For full marks, show all your working in calculations. Give all answers to three (3) significant figures.

Additional Data & Formulae:

$F = kq_1q_2/d^2$
$k = 9.00 \times 10^9$ N m^2 C^{-2}

Question 1: [3 marks]

Rapunzel has been combing her long golden hair with a plastic comb. After she has finished, she places the comb on her plastic desk next to some small pieces of a torn up letter from Prince Charming. She notices the pieces of paper are attracted to the comb and stick to it. Explain her observation in terms of the physics principles involved.
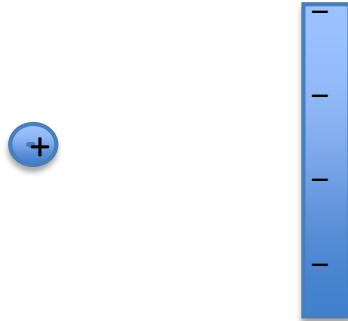
Question 2: [3 marks]

Merlin tosses two metallic balls directly up into the air and they 'magically' acquire opposite charges. Calculate the magnitude and direction of the force which exists between two balls which are 15.0 cm apart. One has a charge of +300 μC and the other has a charge of -230 μC.

Question 3: [3 marks]

Draw the electric field lines around the two charged objects in the diagram below. Include the field lines which occur in the space between them. NB: No more than 10 field lines are required.

Question 4: [3 marks]

Dr. Frankenstein passes an electric current through his 'creature' in order to bring it to life. If he uses a charge of 3.125 x 10^{23} eV for 8.00 seconds, what is the magnitude of the current which is passed through the creature.

Question 5: [2 marks]

Explain the difference between conventional current and electron flow?

Question 6: [8 marks]

Calculate the following:

a) Little Red Riding Hood is making tea for 'granny'. What is the power of the kettle if it draws a current of 15.0 A from the mains electricity? (2 marks)

b) The King of Hearts is mixing the batter for his tarts with a 100 W mixer (it is the Queen's day off). What current will be drawn if it is connected to a 240 V supply? (2 marks)

c) Sleeping Beauty's clock radio has failed to wake her up for 100 years. What is the power of the clock radio if it has a resistance of 1.50 kΩ and draws a current of 0.147 A? (2 marks)

d) Aladdin has swapped his old golden lamp for a shiny new "Genie" brand electric lamp. What is the power of the globe in the electric lamp if it has a resistance of 0.300 Ω and is connected to a 12.0 V dry cell? (2 marks)

Question 7: [3 marks]

A student is conducting an electrical investigation and constructs a circuit which contains a switch, a fixed resistor and a lamp all connected in series with a power pack. The student also has a voltmeter connected to measure the potential across the lamp, and an ammeter which is being used to measure the current supplied to the resistor. Draw a diagram for this circuit.

Questions 8-10 refer to the diagram below:

consider the diagram below
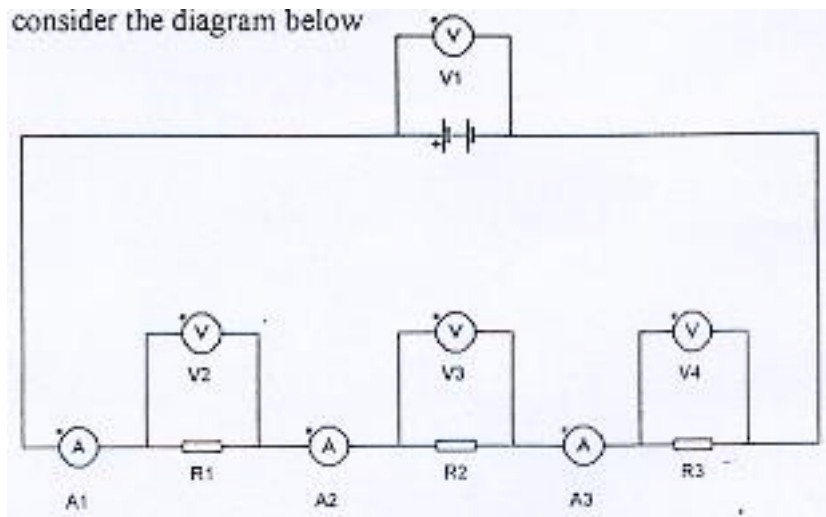
Question 8: [1 mark]

Write an equation that expresses the relationship between V_1, V_2, V_3 and V_4.
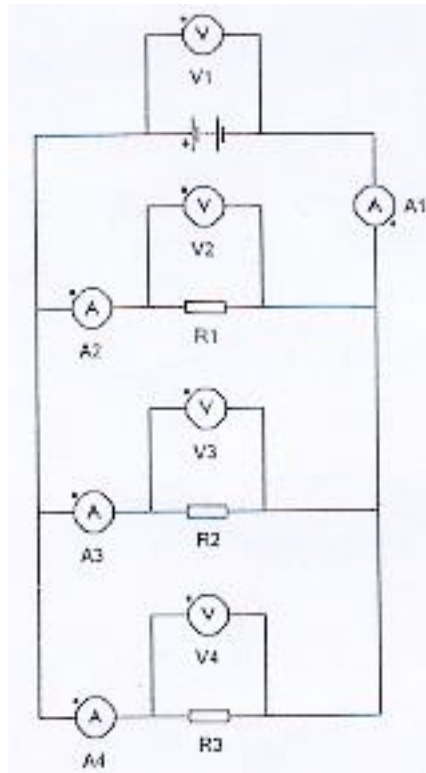
Question 9: [1 mark]

Write an equation that expresses the relationship between A_1, A_2 and A_3.

