Mixed Exam Questions – Set 6

1.

Fig. 2.1 shows the circular track of an electron moving in a uniform magnetic field.

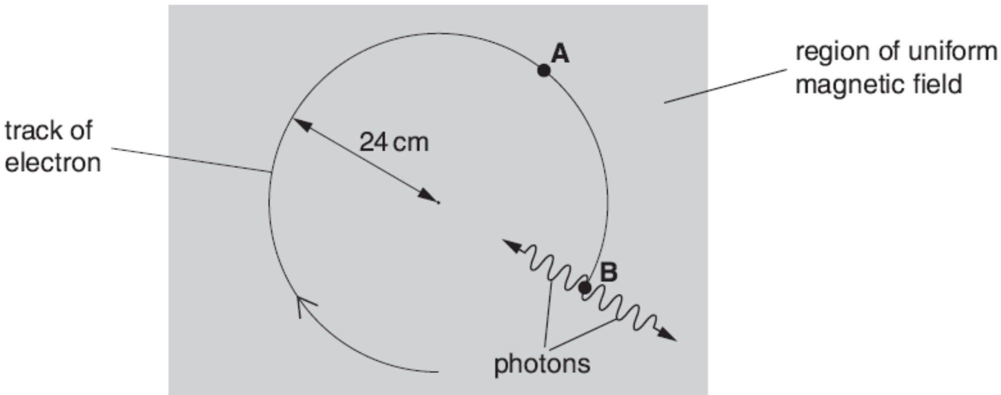

Fig. 2.1

The magnetic field is perpendicular to the plane of Fig. 2.1. The speed of the electron is $6.0 \times 10^7\,\text{m s}^{-1}$ and the radius of the track is 24 cm. At point **B** the electron interacts with a stationary positron.

(a) **(i)** On Fig. 2.1, draw an arrow to show the force acting on the electron when at point **A**. Label this arrow **F**. **[1]**

(ii) Explain why this force does not change the speed of the electron.

....

....

.... **[1]**

(b) Calculate the magnitude of the force F acting on the electron due to the magnetic field when it is at **A**.

F = ... N **[2]**

(c) Calculate the magnetic flux density of the magnetic field.

magnetic flux density = ... T **[2]**

(d) At point **B**, the electron and the positron annihilate each other. A positron has a positive charge and the same mass as the electron. The particles create two gamma ray photons. Calculate the wavelength of the gamma rays assuming the kinetic energy of the electron is negligible.

In your answer, you should make your reasoning clear.

wavelength = ... m **[3]**

2.

(a) Fig. 3.1 shows two charged horizontal plates.

Fig. 3.1

The potential difference across the plates is 60V. The separation of the plates is 5.0mm.

(i) On Fig. 3.1 draw the electric field pattern between the plates. **[2]**

(ii) Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ **[1]**

(b) Positive ions are accelerated from rest in the horizontal direction through a potential difference of 400V. The charged plates in **(a)** are then used to deflect the ions in the vertical direction. Fig. 3.2 shows the path of these ions.

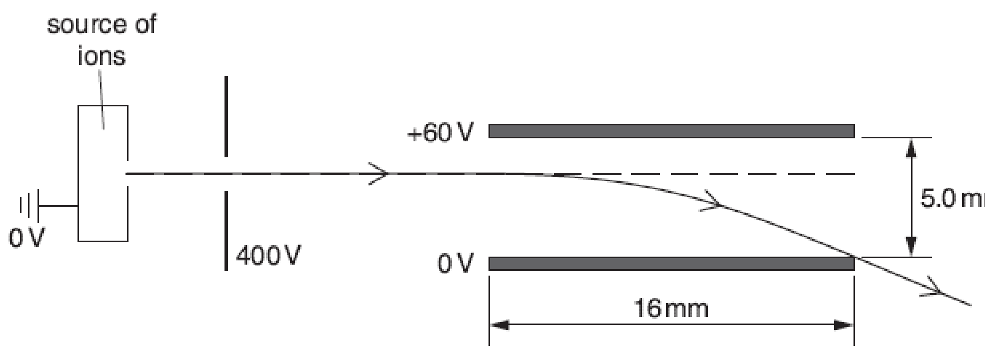

Fig. 3.2

Each ion has a mass of 6.6×10^{-27} kg and a charge of 3.2×10^{-19} C.

