BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

ENGINEERING AND PHYSICS DEPARTMENT

DP002/PH010 (3): ELECTRICITY AND MAGNETISM

DURATION: THREE HOURS **TOTAL MARKS: 100**

Answer **ALL** parts of Section A and any **THREE** questions from Section B. Section A carries 40 marks and Section B carries 60 marks.

Physical constants

Electronic charge, $e = 1.6 \times 10^{-19}$ C

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1}

Mass of an electron, $m_e = 9.11 \times 10^{-31}$ kg

Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ Fm^{-1}

Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ Hm^{-1}

Electric potential at infinity, $V_\infty = 0$

SECTION A

1. a. Figure 1.1 shows two protons (p_c and p) and one electron (e) on an axis.

Figure 1.1: Question 1. a.

Explaining your answer, determine the direction of

i. The electrostatic force on p_c due to e? [3]

ii. The electrostatic force on p_c due to p? [3]

iii. The net electrostatic force on the central proton? [2]

b. You are provided with three capacitors and a battery. How should you combine the capacitors and the battery in one circuit so that the capacitors will store the maximum possible energy? [4]

c. Consider two parallel plates each of area (A) separated by a distance (d) with a medium of permittivity (ε) between them as shown in Figure 1.2. [8]

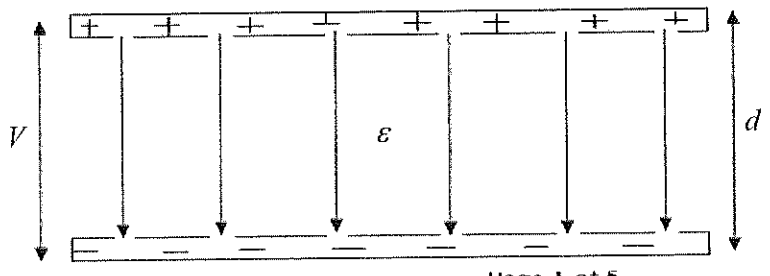

Figure 1.2: Question 1. c.

Show that the capacitance of the capacitor (C) is given by Equation 1.1.

$$C = \frac{\varepsilon A}{d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

d. iv. What is the maximum work that a constant magnetic field B can perform on a charge q moving through the field with velocity v? [3]

e. The four wires shown in Figure 1.3 all carry the same current from point A to point B through the same magnetic field. Rank the wires according to the magnitude of the magnetic force exerted on them, from greatest to least. [8]

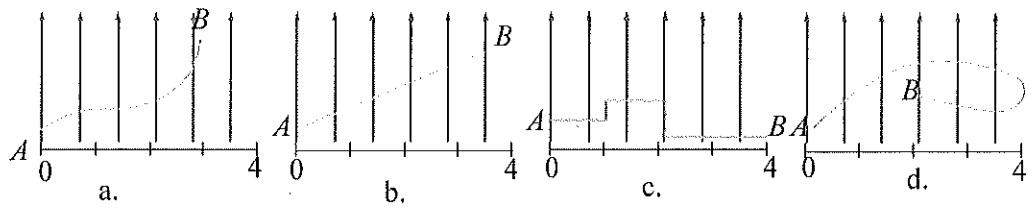

Figure 1.3: Question 1. e

f. A resistor has a p.d of 40 V when the current flowing in it is 120mA. Calculate the p.d. when the current is 600mA. [6]

g. v. Describe the important properties of electric charges [3]

SECTION B

2. a. Figure 2.1 shows two positively charged particles fixed in place on an x axis. The charges are $q_1 = 1.60\times10^{-19}$ C and $q_1 = 3.20\times10^{-19}$ C ,and the particle separation is $R = 0.02$ m . A third particle with charge $q_1 = -3.20\times10^{-19}$ C and is at a distance $3/4R$ from particle 1. [10]

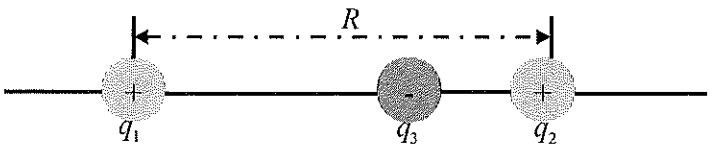

Figure 2.1: Question 2. a.

What is the net electrostatic force on particle $\left(\vec{F}_{1,\text{net}}\right)$ 1 due to particles 2 and 3?

b. i. A battery has an emf of 12.0 V and an internal resistance of 0.05 Ω. Its terminals are connected to a load resistance of 3 Ω.

c. ii. Find the current in the circuit and the terminal voltage of the battery. [6]

d. iii. Calculate the power delivered by the battery. [4]

3. a. Figure 3.1 shows an electrical circuit.

