④ Magnetic Intensity ($\vec{H}$)
Magnetic field strength ($\vec{H}$)
Magnetising Intensity ($\vec{H}$)
Magnetising Force ($\vec{H}$)

The extent to which "magnetising field" can magnetise a substance is known as the Intensity of magnetising field. ($\vec{H}$)

$H = \frac{B_0}{\mu_0}$ or $\boxed{B_0 = \mu_0 H}$ $\mu_0 = 4\pi \times 10^{-7}\ T m A^{-1}$

SI unit of $H = \frac{\text{unit of } B_0}{\text{unit of } \mu_0} = \frac{T}{T m A^{-1}} = A m^{-1}$

Dimensional formula of $\vec{H} = [L^{-1} A]$

See page 44 of ch ④

---

* Consider a long solenoid of "n turns per unit length" and carrying a current I. The magnetic field (B_0) in the interior of the solenoid is given by $B_0 = \mu_0 (nI)$; But $nI = H$, $B_0 = \mu_0 H$

→ If the interior of solenoid is filled with a material with non-zero magnetisation, the field inside the solenoid > B_0

∴ Net B field in the interior of solenoid is

$B = B_0 + B_m$; where B_m is field contributed by the "material core". This additional field $B_m \propto M$ of the material

∴ $B_m = \mu_0 M$ (μ_0 = permeability of vacuum)

~~We know~~ we have defined $H = \frac{B_0}{\mu_0}$

∴ $B = B_0 + B_m$ becomes

$B = H\mu_0 + B_m$ (but $B_m = \mu_0 M$)

Total mag. field. $\boxed{B = \mu_0 (H + M)}$

Mag. Intensity $\boxed{H = \frac{B}{\mu_0} - M}$

$$\boxed{\begin{aligned} B &= \mu_0 H + \mu_0 M \\ \mu_0 H &= B - \mu_0 M \\ H &= \frac{B}{\mu_0} - M \end{aligned}}$$

* IMP: In a nutshell, we have ~~partitioned~~ partitioned the contribution to the total magnetic field inside the sample into two parts.

IMP
① due to external factors such as the current in the Solenoid. This is represented by $\vec{H}$.
② The other is due to the specific nature of the "magnetic material", namely, M. $\vec{M}$ can be influenced by external factors. This influence is mathematically expressed as $M = \chi H$, where χ, a dimensionless quantity called "magnetic Susceptibility"

→ P.T.O.

(5) Magnetic Susceptibility (χ) It is a measure of how a magnetic material responds to an external magnetic field.

"It is the property which determines how easily a substance can be magnetised when placed in the magnetising field".

$M = \chi H \quad \therefore \quad \boxed{\chi = \frac{M}{H}}$ is a number, no unit.

Following table lists χ for some elements:

Magnetic Susceptibility of some elements at 300 K

Diamagnetic substance	χ	Paramagnetic substance	χ
Bismuth	-1.66×10^{-5}	Aluminium	2.3×10^{-5}
Copper	-9.8×10^{-6}	Calcium	1.9×10^{-5}
Diamond	-2.2×10^{-5}	Chromium	2.7×10^{-4}
Gold	-3.6×10^{-5}	Lithium	2.1×10^{-5}
Lead	-1.7×10^{-5}	Magnesium	1.2×10^{-5}
Mercury	-2.9×10^{-5}	Niobium	2.6×10^{-5}
Nitrogen (STP)	-5.0×10^{-9}	Oxygen (STP)	2.1×10^{-6}
Silver	-2.6×10^{-5}	Platinum	2.9×10^{-4}
Silicon	-4.2×10^{-6}	Tungsten	6.8×10^{-5}

χ is small and +ve for paramagnetic materials.
χ is small and −ve for diamagnetic materials
↳ In this case M and H are opposite in direction.

$B = \mu_0 (H + M)$ Since $M = \chi H$

$\mu_0 \rightarrow$ permeability in vacuum.

$B = \mu_0 (H + \chi H)$

$B = \mu_0 H (1 + \chi)$

$B = \mu_0 H (\mu_r) \rightarrow$ where $\mu_r = (1+\chi)$ is a dimensionless quantity called relative mag. permeability of the substance. (It is analog of dielectric constant in electrostatics)

$B = \mu H$

where $\boxed{\mu = \mu_0 \mu_r = \mu_0 (1+\chi)}$

and $\boxed{\mu_r = 1 + \chi}$

IMP.

⑤ Magnetic Permeability (μ)

The extent to which magnetic field lines can enter a substance is known as mag. permeability (μ)

⇒ μ of a substance is a measure of its conduction of magnetic lines of force thro' it.