(i) Show that the horizontal velocity of an ion after the acceleration by the 400 V potential difference is 2.0×10^5 m s^{-1}.

[2]

(ii) The ions enter at right angles to the uniform electric field between the plates. Calculate the vertical acceleration of an ion due to this electric field.

acceleration = ... m s^{-2} **[2]**

(iii) The length of each of the charged plates is 16 mm.

1 Show that an ion takes about 8.0×10^{-8} s to travel through the plates.

[1]

2 Calculate the vertical deflection of an ion as it travels through the plates.

deflection = ... m **[2]**

(c) A uniform magnetic field is applied in the region between the plates in Fig. 3.2. The magnetic field is perpendicular to both the path of the ions and the electric field between the plates.

Calculate the magnitude of the magnetic flux density of field needed to make the ions travel horizontally through the plates.

magnetic flux density = ... T **[3]**

(d) Ions of the same charge but greater mass are accelerated by the potential difference of 400V described in **(b)**. Describe and explain the effect on the deflection of the ions after they have travelled between the plates using the same electric and magnetic fields of **(c)**.

....

....

....

.... **[2]**

3.

Fig. 5.1 shows a rigid, straight metal rod **XY** placed perpendicular to a magnetic field. The magnetic field is produced by two magnets that are placed on a U-shaped steel core. The steel core sits on a digital balance.

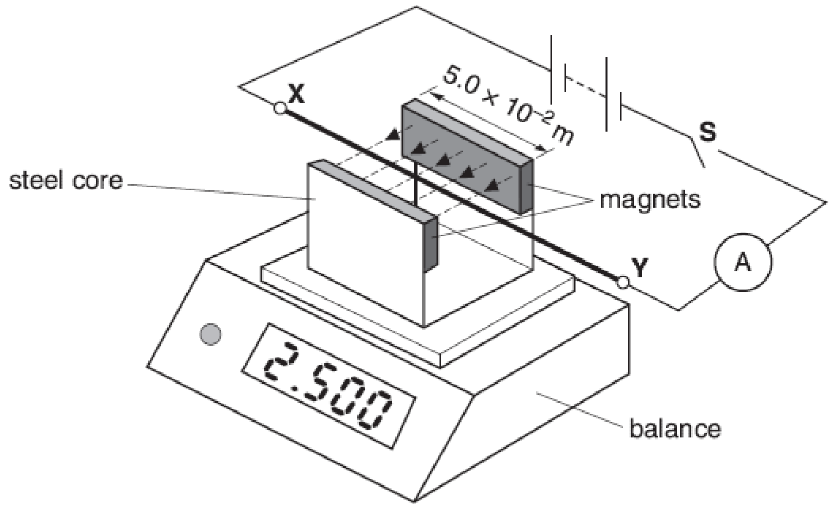

Fig. 5.1

The weight of the steel core and the magnets is 2.500 N. The rod is clamped at points **X** and **Y**. The rod is connected to a battery, switch and ammeter as shown in Fig. 5.1. The direction of the magnetic field is perpendicular to the rod.

Switch **S** is closed.

(a) State the direction of the force that now acts on the rod due to the magnetic field.

.... **[1]**

(b) State how you determined the direction of the force.

....

....

.... **[1]**

(c) The length of the rod in the magnetic field is 5.0×10^{-2} m and the current in the rod is 4.0 A. Assume that the magnets provide a uniform magnetic field of magnetic flux density 0.080 T.

(i) Calculate the force acting on the rod due to the magnetic field.

force = ... N **[1]**

(ii) State and explain the new reading on the balance.

reading on balance = ... N

....

....

....

....

.... **[3]**

(d) The rod is replaced by another rod of the same material having half the diameter of the first wire and the same length. The potential difference across this rod is the same. Calculate the force on this rod due to the magnetic field.

force = ... N **[3]**

4.

Fig. 3.1 shows the variation of the magnetic flux **linkage** with time *t* for a small generator.

