MAGNETIC CHEMISTRY AND ITS POSSIBLE APPLICATIONS IN ANALYTICAL SPECTROSCOPY AND RELATED FIELDS.

By Matthew Burns – Chemist/science/math teacher.

CONTENTS

INTRODUCTION

Since the start of modern science many discoveries in one field has had applications in other fields.

In turn these individual discoveries became fields of study themselves.

For instance, Physics which has many areas/fields of study.

They have had branched off or is the basis for other fields such as chemistry.

In addition chemistry is the basis for biology.

Many of these, if not all of them are interlinked to each other in one form or another.

Chemistry for example is one of them.

Chemistry; the study of matter.

Based on the principles of Physics

That are the fields of Thermodynamics (heat), optics and other fields such as electromagnetism.

These areas/fields have become interlinked and developed into subareas of study.

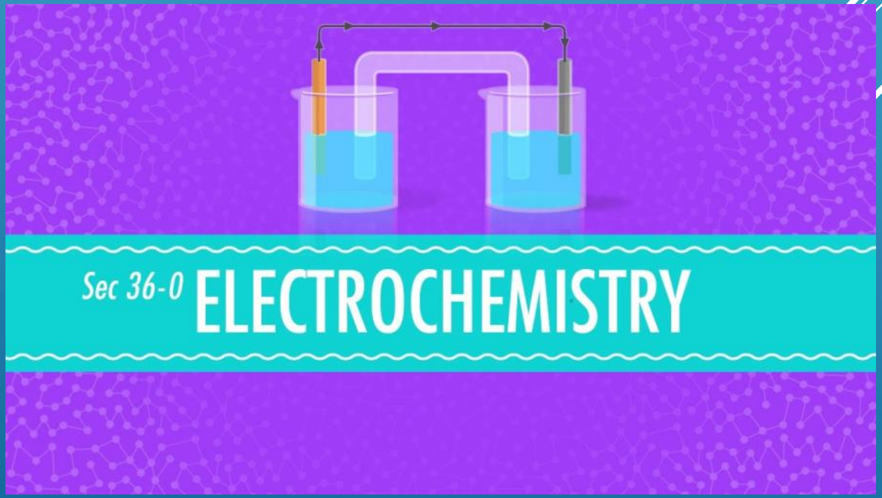
Such as Electrochemistry being based on creating a chemical reaction using an electric current or vice – versa.

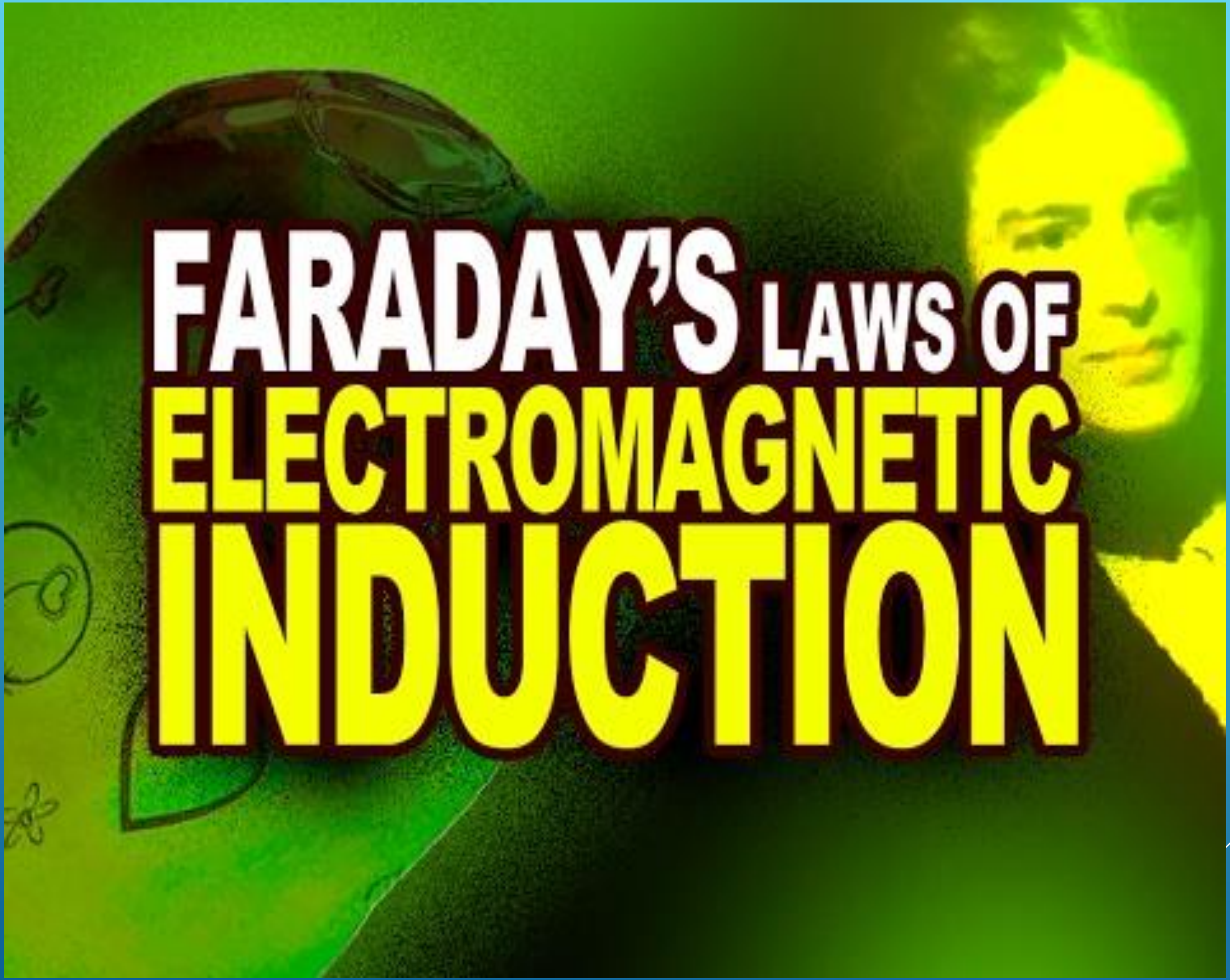
The field relates to oxidation/reduction reactions which shows how valence electrons are transferred or shared between atoms or in molecules.

