5 **(a)** Define magnetic flux density.

....

....

.... [1]

(b) A long conductor carrying a current I is placed 20 cm from a negative stationary point charge. The charge is then made to move towards the conductor with a speed of 1.5 cm s^{-1}. It approaches the conductor at an angle of 30° as shown in Fig. 5.1 below.

The magnetic field strength due to the conductor varies with distance from the conductor. At a perpendicular distance 20 cm away, its field strength is 20 mT.

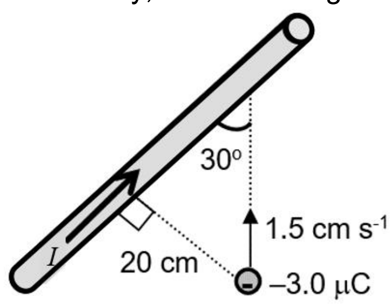

Fig. 5.1

(i) Given that the magnitude of the charge is – 3.0 μC, calculate the magnitude of the force experienced by the charge due to the magnetic field of the wire when it is at a distance 20 cm away from the wire.

force = ………………………… N [2]

(ii) State and explain how the charge will move initially due to the effect of this force.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) In a separate experiment, another long conductor carrying current *I* is placed alongside a horizontal flat coil of rigid wire.

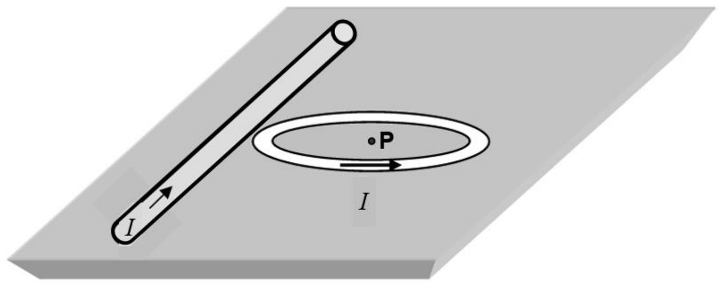

Fig. 5.2

(i) Explain whether the resultant magnetic flux density at the centre of the coil, P, is greater, smaller or unchanged when a current of the same magnitude *I* flows through the coil, in a direction as shown in Fig. 5.2.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………….. [2]

(ii) Briefly describe what would happen to the coil if it is free to move along the horizontal plane.

……………………………………………………………………………………………………..

……………………………………………………………………………………………….. [1]

(d) A small rectangular coil ABCD contains 140 turns of wire. The sides AB and BC of the coil are of lengths 4.5 cm and 2.8 cm respectively, as shown in Fig. 5.3.

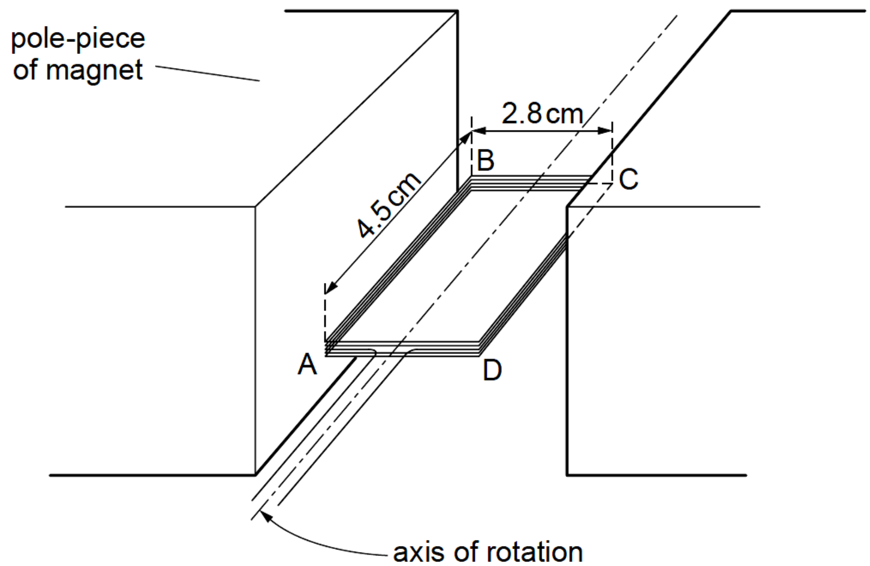

Fig. 5.3

The coil is held between the poles of a large magnet so that the coil can rotate about an axis through its centre.

The magnet produces a uniform magnetic field of flux density *B* between its poles. When the current in the coil is 170 mA, the maximum torque produced in the coil is 2.1×10^{-3} N m.

(i) For the coil in the position for maximum torque, state whether the plane of the coil is parallel to, or normal to, the direction of the magnetic field.

.... [1]

(ii) For the coil in the position shown in Fig. 5.3, calculate the magnitude of the force on side AB of the coil force = ……………………………N [2]

(iii) Use your answer to **(d)(ii)** to determine the magnetic flux density *B* between the poles of the magnet.

magnetic flux density = ……………………………T [2]

(iv) The current in the coil is switched off and the coil is positioned as shown in Fig. 5.3. The coil is then turned through an angle of 90° in a time of 0.14 s. Calculate the average e.m.f. induced in the coil.

average e.m.f. = ……………………………V [2]

[Total: 15]