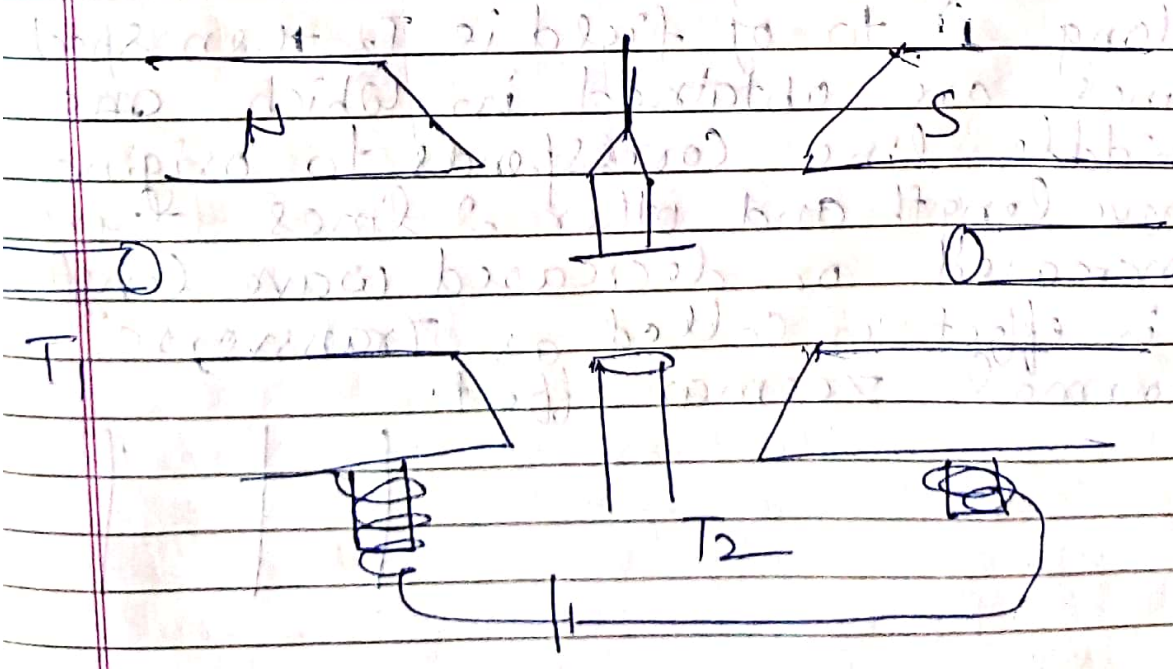
Zeeman effect:- In 1896 Zeeman observed that when any light source giving line spectrum is placed in magnetic field then spectral line splitted into different component. The splitting of spectral line into different component is called as Zeeman effect. It is of two type

Page :
Date : / /

Normal Zeeman effect:- When spectral line is splitted into two to three component then it is called as NZE.

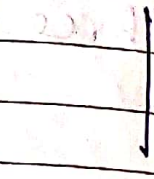
Anomalous Zeeman effect:- When spectral line is splitted into more than 3 component then it is called as : AZE.

Expt Arrangement for NZE:- To observed NZE an electro-magnet is taken on the both ends of this electromagnet a hole is drilled such that observations are taken along direction of M.F.. Two telescopes are T_1 and T_2 of high Resolving power are taken. A light source is placed b/w the poles of this electromagnet such that It strictly gives line spectrum



Observation:-

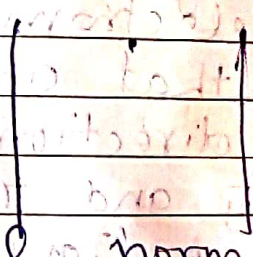
(1) When no M.F is applied then only one spectral line is obtd



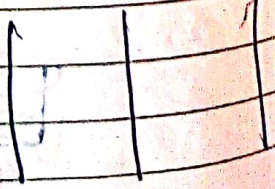
When no field

(2) When M.F is applied and observation are taken from Telescope T_1 then 2 spectral lines are obtd. in which one line has greater wavelength and one line has lesser wavelength but original line was absent.

In this case observation are taken along direction of M.F hence this effect is called as longitudinal normal Zeeman effect.



(3) When M.F is applied and obs. are taken along $\perp^r$ to of field ie T_2 then spectral lines are obtained in which one middle line corresponds to original wave length and other 2 lines are increased or decreased wave length. This effect is called as Transverse normal zeeman effect.



Page :
Date : / /

Zeeman shift :- The separation b/w increased or decreased wavelength with original wavelength is called Zeeman shift.