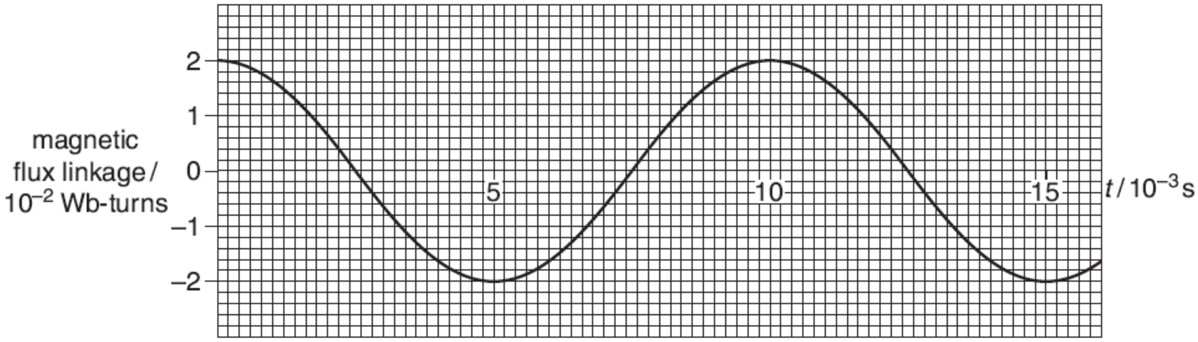

Fig. 3.1

The generator has a flat coil of negligible resistance that is rotated at a steady frequency in a uniform magnetic field. The coil has 400 turns and cross-sectional area $1.6 \times 10^{-3}\,m^2$. The output from the generator is connected to a resistor of resistance 150 Ω.

(a) Use Fig. 3.1 to

(i) calculate the frequency of rotation of the coil

frequency = ... Hz **[1]**

(ii) calculate the magnetic flux density *B* of the magnetic field

B = ... T **[3]**

(iii) show that the **maximum** electromotive force (e.m.f.) induced in the coil is about 12V.

[3]

(b) Hence calculate the **maximum** power dissipated in the resistor.

power = ... W **[2]**

5.

(a) Define *magnetic flux*.

....

.... **[2]**

(b) Fig. 3.1 shows an experiment to demonstrate electromagnetic induction.

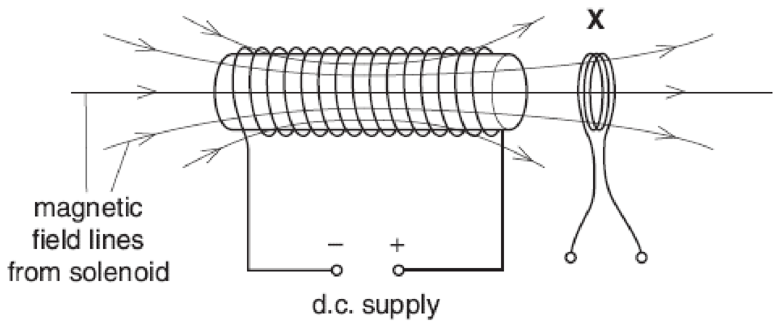

Fig. 3.1

The solenoid is connected to a variable voltage d.c. supply. A coil **X** is placed close to one end of the solenoid. The current in the solenoid is reduced. Fig. 3.2 shows the consequent variation of the magnetic flux density B at right angles to the plane of the coil **X** with time t.

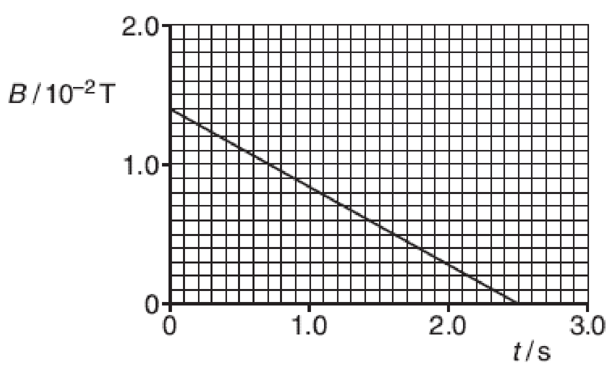

Fig. 3.2

The coil **X** has radius 3.2 cm and 180 turns.