It is defined as the ratio of the magnetic induction $\vec{B}$ inside the magnetised substance to the magnetic Intensity $\vec{H}$ of the mag. field.

$$\boxed{\mu = \frac{B}{H}} \quad \text{or} \quad \boxed{B = \mu H}$$

$$\text{SI unit} = \frac{T}{A m^{-1}} = T m A^{-1} \qquad [MLT^{-2}A^{-2}]$$

⑥ Relative Magnetic permeability (μ_r):

μ_r of a substance is the ratio of the mag. permeability μ of the substance to the permeability of free space (vacuum)

$$\mu_r = \frac{\mu}{\mu_0}$$

μ_0 → absolute permeability of vacuum or free space.

μ_r → dimensionless.

$$\therefore \boxed{\mu = \mu_0 \mu_r}$$

→ Alternatively, μ_r of a substance is defined as the ratio of the magnetic flux density $\vec{B}$ in the substance when placed in a mag. field ~~and~~ to the flux density B_0 in vacuum in the same field.

$$\mu_r = \frac{B}{B_0} = \frac{\mu H}{\mu_0 H} = \frac{\mu}{\mu_0} \qquad \therefore \boxed{\mu = \mu_0 \mu_r}$$

→ We can classify substances in terms of μ_r:

$\mu_r < 1$ (diamagnetic)

$\mu_r > 1$ (paramagnetic)

$\mu_r >> 1$ (Ferromagnetic)

(7) Magnetic Susceptibility (χ_m)

It is the property of a substance which is a measure of how easily the substance can be magnetised when placed in the mag. field.

$$\chi_m = \frac{\text{Magnetization } (M)}{\text{Intensity of magnetising field } (H)} = \frac{M}{H}$$

$$\boxed{\chi_m = \frac{M}{H}}$$

χ_m has no unit. It is just a number.

Relation betn μ, μ_r and χ_m :

Total mag. field ($\vec{B}$) in a solenoid having a material core is the sum of the mag. field in vaccum (B_0) and the magnetic field (B_m) due to the material core having non-zero magnetisation field.

$$B = B_0 + B_m$$

But $B_0 = \mu_0 H$

$B_m = \mu_0 M$

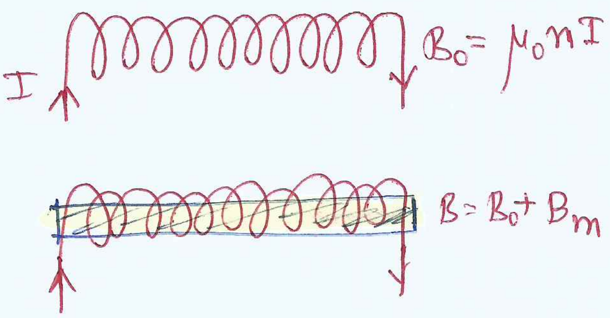
$$\therefore B = \mu_0 (H + M)$$

Dividing both sides by H, we get

$$\frac{B}{H} = \frac{\mu_0}{H}(H+M) \implies \frac{B}{H} = \mu_0\left(1 + \frac{M}{H}\right)$$

But $\frac{B}{H} = \mu$ and $\frac{M}{H} = \chi_m$

$$\therefore \boxed{\mu = \mu_0 (1 + \chi_m)}$$



or $\frac{\mu}{\mu_0} = 1 + \chi_m$

Since $\frac{\mu}{\mu_0} = \mu_r$

$$\boxed{\mu_r = 1 + \chi_m}$$

* Intensity of magnetising field or magnetic Intensity ($\vec{H}$) at the centre of a current carrying solenoid

→ using $H = \frac{B_0}{\mu_0}$, where $B_0 = \mu_0 n I$ is the magnetic field at the centre of the solenoid

$$H = \frac{\cancel{\mu_0} n I}{\cancel{\mu_0}}$$

$$\therefore \boxed{H = nI}$$ Very imp

problem: An ideal solenoid having 2000 turns/metre has an iron core of relative permeability 500 and carries a current of 1 A. Calculate (i) mag. intensity (H) at the centre of the solenoid (ii) mag. permeability of iron (iii) mag. susceptibility of the iron (iv) mag. field B (v) magnetization M_{net} and (vi) magnetising current I_m.