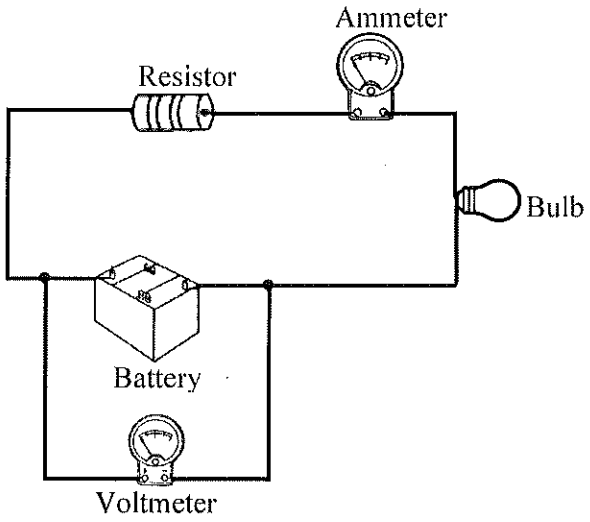

Figure 3.1: Question 3a.

i. Draw this circuit diagram using symbols including a closed switch. [6]

ii. Explain what happens when the switch when the circuit is in a state shown in your diagram in (i). [3]

iii. Explain what happens when the switch is open. [3]

b. The 12-gauge copper wire in a typical residential building has a cross-sectional area of 3.31×10^{-6} m^2. If it carries a current of 10.0 A, what is the drift speed of the electrons? Assume that each copper atom contributes one free electron to the current. The density of copper is 8.95 gcm^{-3} and its molar mass is 63.5 gmol^{-1}. [8]

4. In the circuit diagram in Figure 4.1, find the value of the currents I_1, I_2 and I_3 and comment on the values obtained. [20]

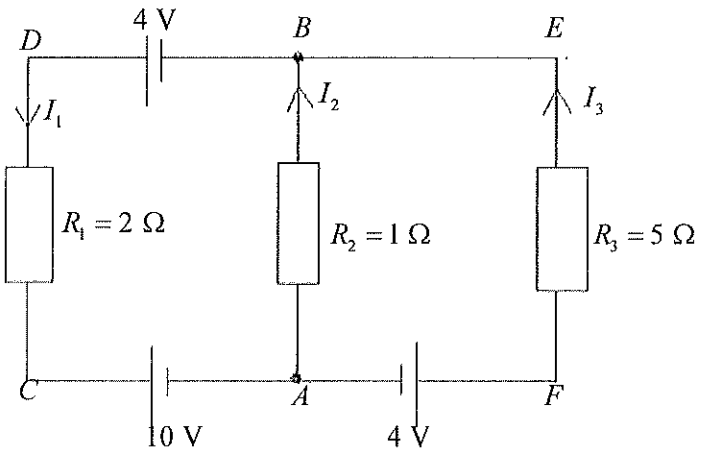

Figure 4.1: Question 4

5. a. Figure 5.1 shows two capacitors in an electric circuit in which the potential difference across the battery terminals is ΔV.

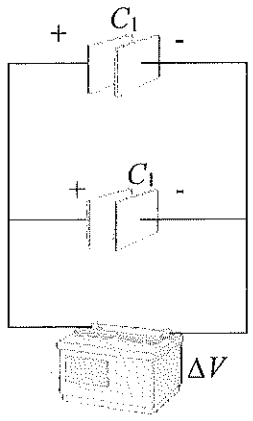

Figure 5.1: Question 5. a.

i. From the polarities of the capacitors, indicate the polarity of the battery on the diagram [1]

ii. Indicate the charge (Q) and the potential difference on each capacitor. [4]

ii. If each capacitor is 2 μF, calculate the effective capacitance. [3]

b. Figure 5.2 shows two capacitors of capacitance 0.3 μF and 0.4 μF respectively are connected in series with a 120 V d.c. supply.

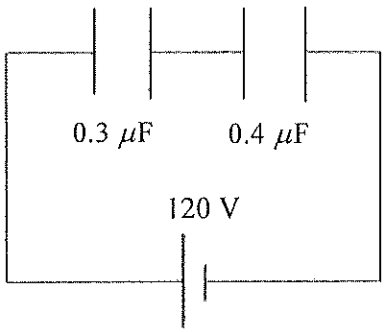

Figure 5.2: Question 5.b.

i. Calculate the charge on each capacitor. [6]

ii. Without discharging, the capacitors are disconnected from the supply and connected in parallel so that those plates having the same charge are connected to each other. Calculate the potential difference across the capacitors. [6]

6. a. An electron in a television picture tube moves toward the front of the tube with a speed of 8.0×10^{6} ms^{-1} along the x axis as shown in Figure 6.1. Surrounding the neck of the tube are [10]

coils of wire that create a magnetic field of magnitude 0.025 T, directed at an angle of 60° to the x axis and lying in the xy plane. Calculate the magnetic force on and acceleration of the electron.

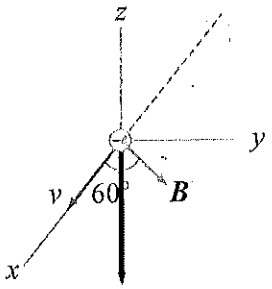

Figure 6.1: Question 6.a.

b. Discuss the important differences between electric and magnetic forces. [6]

c. The north-pole end of a bar magnet is held near a positively charged piece of plastic. Is the plastic attracted, repelled, or unaffected by the magnet? [4]

END OF PAPER