Question 1 is COMPULSORY

Question 1

(a) Convert 6.8×10^{-5} W to the closest standard metric prefix. **[2 marks]**

(b) Convert 4.7 mA to amperes. **[2 marks]**

(c) What is the rate of flow of free electrons in a conductive material called? **[2 marks]**

(d) What is the opposition to current called? **[1 marks]**

(e) To measure current with an ammeter, how would one connect the ammeter in a circuit? **[2 marks]**

(f) For the circuit of Figure 1.1, calculate (i) the total resistance R_T and (ii) the values of the currents I_S, I_1 and I_2. **[5 marks]**

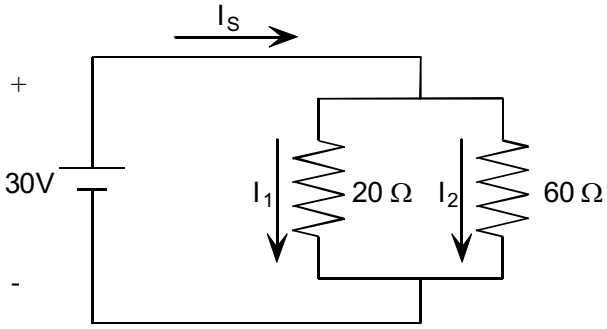

Figure 1.1

(g) What is the relationship between the power rating of a resistor and its surface area? **[2 marks]**

(h) For a circuit that contains a 50 V power supply and a 100 Ω resistor, what power rating should be assigned to the resistor? **[3 marks]**

(i) You got a bargain on a car media player at a flea market. When you got home, you discovered that it has a 6 V power supply that needs to draw 500 mA. However, your car has a 12 V system. You need a resistor that will drop 6 V at 500 mA. What value resistor do you need? **[3 marks]**

(j) A smartphone uses a small 3.6 V lithium-ion battery with a nominal stored energy of 40 kJ. For how long will it power the phone if it draws (i) 100 mA of current when making a call and (ii) 200 mA when making a video call? **[4 marks]**

(k) If a unit of electricity (1 kWh) costs 40 cents, how much will it cost to operate a 2400 W heater and twenty 10 W LED bulbs from 6:30 to 8:30 in the morning for a full week, and how many joules will be used? **[4 marks]**

[30 marks in total]

Answer any TWO questions from Questions 2, 3 and 4

Question 2

(a) State the following formulae:

(i) Kirchhoff's Current Law **[2 marks]**

(ii) Kirchhoff's Voltage Law **[2 marks]**

(iii) The Voltage Divider Rule **[2 marks]**

(iv) The Current Divider Rule **[2 marks]**

(b) The ammeter in the circuit of Figure 2.1 registers a value of 2A. Using this information, determine the value of the unknown resistor R. Proceed to calculate the power dissipated in this resistor. **[5 marks]**

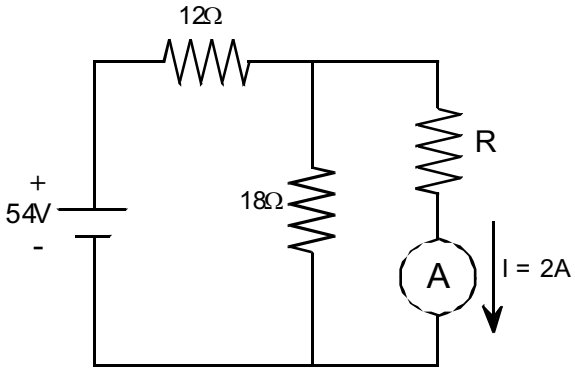

Figure 2.1

(c) For the circuit shown in Figure 2.2, use Kirchhoff's laws to calculate:

(i) The current I_1 **[2 marks]**

(ii) The current I_2 **[2 marks]**

(iii) The current I_3 **[2 marks]**

(iv) The voltage across the 45Ω resistor **[1 mark]**

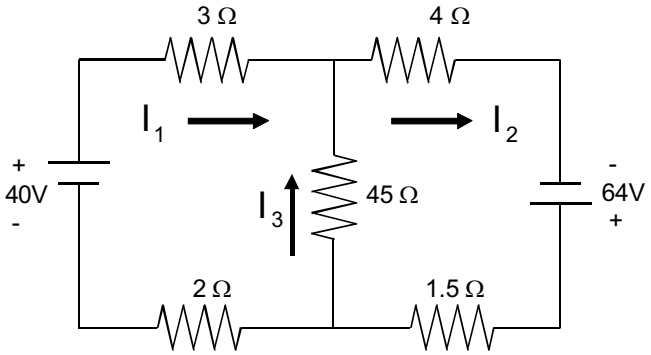

Figure 2.2

[20 marks in total]