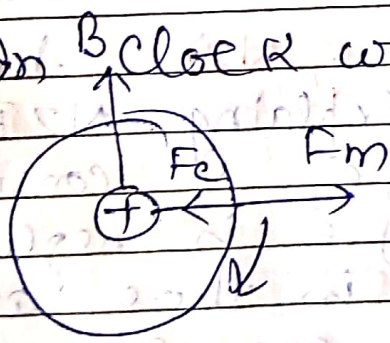
Let in any atom e is restricted around the nucleus in circular orbit of radius r, velocity v. The centripetal force

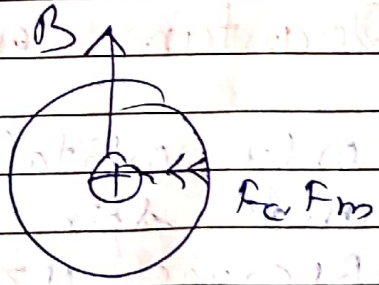
$$F_c = \frac{mv^2}{r} = mr\omega^2$$

Now e can revolves around the nucleus in its orbit in clock wise direction or anti clock wise direction. When field is applied to plane of orbit of e then an e experiences L.F which

$$F_m = qvB\sin\theta = evB$$

In B clock wise





Net force $= F_c - F_m = mr(\omega + \delta\omega)^2$

$$mr\omega^2 - evB = mr(\omega^2 + \delta\omega^2 + 2\omega\delta\omega)$$

$$-evB = 2mr\omega\delta\omega \quad \delta\omega^2 \approx 0$$

$$-evB = 2mv\delta\omega \Rightarrow \delta\omega = -\frac{eB}{2m}$$

For anticlockwise

$$\delta\omega = \frac{eB}{2m}$$

Combining $\delta\omega = \mp \frac{eB}{2m}$

$$\omega = 2\pi\nu$$

$$\delta\omega = 2\pi\delta\nu$$

$$\delta\nu = \frac{\delta\omega}{2\pi} = \mp \frac{eB}{4\pi m}$$

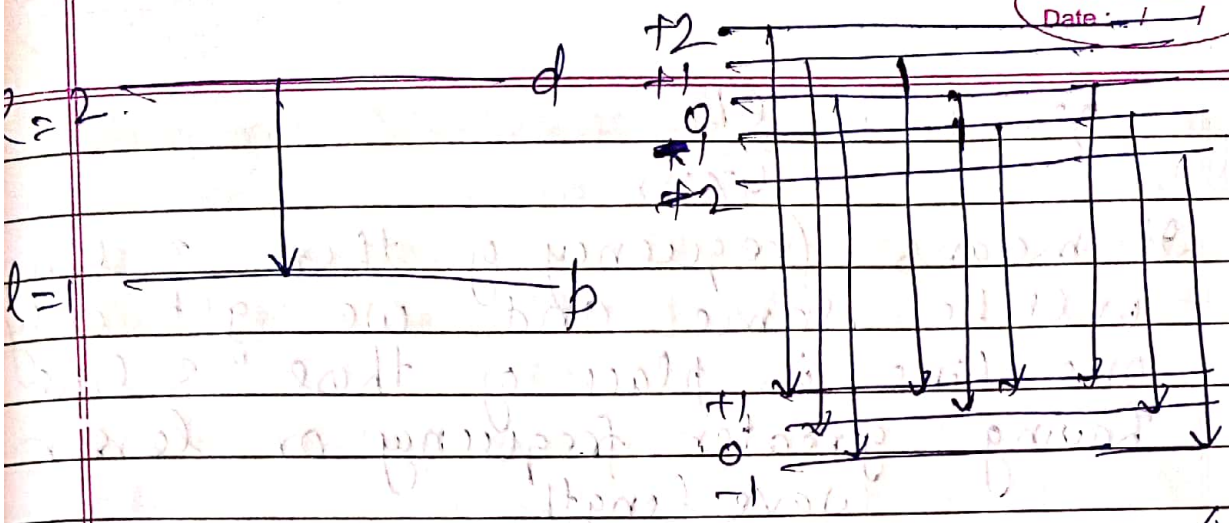
$$\nu = c/\lambda \Rightarrow \delta\nu = -\frac{c}{\lambda^2}\delta\lambda$$

$$\delta\lambda = -\frac{\lambda^2}{c}\left(\mp\frac{eB}{4\pi m}\right) = \pm\frac{eB\lambda^2}{4\pi mc}$$

Quantum explanation of NZE:- In explaining NZE only orbital motion of e⁻ is considered and spin motion of e⁻ is neglected Because NZE occurs in those atoms in which no of e⁻ are even so net magnetic moment due to spin motion of e⁻ is zero.

When no field is applied then e⁻ jumps from d (orbital) to p orbital one spectral line is obtained.

When M.F is applied these subshell splitted into several sub energy level



$\Delta m_l = +1$ $\Delta m_l = 0$ $\Delta m_l = -1$

For d orbital $l = 2$

$m_l = +2, +1, 0, -1, -2$

For p orbital $l = 1$

$m_l = +1, 0, -1$

Now e can jump from any higher sub energy levels to lower sub energy levels several transitions are possible but accord. to selection rules only these transitions are possible for m which

$\Delta m_l = 0, \pm 1$

The frequency of spectral line during these

$$\nu = \nu_0 \pm \Delta m_l \frac{eB}{4\pi m}$$

Where ν_0 : frequency of original line

Now from figure ① for 1^{st} 3 lines

$\Delta m_l = +1$

$$\nu = \nu_0 + \frac{e \cdot B}{4\pi m}$$

It means frequency of these 3 lines will be same and we get only one line in place of these 3 lines having greater frequency or lesser wave length.

Now for next 3 lines $\Delta m_l = 0$

$$\nu = \nu_0$$

Again we get only one line in place of 3 line having original ν.

$$\Delta m_l = -1$$

$$\nu = \nu_0 - \frac{eB}{4\pi m}$$

It means in place of 9 lines we get 3 spectral lines and therefore it is NZE.