Also relates to acid/base reactions in which an acid which is an electron acceptor and a base which is an electron donor by the Lewis concept.

Can also be seen as or applied to nucleophilic/electrophilic concepts in organic chemistry.

- Bottom line; principles from one area are applied in other fields or subfields which are interlink and the basis of other fields.
- From the example of the field of electromagnetism which shows the movement of electrons to one atom to another and the magnetic field produced is prevalent in many subfields of chemistry. (the equal sign mean a link to not equal to)




FARADAY'S LAWS OF
ELECTROMAGNETIC
INDUCTION

Faraday's law of electromagnetic induction

Faraday's First Law

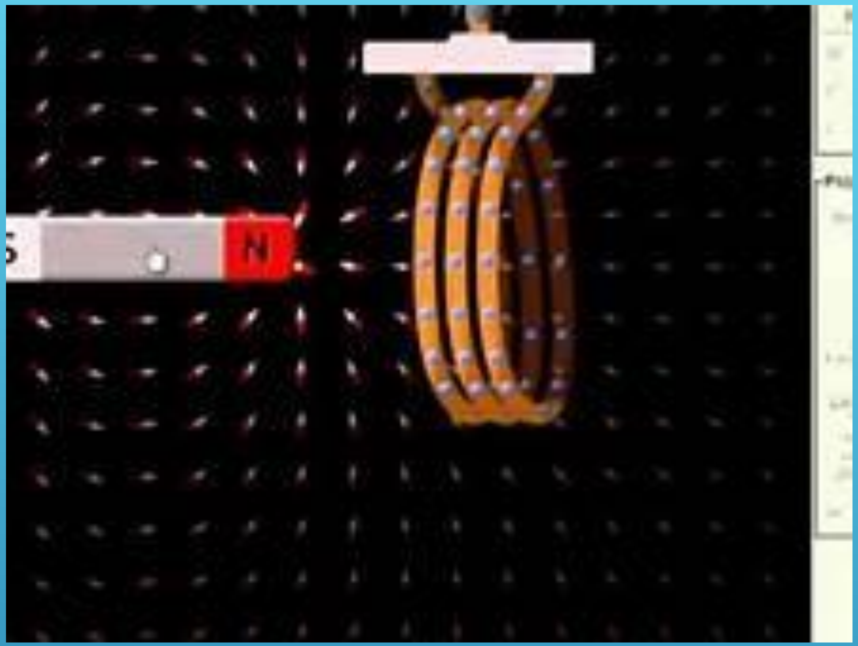
- Any change in the magnetic field of a coil of wire will cause an emf to be induced in the coil. This emf induced is called induced emf and if the conductor circuit is closed, the current will also circulate through the circuit and this current is called induced current.

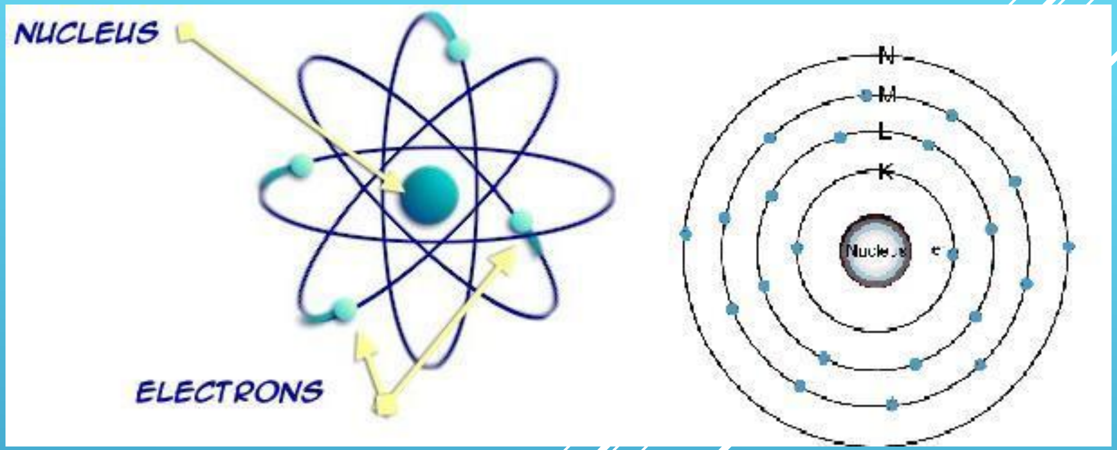
Method to change magnetic field:

1. by moving a magnet toward or away from the coil
2. by moving the coil into or out of the magnetic field.
3. by changing area of a coil placed in the magnetic field
4. by rotating the coil relative to the magnet.

