) If the cost of a unit of electricity is 13.47 cents, calculate how much it costs to heat the water.

$$t = 1.906 \times 10^4 \text{ s} = 5.293 \text{ hrs.}$$

$$\text{Cost} = P \times t \times 13.47$$

$$= (3.60)(5.293)(13.47) \quad (1)$$

$$= 2.567 \times 10^2 \text{ cents}$$

$$\therefore \text{Cost} = \$2.57 \quad (1)$$

(2)

(c) Determine the resistance of the heater unit.

$$P = \frac{V^2}{R}$$

$$\Rightarrow R = \frac{V^2}{P}$$

$$= \frac{(2.40 \times 10^2)^2}{(3.60 \times 10^3)} \quad (1)$$

$$= 16.0 \, \Omega \quad (1)$$

(2)

7. Explain why an earth leakage device (ELD) or a residual current device (RCD) is far more effective than wire fuses in protecting humans from electric shocks in the household. Comment on how each each device works to protect us.

FUSES
- Take 6-8 times longer than RCD to melt. (1)
- Person will receive a shock - possibly fatal. (1)

RCD
- Designed to "trip" in 30ms if a current difference is detected. (1)
- Person does not feel a shock as the time is very short. (1)

(4)

8. Why is a double throw (pole) switch safer than a single throw (pole) switch?

SINGLE POLE
- Cuts the active wire only.
- Becomes a problem if the switch is wired incorrectly and the "neutral" becomes "active". ie. Appliance is always "live". (1)

DOUBLE POLE
- Cuts both the active and neutral wires. (1)

(2)