Sol^n^ Given $\mu_r = 500$, $n = 2000$ turns/m, $I = 1A$

(i) using $H = nI = 2000 \times 1 = 2000 \ Am^{-1}$

(ii) $\mu = \mu_0 \mu_r = (4\pi \times 10^{-7})(500) = 6.28 \times 10^{-4} \ TmA^{-1}$

(iii) using $\mu_r = 1 + \chi_m$

$\chi_m = \cancel{\frac{\mu_r - 1}{\mu_r}} \mu_r - 1 = 500 - 1 = 499$

(iv) using $B = \mu_0 \mu_r H$

$B = \mu H = (6.28 \times 10^{-4})(2000)$

$= \cancel{9.98 \times 10^{5}} = 1.26 \ T$

(v) Magnetisation $M = (\mu_r - 1) H$

$= \chi_m H$

$= 499 \times 2000 = 9.98 \times 10^{5} \ Am^{-1}$

(vi) Magnetising current (is the current required to get same value of flux density $\vec{B}$ inside the solenoid as available when magnetic core is used in the solenoid)

$B = n \mu_0 (I + I_m)$

$\therefore I_m = \frac{B - n\mu_0 I}{n\mu_0} = \frac{B}{n\mu_0} - I$

$I_m = \left[\frac{1.26 \ T}{(2000)(4\pi \times 10^{-7})} - 1A\right] = 5000.6 \ A$

Table

physical quantity	Symbol	Nature	Dimension	Unit	Remarks
Magnetic field ~~or Mag~~ or Magnetic Induction, Mag. flux density, Mag. field strength	B	Vector	$[MT^{-2}A^{-1}]$	T	$1T = 10^4$ Gauss $= 10^4 G$
Intensity of Magnetisation, Magnetisation	M	vector	$[L^{-1}A]$	$A\,m^{-1}$	$\vec{M} = \frac{m}{V} = \frac{\text{mag. moment}}{\text{volume}}$
Magnetising intensity, Magnetising Force	H	Vector	$[L^{-1}A]$	$A\,m^{-1}$	$B = \mu_0(H+M)$
Magnetic moment	m	vector	$[L^2A]$	$A.m^2$ $(A\,m^2)$	
Magnetic flux	ϕ_B	Scalar	$[ML^2T^{-2}A^{-1}]$	Weber (W)	$W = Tm^2$, $\phi_B = B \cdot A$
permeability of Free space (or vacuum)	μ_0	scalar	$[MLT^{-2}A^{-2}]$	TmA^{-1}	$\frac{\mu_0}{4\pi} = 10^{-7}$
Magnetic permeability	μ	Scalar	$[MLT^{-2}A^{-2}]$	TmA^{-1} or NA^{-2}	$\mu = \mu_0\mu_r$, $B = \mu H$
Relative magnetic permeability	μ_r	scalar	—	—	$B = \mu_0\mu_r H$
Magnetic Susceptibility	χ_m	Scalar	—	—	$M = \chi H$

Magnetic properties of materials

Classification based on χ_m, μ and μ_r of mag. substances

Diamagnetic	Paramagnetic	Ferromagnetic
$-1 \leq \chi < 0$	$0 < \chi < \epsilon$	$\chi >> 1$
$0 \leq \mu_r < 1$	$1 < \mu_r < (1+\epsilon)$	$\mu_r >> 1$
$\mu < \mu_0$	$\mu > \mu_0$	$\mu >> \mu_0$
	Where ϵ is a small +ve number introduced to quantify paramagnetic materials.	

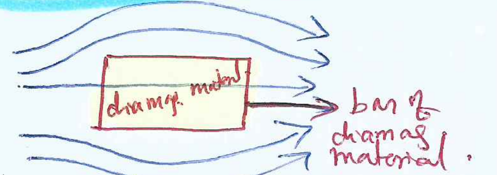
I Diamagnetic materials:

A diamagnetic substances are those in which the individual atoms/molecules/ions donot possess any net magnetic moment on their own. When such substances are placed in an external magnetising field, they get feebly magnetised in the direction opposite to the magnetising field.

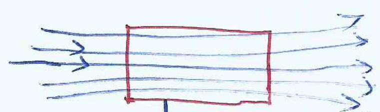
Ex:- Antimony, Bismuth, copper, Lead, Gold, Silver, Diamond, Zinc, Quartz, Water, alcohol, Mercury, Air, Hydrogen, Nitrogen and all inert gases like Helium, Neon, Argon etc.

Diamagnetic substances are those that have tendency to move from stronger to the weaker part of the external mag. field. In other words, unlike the way a magnet attracts metals like iron, the magnet repels a diamagnetic substance.

Field lines are repelled or expelled and field inside the material is reduced



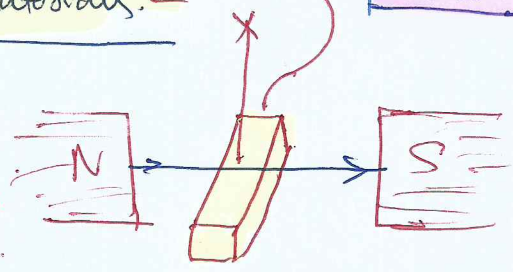
diamagnetic substance



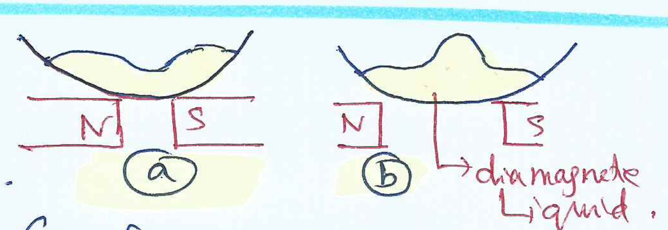
paramagnetic material.