Question 3

(a) For the circuit shown in Figure 3.1, with V_S = 5 V, calculate the total resistance for the circuit, the total current flowing out of the voltage source, and the individual currents flowing through R_1, R_2 and R_3. Repeat the calculations for V_S = 10 V. **[10 marks]**

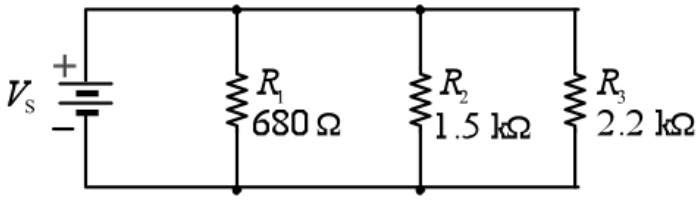

Figure 3.1

(b) A standard 12 V battery in a car is used to power four identical interior lamps in parallel, as depicted in Figure 3.2. Assume that each lamp has a resistance of 192 Ω. Explain what effects each of the following two scenarios will have on the voltage, current and resistance in the overall circuit *and* in the circuit elements in each of the branches:

(i) The conducting path through the first lamp is broken when the lamp bulb blows, **[3 marks]**

(ii) A fifth path is added through a new lamp connected in parallel with the others. **[2 marks]**

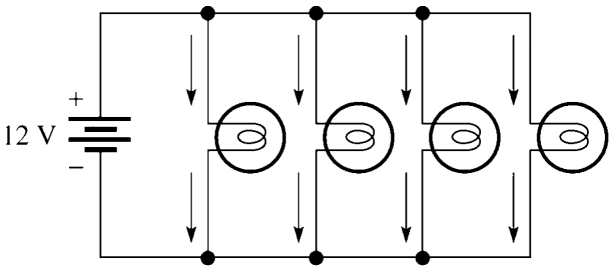

Figure 1.2

(c) For the circuit of Figure 3.3, a voltmeter placed across either of the two resistors will show a voltage of 4.47 V. Explain what is happening. **[5 marks]**

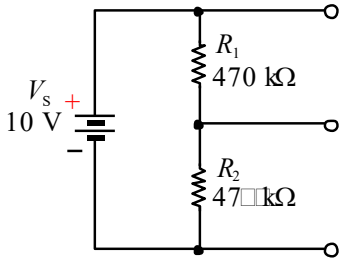

Figure 3.3

[20 marks in total]

Question 4

(a) Assume a sinusoidal input voltage of V_1 = 30 V (peak) is connected across two resistors in series, R_1 and R_2, both with a value of 1 k. Find (i) the RMS current flowing through resistor R_1, and find (ii) the RMS voltage across resistor R_2. (Hint: you can use the fact that the same sinusoidal current flows through all resistors in a series circuit.)

[7 marks]

(b) Figure 4.1 shows a Wheatstone bridge circuit. If all the resistors are equal to R, the bridge should be balanced and the output voltage (V_{OUT}) should be zero. State the relationship between the resistors, and then find R_2 if the bridge is balanced, and where R_1 = 470 Ω, R_3 = 330 Ω and R_4 = 270 Ω. **[4 marks]**

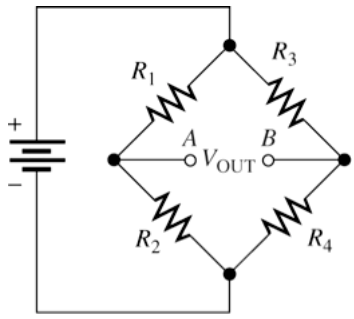

Figure 4.1

(c) For the circuit shown in Figure 4.2, calculate:

(i) The total equivalent resistance R_T, **[5 marks]**

(ii) The current I_S, **[2 marks]**

(iii) The power dissipated across the resistor R_1. **[2 marks]**

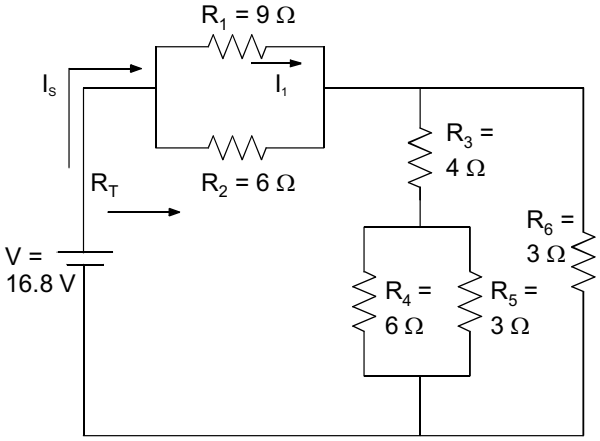

Figure 4.2

[20 marks in total]