Question 12 **(17 marks)**

Mass spectrometry can be used to analyse the isotope composition of an element. Chlorine has two isotopes, Cℓ-35 and Cℓ-37. The mass of each is shown in the table below.

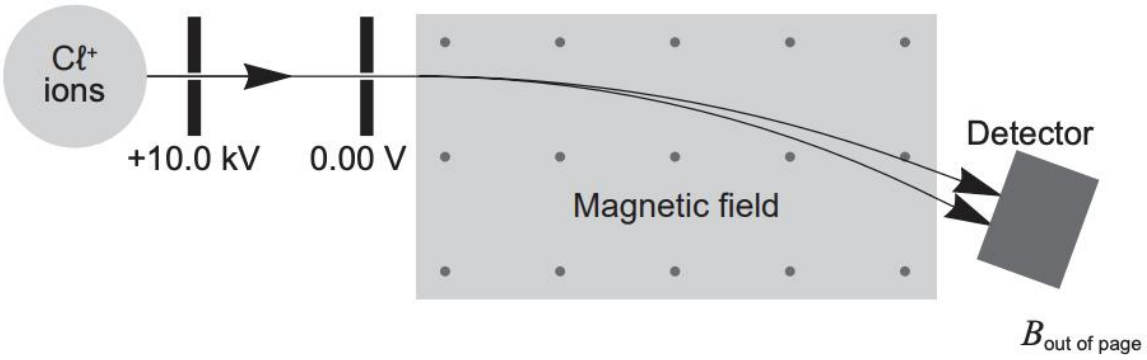
Isotope	Mass (amu)
Cℓ-35	34.97
Cℓ-37	36.97

1 amu = 1.6605×10^{-27} kg.

The atoms in the gaseous chlorine sample are ionised by being bombarded with electrons of energy 15.0 eV. The minimum energy required to ionise a chlorine atom is 12.9676 eV. The chlorine ions now have a charge of +1 e.

The moving ions are accelerated across a potential difference of 1.00×10^4 V, and then enter a 0.930 T magnetic field with their velocity perpendicular to the flux lines. Here they are separated by their momentum.

This process is illustrated below.



Schematic of a mass spectrometer

(a) Describe **two** reasons why the ions would take different paths in the magnetic field given that $r = \frac{mv}{qB}$. (4 marks)

One:

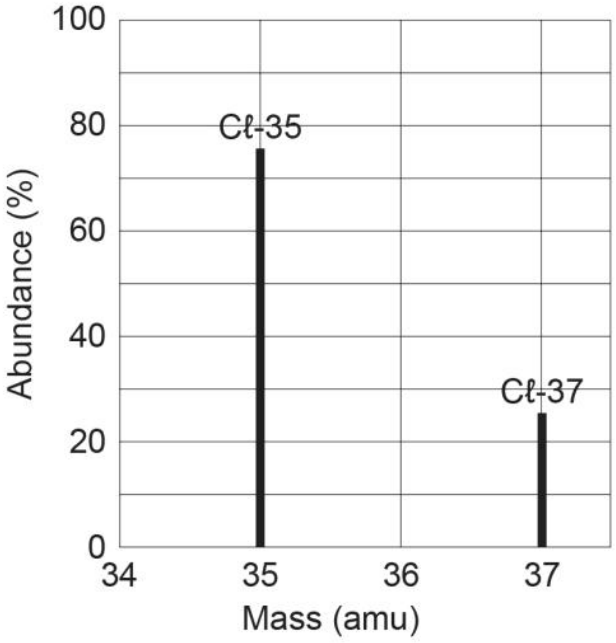
Two:

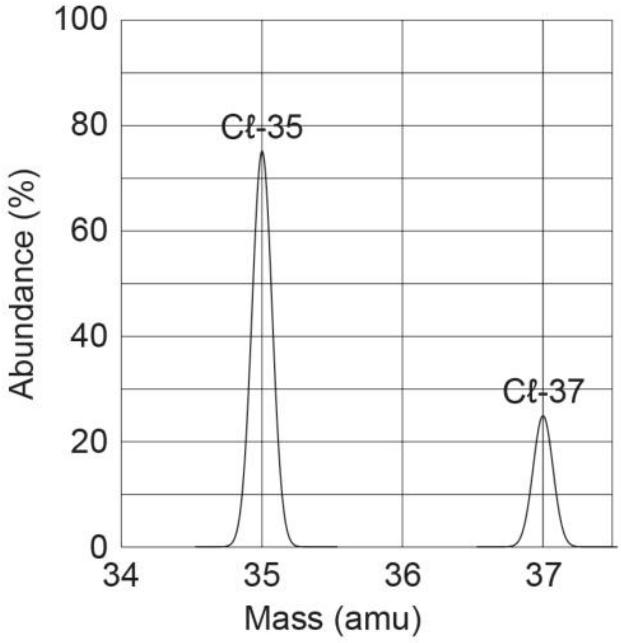
(b) Calculate the velocity of a Cℓ-35 ion when it leaves the electric field if it entered with a velocity of 4.51×10^4 m s^{-1}. Ignore relativistic effects. (7 marks)

(c) Calculate the radius of the circular path taken by this Cℓ-35 isotope in the magnetic field. If you could not obtain an answer to part (b) on page 14, use 3.72×10^5 m s^{-1}. (3 marks)

Answer: _____ m

The graph of the actual relative abundance of the two isotopes is shown in the diagram below left. The graph below right is what is produced in the mass spectrometer printout.





(d) Explain why there is a range of masses in the printout instead of clearly-defined lines, as in the graph above left. (3 marks)