Question 10: [1 mark]

If R_1, R_2 and R_3 each have a resistance of 30.0 Ω, what is the effective resistance in the circuit?

Questions 11-13 refer to the diagram below:

Question 11: [1 mark]

Write an equation that expresses the relationship between V_1, V_2, V_3 and V_4.

Question 12: [1 mark]

Write an equation that expresses the relationship between A_1, A_2 and A_3.

Question 13: [1 mark]

If R_1, R_2 and R_3 each have a resistance of 30.0 Ω, what is the effective resistance in the circuit?

Question 14: [8 marks]

Wayne Manor has a 240 V, 1600 W electric toaster which has a power cord which is far too long and Robin keeps tripping over it and pulling the plug from the wall. Batman wants his toast so Alfred is trying to solve the problem. Alfred is definitely not an electrician! The diagram below shows the electric toaster connected to the domestic electrical circuit.
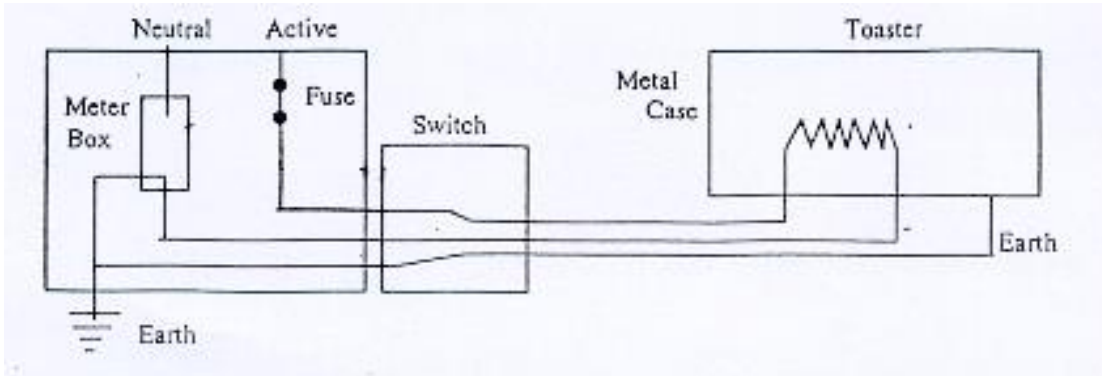
Alfred wished to shorten the cord on the toaster and began work while the plug was in and switched on. After taking off the outer metal case he undid the neutral wire from its terminal. Surprised at his good fortune (for not getting a shock!!), and realising the error of his ways, Alfred unplugged the toaster before continuing.

Give physics-based answers to the following questions:

(a) Explain why Alfred did not get a shock even though the toaster was plugged in and switched on.

(2 marks)

(b) Alfred cut the cord and reconnected the three-pin plug. In the process, however, he connected the earth wire to the active (phase) pin, and the active wire to the earth. Explain whether the toaster will still operate or not.

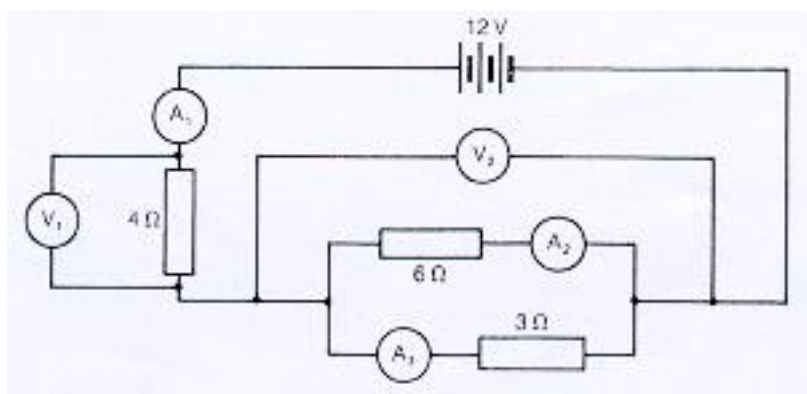(2 marks)

Question 14 (Contd)

(c) Explain the function and purpose of an RCD and whether or not it will be tripped.　　(2 marks)

(d) Is the toaster now a safety hazard? Explain.　　(2 marks)

Question 15:　　　　　　　　　　　　　　　　　　　　　　　　**[5 marks]**

In the circuit diagram below, calculate the current readings on the ammeters A_1, A_2 and A_3 and the potential difference readings on the voltmeters V_1 and V_2.

(a) Current showing on A_1:　　(1 mark)

(b) Current showing on A_2:　　(1 mark)

(c) Current showing on A_3:　　(1 mark)

Question 15 (Contd)

    (d) Potential difference showing on V_1:   (1 mark)

    (e) Potential difference showing on V_2:   (1 mark)

Question 16   **(9 marks)**

A student was investigating how current varied with voltage for two resistors combined in series in a circuit. The data obtained is presented in the table below:

Table 1: Current measured at various voltages for two resistors ("P" and "Q") combined in series.

	Voltage (V)				
	2.0	**4.0**	**6.0**	**8.0**	**10.0**
Current (A) Resistor "P"	1.0	1.8	2.5	2.8	3.0
Current (A) Resistor "Q"	1.5	3.0	4.5	6.0	7.5

    (a) plot the I-V characteristic of these two resistors on the graph below, as well as the I-V characteristic of the series combination. You may use the blank row in the table to calculate the values for the series combination.   (5 marks)

    (b) Are the resistors ohmic or non-ohmic? Give a brief reason for your answer and refer to your graph.   (2 marks)

    (c) From your graph, determine the effective resistance for the combination at 5.0 V.   (2 marks)

Question 16 (Contd)