

PART A (100 MARKS)**QUESTION 1**

- a) Write down the factors that control the capacitance of a parallel-plate capacitor.

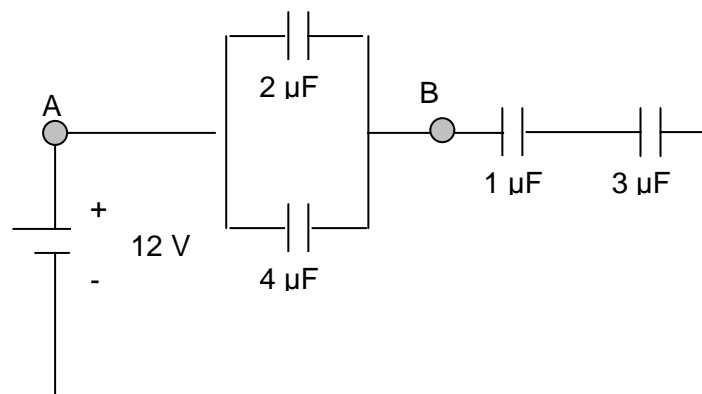
(3 marks)

- b) Experiments have shown that the amount of charge q , deposited on capacitors is directly proportional to the potential difference V , across the plates, or $q = CV$. In addition, the electric potential energy stored in a parallel-plate capacitor can be shown to be, $\text{Energy} = \frac{q^2}{2C}$.

- i) Show that the electrical potential energy can also be written as $\text{Energy} = \frac{q^2}{2C}$.
- ii) A parallel plate capacitor is charged up by a battery and then the connection to the battery is broken. Explain how capacitance changes if the separation of the plates is reduced by a factor of 2.

(7 marks)

- c) The figure below shows capacitors connected together in a circuit with a 12 volts battery.

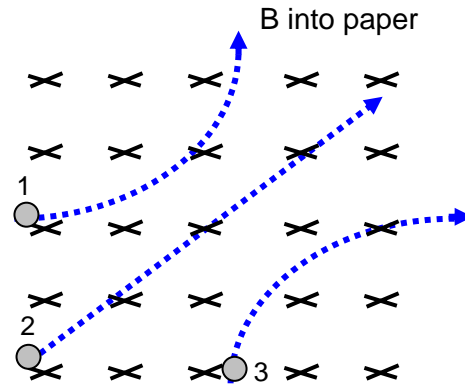


- i) Obtain the total capacitance for the configuration in the figure.
- ii) Determine the total charge stored and the total electrical potential energy stored by the capacitance in the configuration above.
- iii) Determine the potential difference between points A and B.

(10 marks)

QUESTION 2

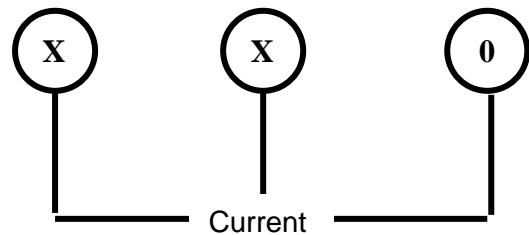
- a) Three particles move through a constant magnetic field and follow the paths shown in the drawing. Determine whether each particle is positively charged, negatively charged, or neutral. Give a reason for each answer.



(5 marks)

- b) The drawing below shows an end-on view of three parallel wires that are perpendicular to the plane of the paper. All carries current I and the wires are separated from each other by a distance d . In two of the wires the current is directed into the paper, while in the remaining wire the current is directed out of the paper. The two outermost wires are held rigidly in place.

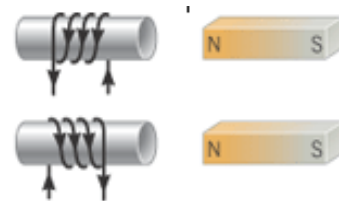
- i) Draw the magnetic field lines for the two rigid wires.
 ii) Write the magnitude of the magnetic field at the position of the middle wire.
 ii) Indicate the direction of the force acting on the middle wire.