Important properties of "diamagnetic materials."

① When suspended in a uniform $\vec{B}$, they set their longest axis at right angles to the direction of field. Shortest axis is along the direction of the field $\vec{B}$.



② When placed in a non-uniform $\vec{B}$, the diamag. substances have tendency to move from stronger ~~field to weak~~ parts of the field to the weaker parts.

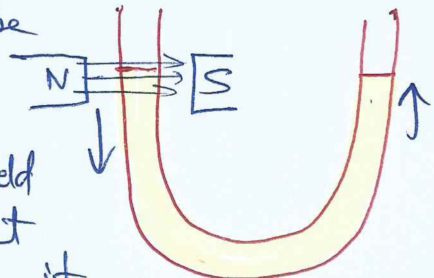


→ Consider a diamag. liquid in a glass (see fig).

(i) When electromagnets held close to each other (≈ 2m), the liquid acquires shape as shown in fig (a). The liquid accumulates on the sides where field is weaker. The depression in the middle is due to very strong field at the centre of magnet.

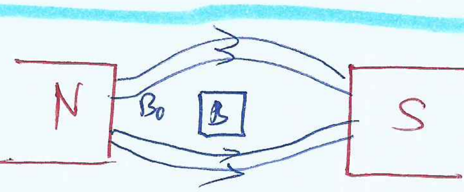
(ii) When distance betn poles increased (fig ⓑ), the effect is reversed, as in this case, the field is weaker at the centre of magnets.

③ The level of a diamag. ~~metal~~ liquid in U tube is depressed, in the limb which is betn magnets. It confirms movement of diamagnetics from stronger part of ~~the~~ the field to weaker parts. This property implies that whereas a magnet attracts metals like iron, it would repel a diamagnetic substance like copper.



④ When a specimen of a diamagnetic material is placed in a magnetising field, the magnetic lines prefer not to pass thro' the specimen.

⇒ mag. field lines are repelled or expelled and the field inside the material is reduced. This reduction is slight, being one part in 10^5.

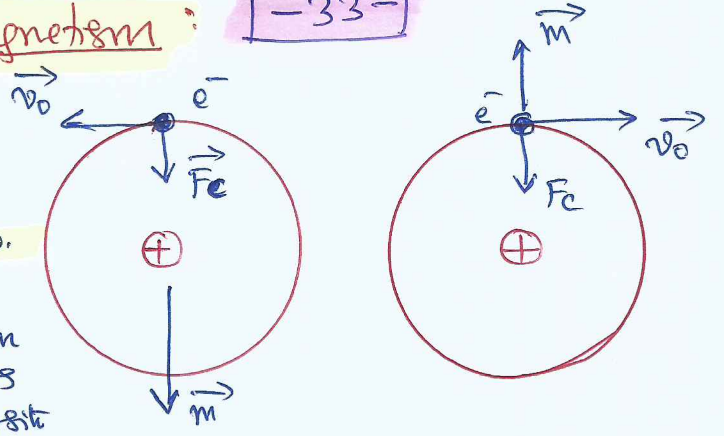


⑤ $\mu_r < 1$ always; $\mu_r = B/B_0$ and $B < B_0$, $\mu_r < 1$

⑥ From relation, $\mu_r = (1 + \chi_m)$; as $\mu_r < 1$, χ_m is $-ve$.

⑦ Susceptibility of diamagnetics does not change with temperature. (Bismuth ~~is~~ is an exception to this general property). Values are given in previous pages at $T = 300\,K$.

Electron theory of Diamagnetism :



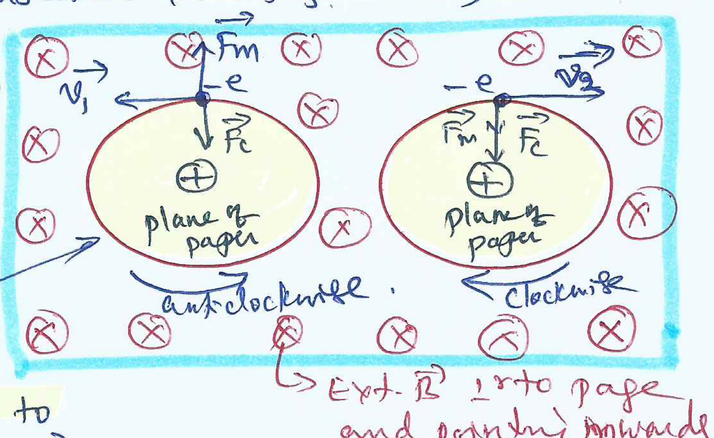
- A revolving electron in the orbit of nucleus represents a tiny loop of current. Hence, it possesses some orbital mag. dipole moment $\vec{m}$ = current × Area of loop.