FARADAY'S SECOND LAW:

"THE MAGNITUDE OF EMF INDUCED IN ANY CONDUCTRO IS EQUAL TO THE RATE OF CHANGE OF FLUX LINKAGES WITH IT."





This also applies to any material that has electrons moving or flowing through it.

Or has a magnetic or electric field.

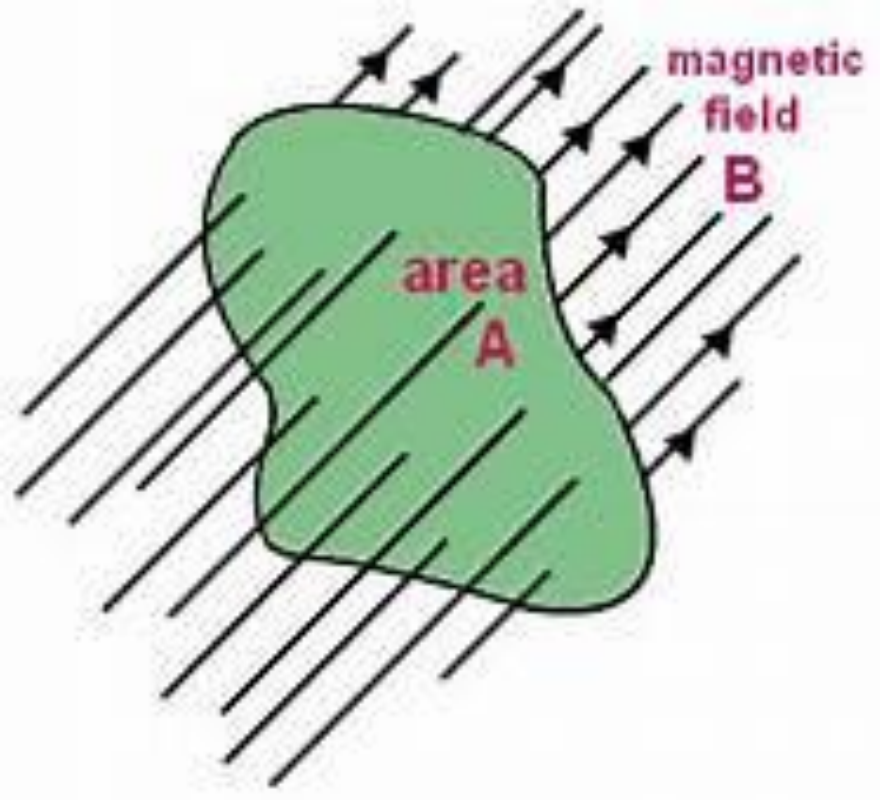
This includes any chemical compound which has electrons moving within them.

An atom and/or a molecule has electrons orbiting within in them which can be thought of a loop or coil. As depicted in the figure above.

Being thought as that, you can say the electron orbitals as coil of a loop of wire.

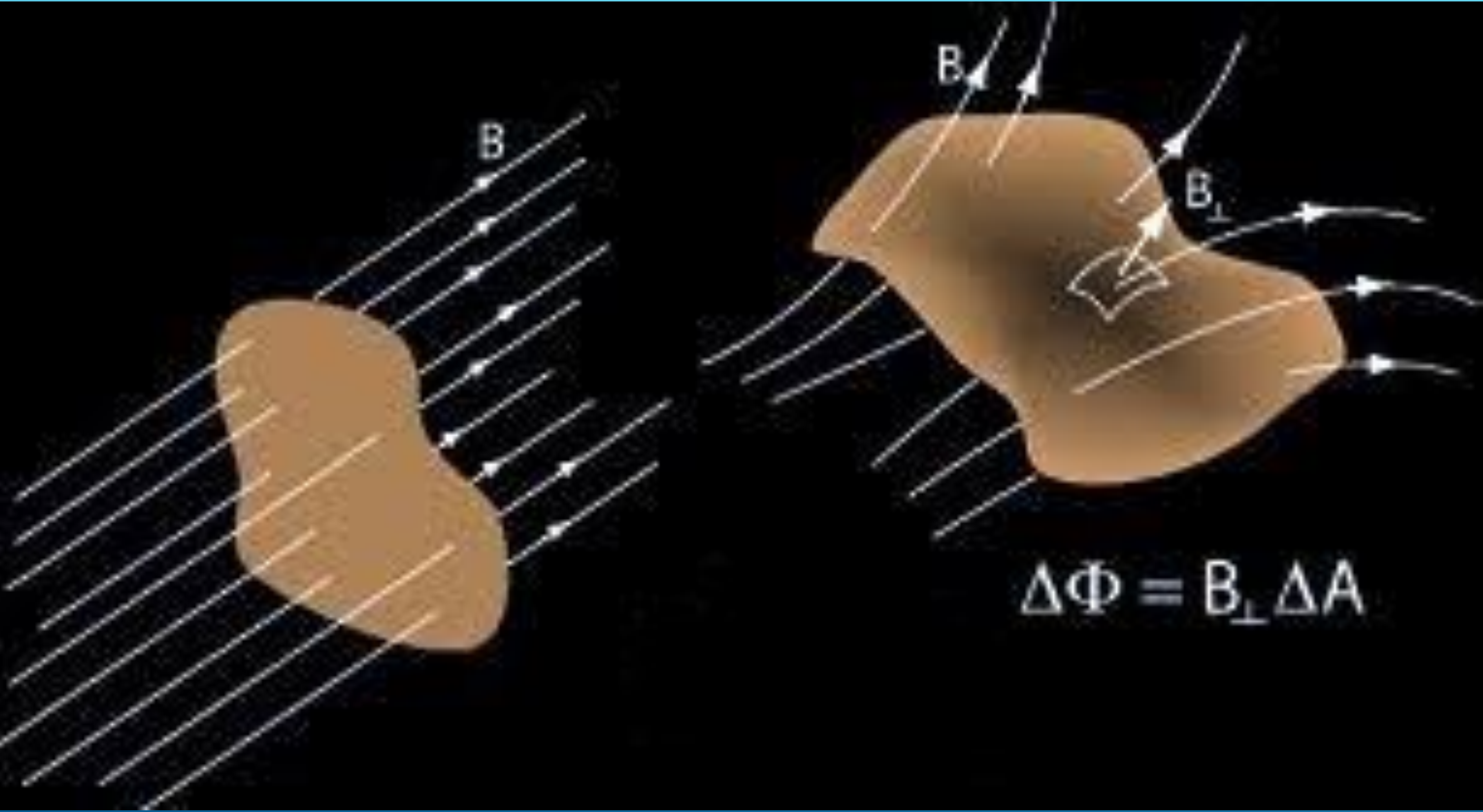
Further, a bulk sum of material can be consider a “loop.” being it has atoms that have electron moving in them within molecules