(5 marks)

- c) For each electromagnet on the left of the bar magnet in the drawing below,

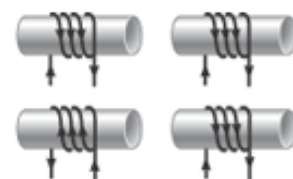
- i) label the polarity of the induced magnetic field
 ii) explain whether it will be attracted to or repelled from the permanent magnet at the right.



(4 marks)

- d) For each electromagnet in the drawing on the right,

- i) label the polarity of the induced magnetic fields.
 ii) explain whether the left electromagnet in the drawing will be attracted to or repelled from the adjacent electromagnet on the right.



(6 marks)

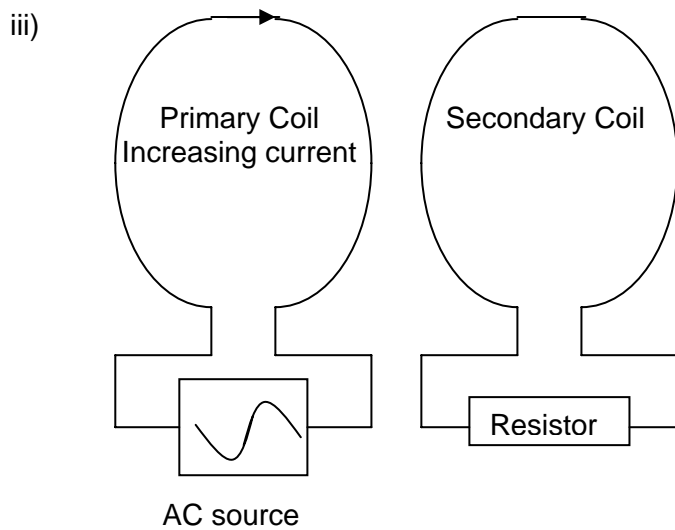
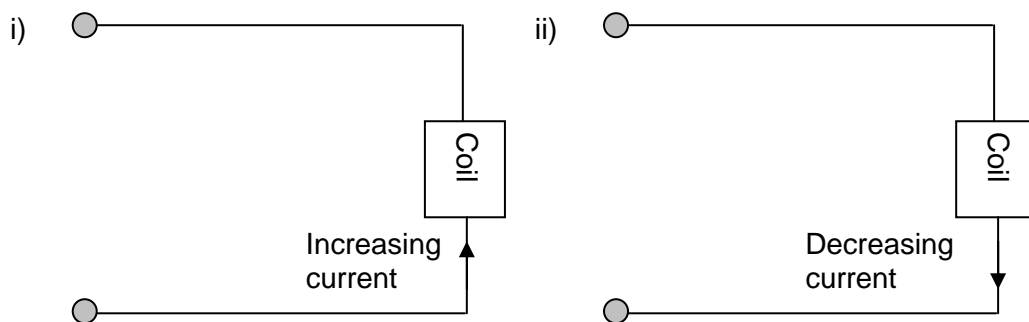
QUESTION 3

a) Briefly, explain the following:

- i) induced electromotive force (emf) and induced current.
- ii) magnetic flux
- iii) Faraday's and Lenz's law of electromagnetic induction.

(10 marks)

b) In the diagrams below, label the high and low potential points of the coil by the usual symbol '+' and '-' and indicate the direction of the induced electromotive force (emf).



(6 marks)

c) During a 72-ms interval, a change in the current in a primary coil occurs. This change leads to the appearance of a 6.0 mA current in a nearby secondary coil. The secondary coil is part of a circuit in which the resistance is 12 Ω. The mutual inductance between the two coils is 3.2 mH. Remembering Ohm's law and the fact that the induced emf in the secondary coil is because of the change in current in the primary coil, determine the change in the primary current, Δi_p .