- In diamagnetic materials, electrons in an atom are considered to exist in pairs having their orbital motion ($\vec{v_0}$) in opposite direction as shown in figure.

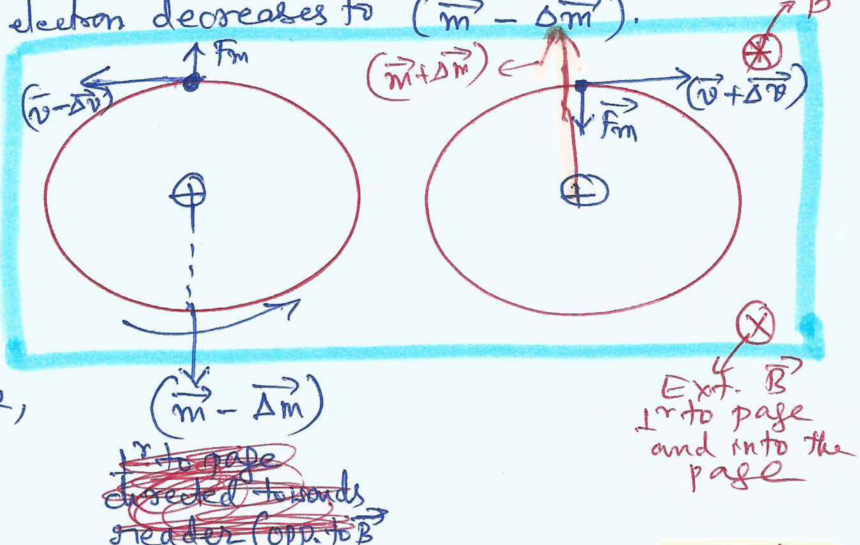
- The mag. moments of both electrons are equal & opposite in direction in the absence of external applied magnetic field. Hence, net magnetic moment of each atom of diamagnetic substance is zero.

- Now, let a uniform mag. field $\vec{B}$ be applied $\perp^r$ to the rotation of electron and in the downward direction (see fig. below)

- Now beside centripetal force, an additional mag. field $\vec{F_m} = -e(\vec{v} \times \vec{B})$ or $F_m = evB$ acts on each electron. (This is Lorentz force).



(a) According to Fleming's LHR, for electron revolving in anti-clockwise direction, $\vec{F_m}$ acts radially outwards (opposite to centripetal force) ⇒ Note $\vec{F_m}$ and $\vec{F_c}$ are on the plane of paper but in opposite directions which tends to decrease the centripetal force and hence decrease the "Velocity of electron" to $(\vec{v} - \Delta\vec{v})$. As a result the mag. moment of electron decreases to $(\vec{m} - \Delta\vec{m})$.

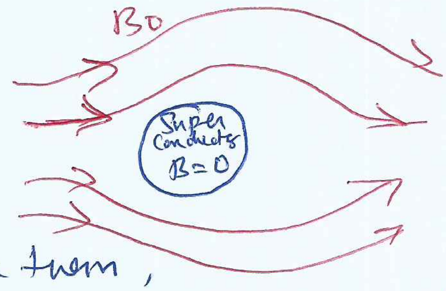


(b) According to FLHR, for electron revolving in "clockwise direction", $\vec{F_m}$ acts radially inwards (in line with centripetal force) ⇒ hence increases the velocity of electron to $(\vec{v} + \Delta\vec{v})$. Therefore, mag. moment of electron increases to $(\vec{m} + \Delta\vec{m})$

∴ Net dipole magnetic moment $= (\vec{m} + \Delta\vec{m}) - (\vec{m} - \Delta\vec{m}) = 2\,\Delta\vec{m}$

The net mag. moment $2\Delta\vec{m}$ so developed is called "Induced mag. moment", which is $\perp^r$ to plane of rotation of electron and upwards. So, direction of induced mag. moment is opposite to applied mag. field $\vec{B}$. The mag. moments induced in different atoms add vectorially to give a net magnetisation in a direction opposite to applied field $\vec{B}$. This accounts for diamag. behaviour of materials. If temp. of diamag. substance is changed, there is no effect on its diamag. property. Thus, diamagnetism is temp. independent.