(i) Explain why the induced e.m.f. across the ends of the coil has a constant value from $t = 0$ s to $t = 2.5$ s.

....

....

.... **[1]**

(ii) Calculate the magnitude of the induced e.m.f. across the ends of coil **X** from t = 0 s to t = 2.5 s.

e.m.f. = ... V **[3]**

(c) Fig. 3.3 shows a transformer circuit.

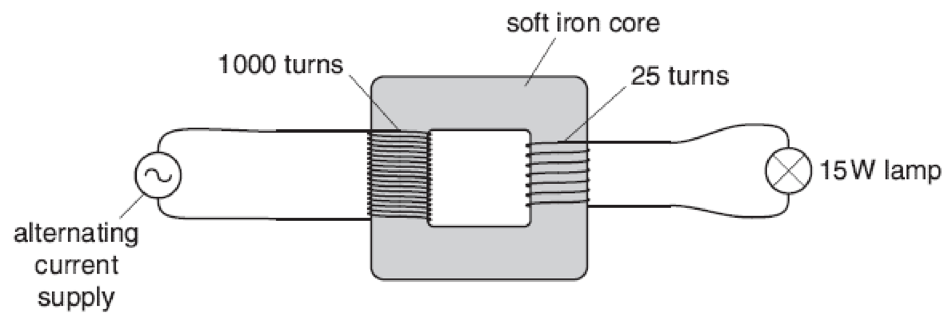

Fig. 3.3

The primary coil has 1000 turns and the secondary coil 25 turns. A lamp is connected to the output of the secondary coil. The potential difference across the lamp is 6.0 V and the lamp dissipates 15 W. The transformer has an efficiency of 100%.

(i) Calculate the current in the primary coil.

current = ... A **[2]**

(ii) The alternating voltage supply is replaced by a battery. Explain why the p.d. across the lamp is zero some time after the battery is connected.

....

....

....

....

.... **[1]**

6.

(a) Define *electromotive force*.

....

.... **[1]**

(b) Define *magnetic flux*.

....

....

.... **[1]**

(c) Fig. 1.1 shows a simple transformer.

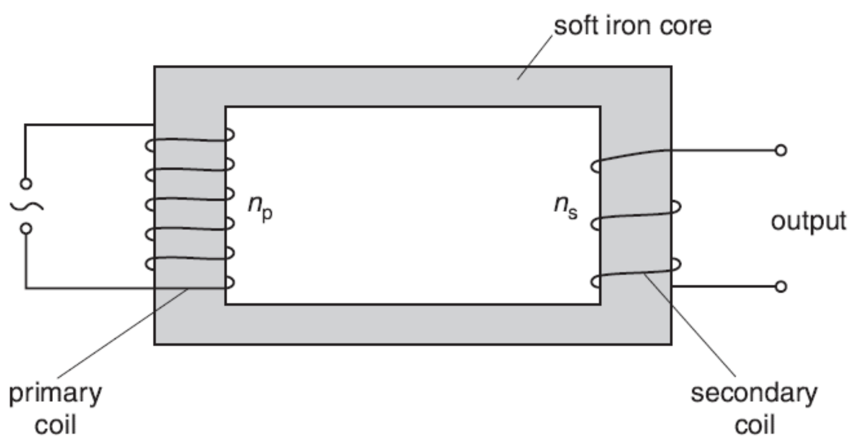

Fig. 1.1

(i) The primary coil is connected to an alternating voltage supply. Explain how an e.m.f. is induced in the secondary coil.

....

....

....

....

....

....

.... **[3]**

(ii) State how you could change the transformer to increase the maximum e.m.f. induced in the secondary coil.

....

....

.... [1]

(d) A transformer with 4200 turns in the primary coil is connected to a 230V mains supply. The e.m.f. across the output is 12V. Assume the transformer is 100% efficient.

(i) Calculate the number of turns in the secondary coil.

number of turns = ... **[2]**

(ii) The transformer output terminals are connected to a lamp using leads that have a total resistance of 0.35 Ω. The p.d. across the lamp is 11.8V. Calculate

1 the current in the leads connected to the lamp

current = ... A **[2]**

2 the power dissipated in the leads.

power = ... W **[2]**