(4 marks)

QUESTION 4

- a) Briefly, explain the following:
- i) the wave-particle-duality
 - ii) blackbody radiation
 - iii) photons
 - iv) Heisenberg uncertainty principle
- (10 marks)
- b) i) Explain the photoelectric effect.
- (4 marks)
- ii) Draw an energy-frequency graph representing the phenomenon. Label all the axis.
- (4 marks)
- iii) A silver surface has a work function of 4.73 eV (1 eV = 1.6×10^{-19} J). Find the minimum frequency that light must have to eject electrons from this surface. (Planck's constant, $h = 6.63 \times 10^{-34}$ Js)
- (2 marks)

QUESTION 5

- a) Briefly, explain the following:
- i) Rutherford's nuclear atom
 - ii) Bohr's model of the hydrogen atom
 - iii) Balmer series
 - iv) ground state
- (10 marks)
- b) Describe, with the help of a picture, how x-rays are produced.
- (10 marks)

PART B (100 MARKS)**QUESTION 1**

a) Briefly, explain the following:

- i) the law of electrical charge conservation
- ii) charging by contact and induction
- iii) Electric field lines
- iv) Electric flux

(10 marks)

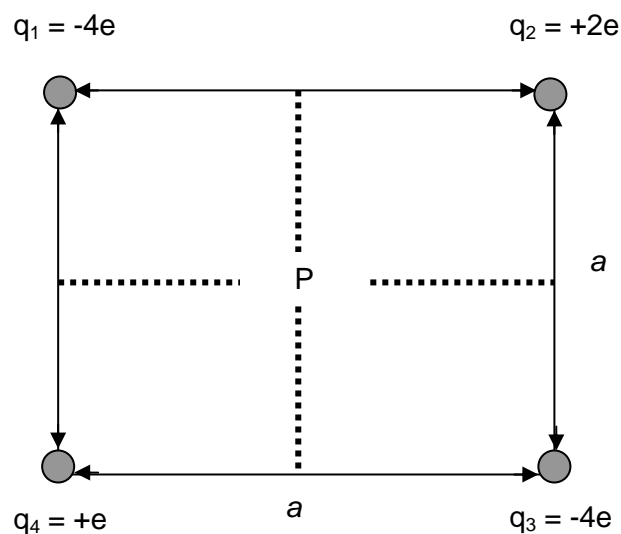
b) Consider three identical metal spheres, A, B, and C. Sphere A carries a charge of $+5q$. Sphere B carries a charge of $-q$. Sphere C carries no net charge. The following process were performed on the spheres:

1. Spheres A and B are touched together and then separated.
2. Sphere C is then touched to sphere A, and then separated from it.
3. Lastly, sphere C is touched to sphere B and separated from it.

- i) What is the total charge on the three spheres before they are allowed to touch each other? Explain your answer.
- iii) What is the total charge on the three spheres after they have touched? Explain your answer.
- iii) Determine the amount of charges on each sphere after each of the process. Explain your answer.

(10 marks)

c) The figure below shows a configuration of charged particles placed at the corners of a square measuring a by a



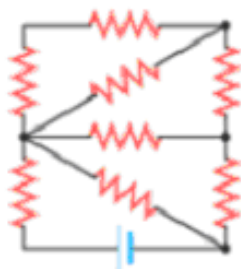
- i) Draw and label the electric field due to each of the four charges at position P, the center of the square, E_1 , E_2 , E_3 , and E_4 . (4 marks)
- ii) Using Pythagoras theorem, determine the distance from P to the charge at the corners. (2 marks)
- iii) Write down the electric field strength for each of the charges at position P, E_1 , E_2 , E_3 , and E_4 . (4 marks)
- iv) Obtain the electric field along the x-axis and the electric field along the y-axis, respectively, for E_2 and E_4 at position P. (8 marks)
- v) Use the results of part (iv) and the symmetry of the problem to obtain the total electric field acting at position P. (8 marks)
- vi) Explain what would happen to a positive test charge, q_0 , if it was placed at position P. (4 marks)