* IMP : Superconductors are the most exotic diamagnetic materials. These are metals cooled to very low temp^r, (which have zero resistance i.e. perfect conductivity) is associated with perfect diamagnetism. The mag. field lines are completely expelled from super conductors



$\therefore \mu_r = \frac{B}{B_o} = 0$

Since $\mu_r = 1 + \chi_m = 0$

$\boxed{\chi_m = -1}$

- A super conductor repels a magnet and in turn, is repelled by the magnet.
- The phenomenon of perfect diamagnetism in super conductors is called "Meissner effect".
- Superconducting magnets have been used for running magnetically leviated superfast trains.

paramagnetic Materials

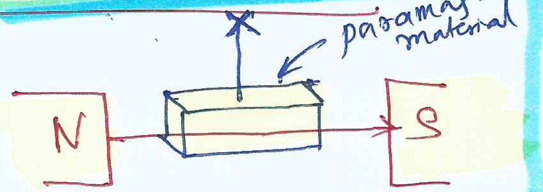
paramag. substances are those in which each individual atom / molecule / ion has a net non-zero magnetic moment of its own. When such substances are placed in an external mag. field, they get feebly magnetised in the direction of the magnetising field.

Ex: Al, Chromium, Manganese, Lithium, Mg, platinum, Tungsten, Sodium, K, ~~Ca~~, copper chloride, oxygen etc...

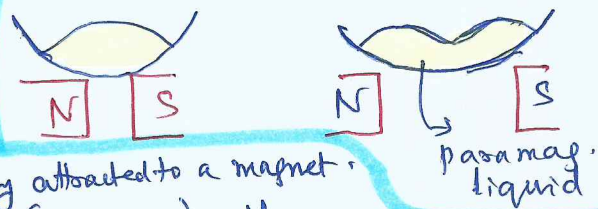
(•) paramag. substances are those which get weakly magnetised when placed in an external magnetic field. They have tendency to move from a region of weak mag. field to strong mag. field ⟹ they get attracted to a magnet.

Imp. properties of paramagnetic Substances

1. When paramag. material is suspended freely in a uniform $\vec{B}$, they rotate so as to bring their longer axis along the direction of the field $\vec{B}$

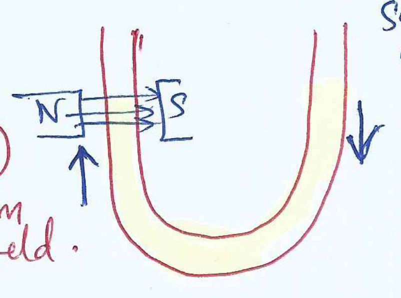


2. When placed in a non-uniform $\vec{B}$ they tend to move from weaker parts of the field to the stronger parts.



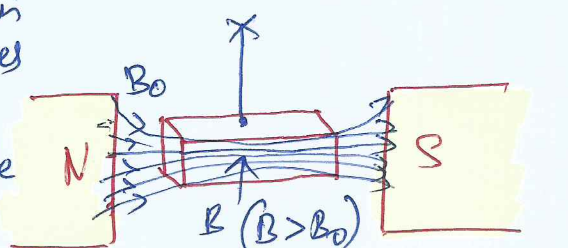
⟹ paramag. substances are weakly attracted to a magnet.
 - → If magnets are close to each other (≈ 2mm), the liquid accumulates at the centre, shape is shown in fig where the field is the strongest
 - → If magnets are kept at a distance (see fig), the effect is reversed, as in that, the field is weaker at the centre of magnet.

3. When a mag. field is applied to the liquid in one limb of a paramag. liquid level of a U-tube, the liquid level rises (see fig)
It confirms that paramag. substances move from weaker to stronger parts of the magnetic field.



See this is opposite to diamag. case.

4. When a specimen of a paramag. substance is placed in a magnetising field, the mag. field lines prefer to pass thro' the specimen rather than thro' air. Thus mag. induction B inside the sample is more than the mag. induction B_0 outside the sample ⟹ $B > B_0$. This enhancement is slight → One part in 10^5.



P.T.O.

(5) Relative mag. permeability of paramag. substances is always > 1

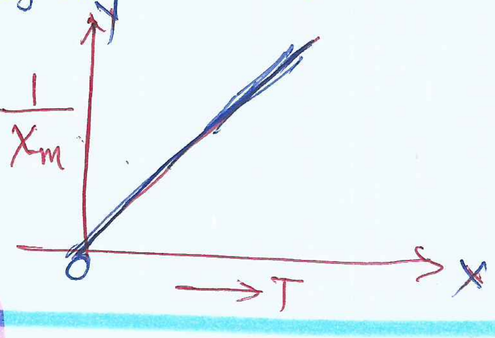
As $\boxed{\mu_r = \frac{B}{B_0}}$ and since $B > B_0$; $\mu_r > 1$

$\Rightarrow$ paramag. substances have a tendency to pull mag. field lines when placed in an external magnetising field.