- We’ll can the electron orbitals the “loop.”
- The magnetic flux, (often denoted Φ or Φ_B) through a surface is the surface integral of the normal component of the magnetic field flux density **B.**
- **That is** passing through that surface area which will be called the “loop” is proportional to the number of magnetic flux lines that pass through the “loop” (See picture below.)
- The next two slides show the equation for magnetic flux and the pictorial representation of the equation.

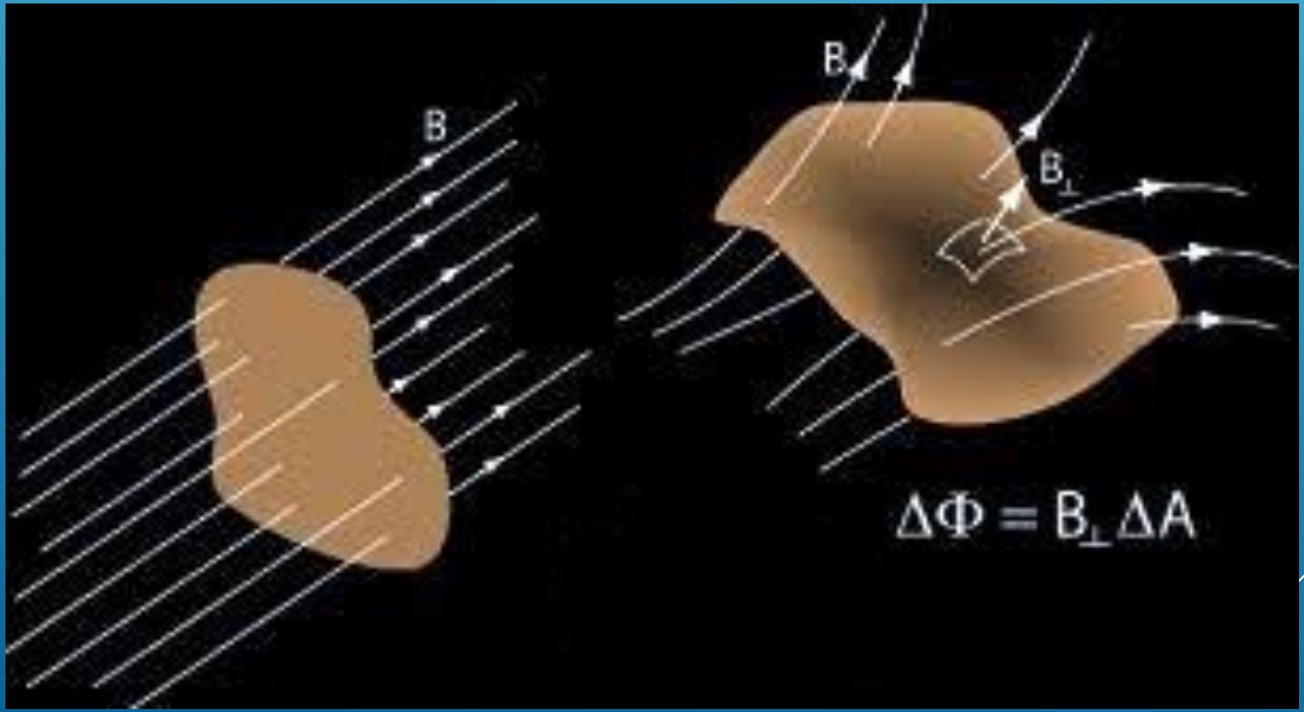


$$\Phi(t) = \int_S \mathbf{B}(t)\, d\mathbf{S}$$

[The Magnetic Flux Φ is the Sum (Average) of the $\mathbf{B}$ – field over the area S]


B
B
$B_\perp$
$\Delta\Phi = B_\perp \Delta A$

- Now for atoms and molecules especially organic ones from hydrocarbon fuels which will be discussed later.
- They can be considered a “loop” being they have atoms(Hydrogens) with electrons moving in them.
- As the molecules move though the magnetic field .
- The flux and/or the field going though it changes.
- As shown in the picture below.