QUESTION 2

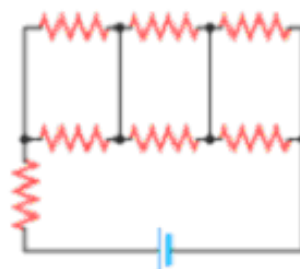
- a) Briefly, explain the following:
 - i) alternating current
 - ii) parallel wiring
 - iii) resistance
 - iv) electrical power
 - v) ammeter

(10 marks)

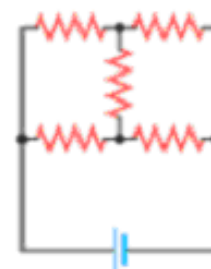
- b) Redraw each of the circuits below and identify which circuit is connected neither in series nor in parallel.



Circuit 1



Circuit 2



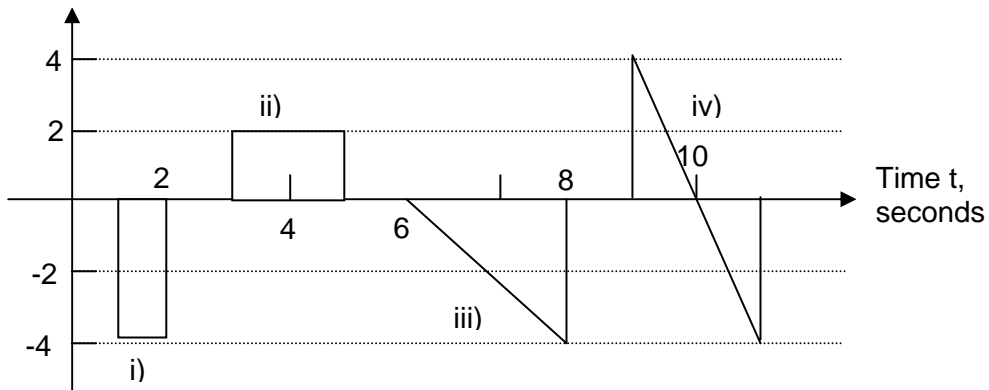
Circuit 3

(10 marks)

- c) The figure below show plots of the electric current I through a certain cross section of a conducting wire over four different time periods. Determine the amount of net charge that pass through each cross section.

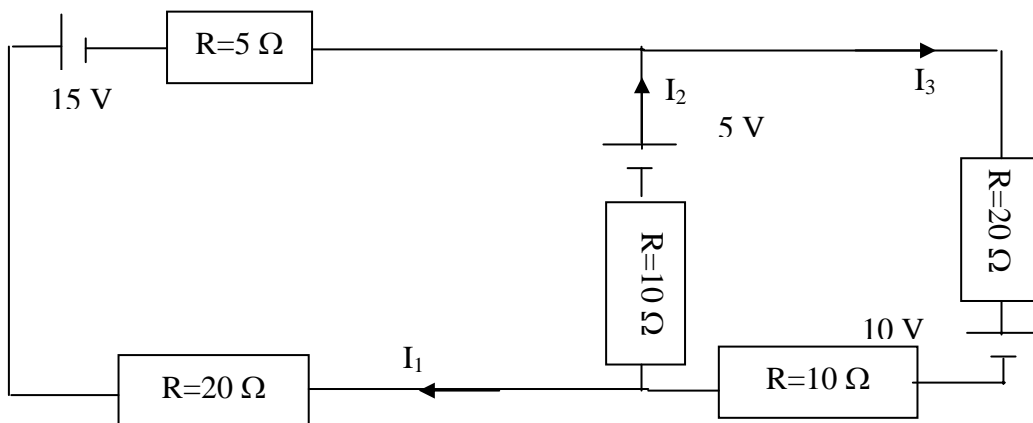
(10 marks)

Current, I , A



- d) Given the circuit below,

- i) Label the '+' and '-' signs at the ends of each resistor and battery to indicate the high and low potential.
- ii) Using Kirchoff's laws, and the results of part (i), determine the currents I_1 , I_2 , and I_3 . Show ALL your work.



(20 marks)

END OF QUESTION PAPER