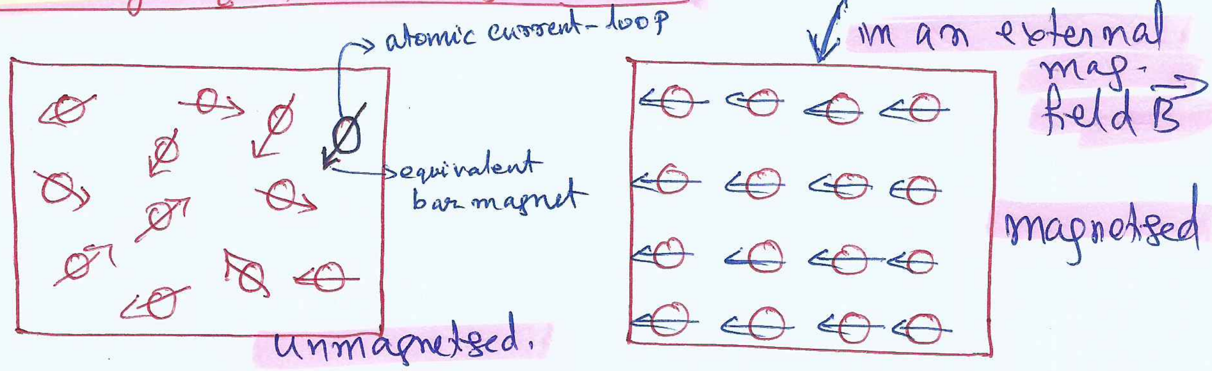
(6) We know that $\mu_r = 1 + \chi_m$; as $\mu_r > 1$, χ must be +ve.

$\therefore$ Susceptibility of paramag. substances is +ve, though small.

(7) Susceptibility of paramagnetic substances varies inversely as the temp^{re} of the substance i.e. $\chi_m \propto \frac{1}{T}$ $\Rightarrow$ they lose their magnetic property with rise in temp^{re}.



Electron theory of paramagnetism



The property of paramagnetism is found in those substances whose atoms (or ions or molecules) have an excess of electrons spinning in the same direction. Hence atoms (or ions / molecules) of paramag. substances have a net non-zero magnetic moment of their own, and behave like tiny bar-magnets. Even then the paramag. substances do not exhibit any magnetic effect in the absence of external magnetic field. The reason is that the individual atomic magnets are randomly oriented and so the net mag. moment of the bulk of the substance remains zero.

P.T.O $\longrightarrow$

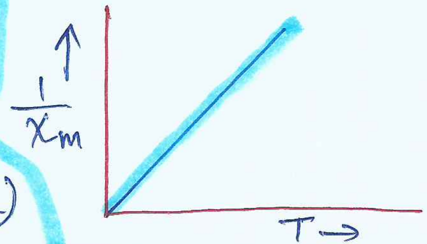
Contd. from pre. page :

When this paramag. substance is placed in an external mag. field $\vec{B}$, then each atomic magnet experiences a torque which tends to align the magnet in the direction of $\vec{B}$. Hence the atoms of the substance are aligned in the direction of $\vec{B}$. As such, the substance acquires a net mag. dipole moment $\Rightarrow$ it is magnetised in the direction of $\vec{B}$. The field lines are more dense inside the paramag. substance compared to those outside.

The atoms of substances undergo thermal agitation. If the substance is a gas, its atoms are in the state of random motion. If it is a solid, the atoms vibrate. This agitation disturbs the magnetic alignment of the atoms. Hence, normally, the magnetism in paramag. substances is very weak.

The magnetism increases on increasing the external mag. field or on reducing the tempr. Thus, paramagnetism is temp^re-dependent. Also χ of paramag. materials decreases with rise in temp^re.

Curie law in paramagnetism :



Curie law : In 1895, Curie discovered experimentally that the "Intensity of magnetization" (M) (mag. moment / unit volume) of a paramag. substance is directly $\propto$ to the "magnetic intensity (H) of the magnetising field and inversely $\propto$ to the Kelvin tempr T.

$$\Rightarrow M = C\frac{B_0}{T}$$ where C = Curie constant

Since $B_0 = \mu_0 H$ $\therefore$ $\boxed{M = C\mu_0\left(\frac{H}{T}\right)}$ Since $\chi_m = \frac{M}{H}$

$\therefore$ $\boxed{\chi_m = \frac{\mu_0 C}{T}}$ or $\chi_m \propto \frac{1}{T}$

This eqn is called Curie's law

This law, however, holds good so long the ratio $\left(\frac{H}{T}\right)$ does not become too large. (M cannot increase without limit). It approaches a maximum value corresponding to the complete alignment of all the atomic magnets contained in the substance.

Ferro magnetic Materials:

Ferro mag. substances are those in which each individual atom/molecule/ion has a non-zero magnetic moment, as in ~~the~~ a paramagnetic substance. When such a substance is placed in an external magnetising field, they get strongly magnitised in the direction of the field.