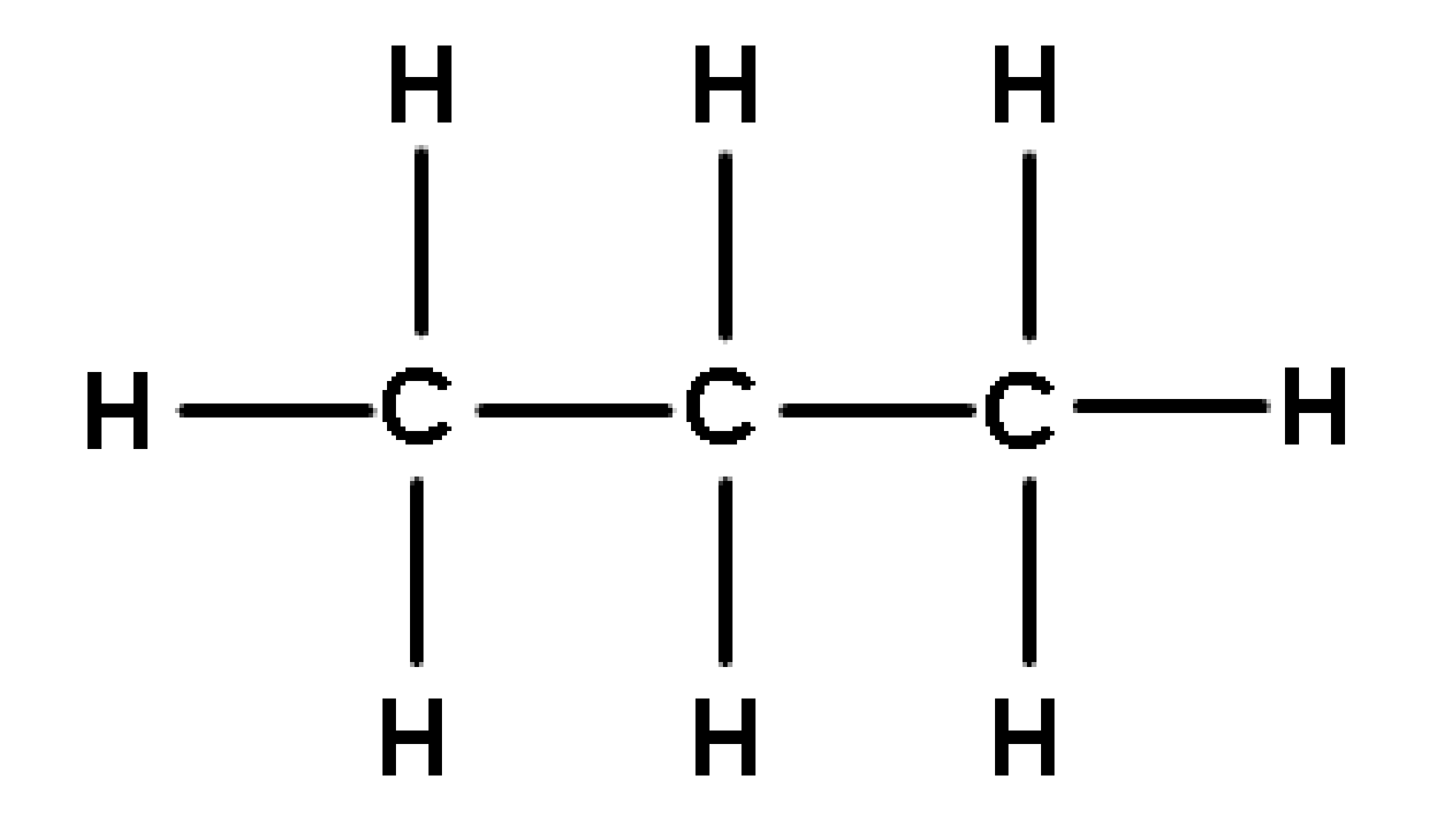


- When flux changes is due to changes in B or “loop” is moved or deformed.
- It acquires on EMF (Electro motive force or voltage.)
- EMF – given by rate of change of magnetic flux;