Ex: Iron, Cobalt, Nickel, Gadolinium, and their no of alloys.

Ferromag. materials show all the properties of paramag. substances, but to a much greater degree. For example ---

(i) They are strongly magnetized in the direction of external magnetising field in which they are placed.

(ii) They have a strong tendency to move from ~~to~~ a region of weak mag. field to the region of strong mag. field ⇒ they get strongly attracted to a magnet.

(iii) μ_r of Ferromag. materials is very large ($\approx 10^3$ to 10^5)

(iv) χ of ———— is also very large ⇒ they can be ~~easily~~ magnetised easily and strongly.

(v) With rise in temp^r, χ of ferromagnetics decreases. At a certain temp^r, ferromagnetics change over to paramagnetics. This transition temp^re is called Curie temp^re. For example, Curie temp^r of iron is about 1000 K.

Explanation of Ferromagnetism:

⊙ The difference in paramagnetism and ferromagnetism is only that of intensity. In fact, the ferromag. substances ~~which acquire strong magnetism in external field~~ are such paramag. substances which acquire strong magnetism in external mag. field. Like paramag. substances, atoms of ferromag. substances have a ~~set of~~ net non-zero magnetic moment of their own and behave like tiny magnets.

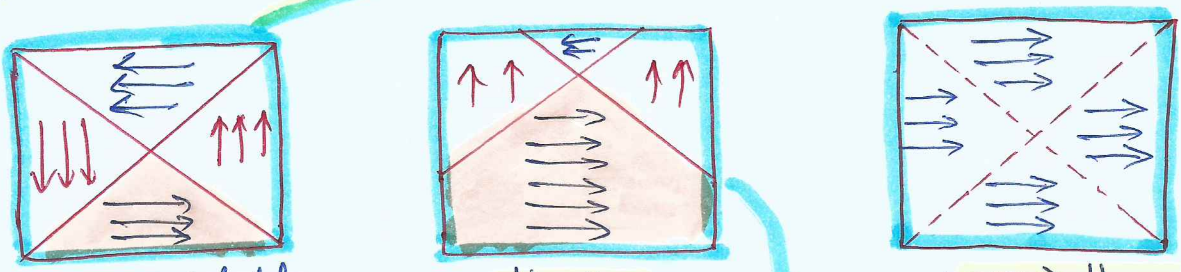
⊙ But in ferromag. substances, the atoms, due to some mutual interaction, form innumerable small effective regions called 'domains'. Each domain has around 10^{11} atoms whose magnetic axes are aligned in the same direction (but different from the atoms of the neighbouring domains)

P.T.O →

Contd. from pre. page :

① When there is no external mag. field, the mag. moments of domains are oriented in different directions such that net mag. moment of the substance in any direction is zero (That is why every piece of iron is not a magnet). (See fig Ⓐ)

② Following figure shows the probable directions of the mag. moments of four domains of iron.



No external field (A) Fig Ⓐ

$H \longrightarrow$ Weak field (B) Fig Ⓑ

$\longrightarrow H$ Very strong field Fig Ⓒ

③ When the substance is placed in an external magnetic field, the magnetic moment or the magnetism of the substance can increase in 2 different ways

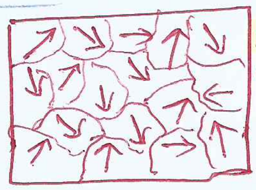
① **By the displacements of the boundaries of the domains :** This implies, the domains which are oriented favourably w.r.t. the external field increase in size, whereas those oriented opposite to the external field are reduced. [See fig Ⓑ]

② **By the rotation of the domains :** ⟹ the domains rotate until their magnetic moments are aligned more or less in the direction of the applied external mag. field. [See fig Ⓒ] This would happen only when mag. field applied is very strong.

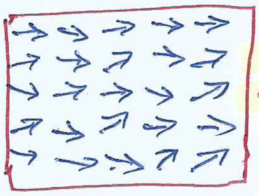
Imp : ⟶ When external $\vec{B}$ is weak, then the substance is magnetised mostly by the "displacement of the boundaries of the domain". (#1 above)

⟶ But in strong fields, the magnetisation takes place mostly by the "rotation of the domains" (# 2 above). The field lines inside the ferromag. substance are much more dense than outside.

* The existence of domains and their motion in H are not speculations. One may observe this under a microscope after ~~sprinkling~~ sprinkling a liquid suspension of ~~powered~~ powdered ferromagnetic substance of samples. This motion of suspension can be observed.



Randomly Oriented domains



Aligned Domains

* Thus, in a ferromag. material, the field lines are highly concentrated. In non-uniform field, the sample tends to move towards the region of high field strength.