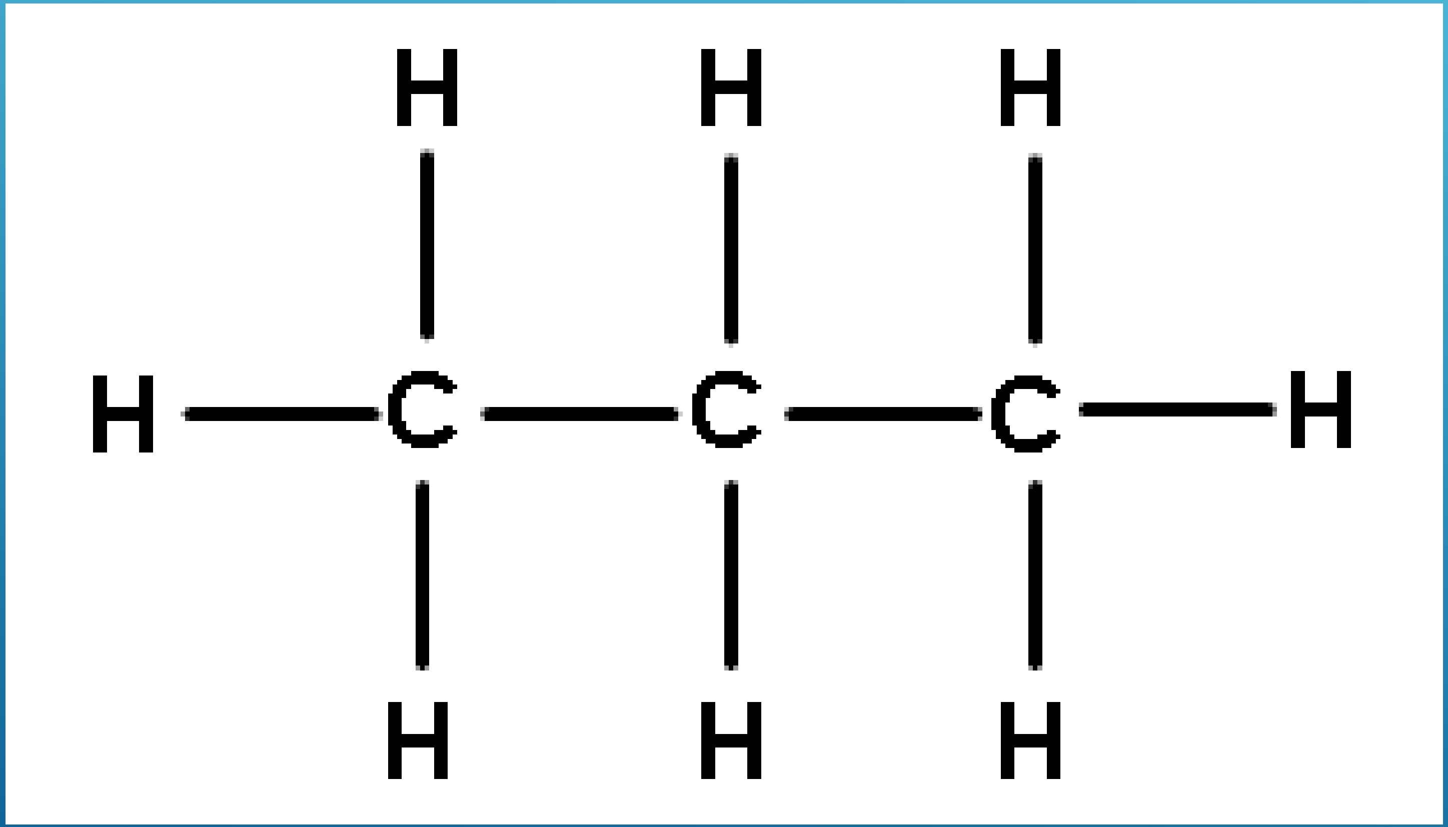
$$\varepsilon \propto \frac{\Delta\Phi}{\Delta t} \Leftrightarrow \varepsilon = -\frac{\Delta\Phi}{\Delta t}$$

If there are N number of coils then $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

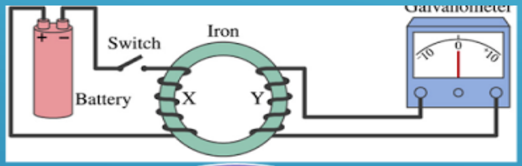
- Now here is a figure of an organic molecule.
- The Hydrogens are connected to the carbons which are the covalently bonded electrons are shared between the carbon and hydrogen.
- These bonding electrons orbit both the carbon and hydrogen in each C-H bond.



- This means each hydrogen/carbon bond is in a sense an electric circuit or conductor, which can be considered a “loop”
- Thus, can be affected by an external magnetic field and produce an electric current and magnetic field.



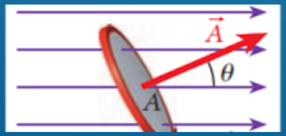
Continuing on, after Michael Faraday created his law of induction, Hein Lenz continued Faraday's work and made a discovery. As shown below and in the next side.



$$\varepsilon = -\frac{d\Phi}{dt}$$

Magnetic flux, ϕ → **Faraday's Experiment** → **Faraday's Law (1831)** → **Lenz's Law (1834)**

$$\Phi = \vec{B} \bullet \vec{A} = BA\cos\theta$$



Faraday's Experiment

- a *steady magnetic flux/ field* produces *no current*
- a *changing magnetic* flux/ field can *produce an electric current*

Faraday's Law (1831)

- the magnitude of the induced emf is **proportional** to the rate of change of the magnetic flux

Lenz's Law (1834)

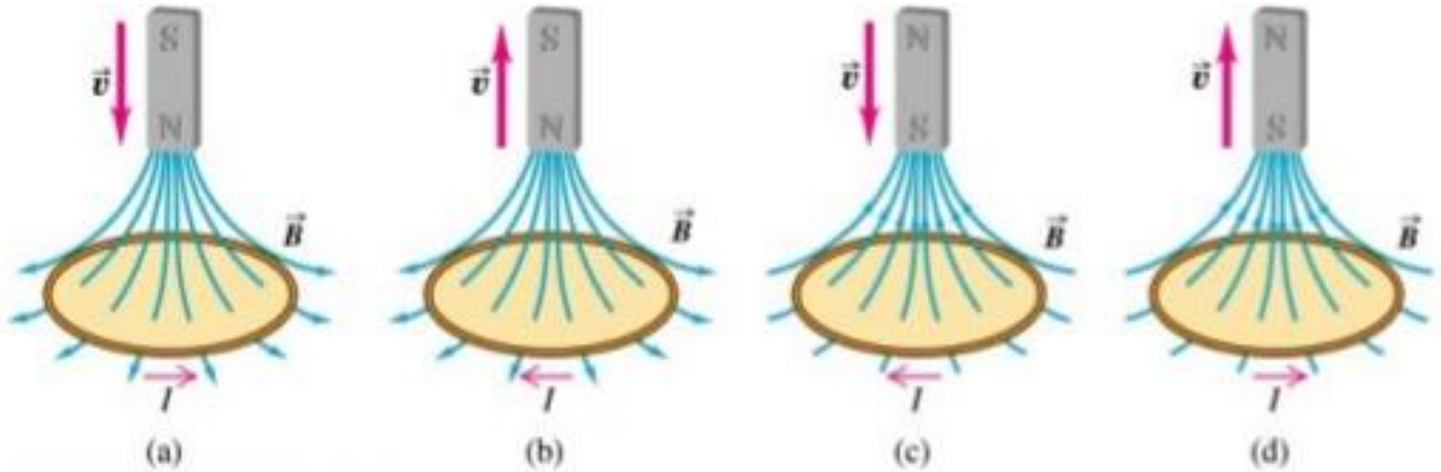
- an induced electric current always flows in such a direction that it **opposes** the change

Lenz's Law

Lenz's law gives the direction of the induced emf and current resulting from electromagnetic induction. The law provides a physical interpretation of the choice of sign in Faraday's law of induction, indicating that the induced emf and the change in flux have opposite signs.

$$\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

Lenz's Law

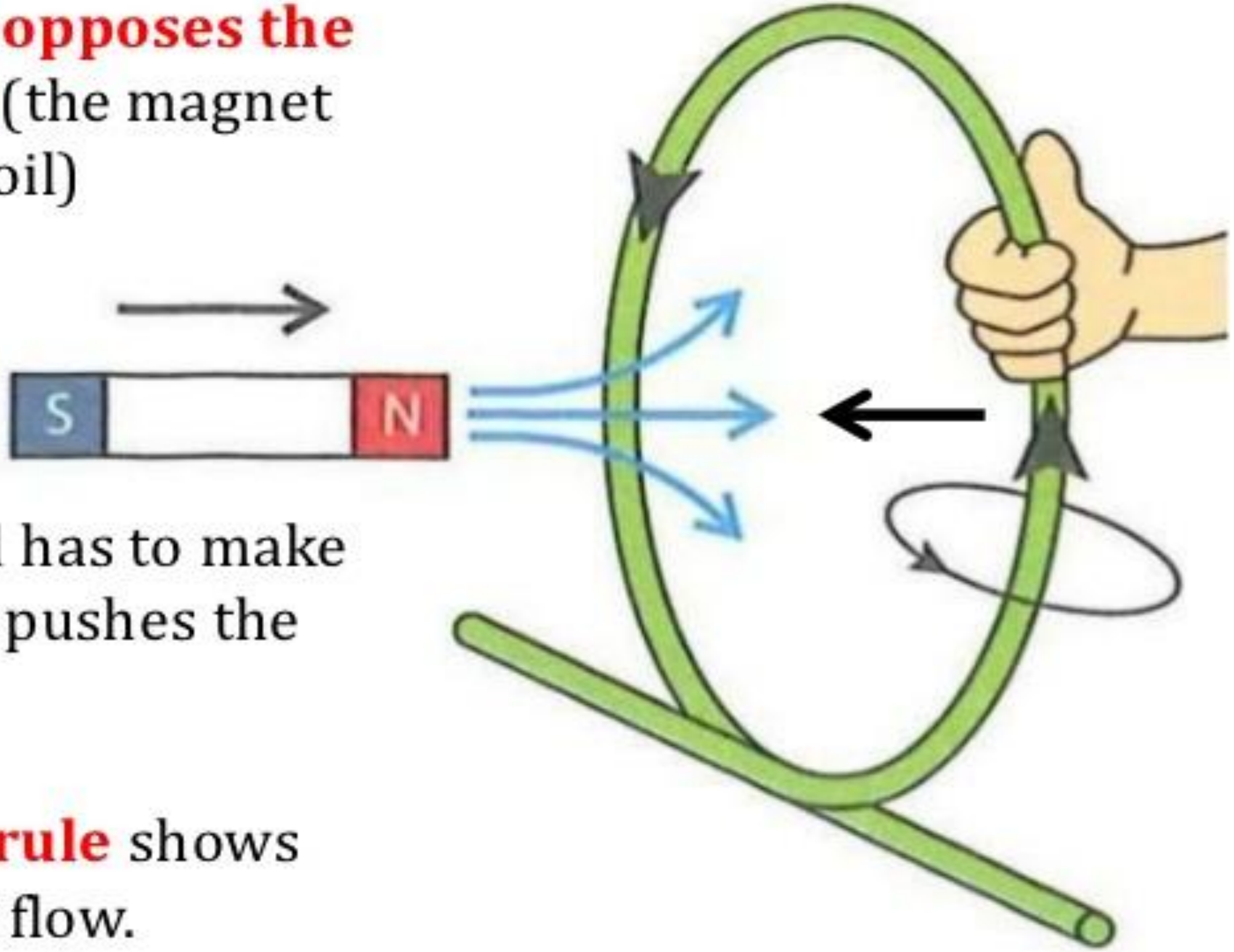


In the figure above, we see that the direction of the current changes. Lenz's Law helps us determine the **DIRECTION** of that current.

Faraday's and Lenz's Laws – Example 1

B) Lenz's Law

The direction of the Induced current is such that **it opposes the change producing it** (the magnet moving towards the coil)



The current in the coil has to make a **magnetic field** that pushes the Magnet away....

The **Right hand grip rule** shows how the current must flow.

NOW A BRIEF DISCUSSION ABOUT MAGNETISM BEFORE GETTING ON WITH PARAMAGNEITSM AND DIAMAGNETISM

MAGNETISM

Magnetic materials may be identified as belonging to one of four categories: ferromagnetism, paramagnetism, diamagnetism, and antiferromagnetism.

The strongest form of magnetism is ferromagnetism.

Antiferromagnetism - magnetic moments of molecules or atoms align in a pattern in which neighbor electron spins point in opposite directions.

The magnetic ordering vanishes above a certain temperature.

The magnetization approximately follows Curie's law, stating that the magnetic susceptibility χ is inversely proportional to temperature:

$M = \chi H = CH/T$

M is magnetization, χ is magnetic susceptibility, H is the auxiliary magnetic field, T is the absolute (Kelvin) temperature, and C is the material-specific Curie constant.

PARAMAGNETISM/DIAMAGNETISM

Paramagnetism refers to a property of certain materials that are weakly attracted to magnetic fields. The Valence electrons are unpaired.

When exposed to an external magnetic field, internal induced magnetic fields form.

Aligned in the same direction as the applied field.

Once the applied field is removed, the materials lose their magnetism.

Diamagnetic materials are weakly repelled by magnetic fields and valence electrons are paired.

The next slide summarizes this.

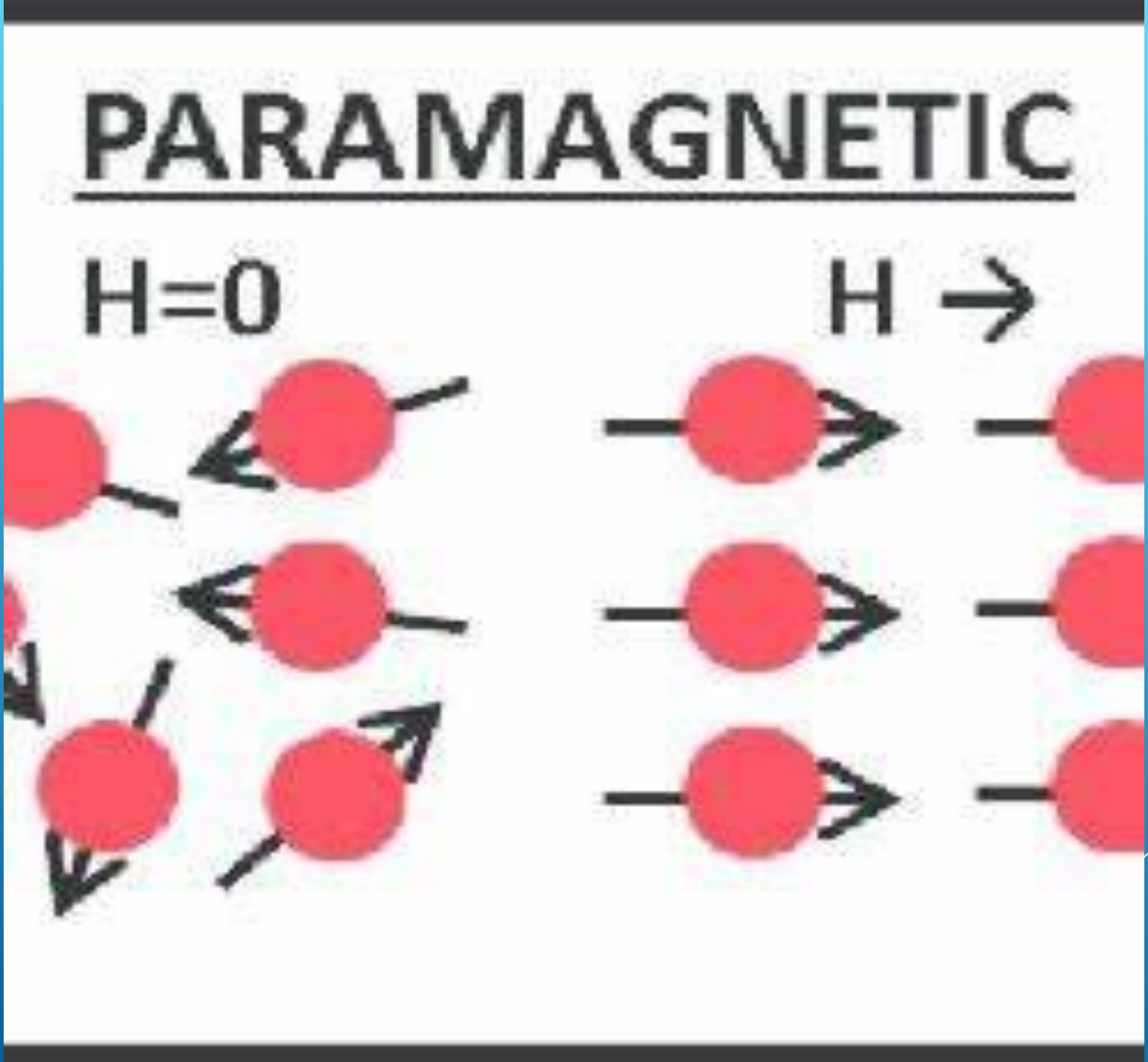
Paramagnetism and Diamagnetism

- Atoms with unpaired $\underline{\uparrow}$ electrons are called ***paramagnetic***.
  - Paramagnetic atoms are attracted to a magnet.
- Atoms with paired $\underline{\uparrow\downarrow}$ electrons are called ***diamagnetic***.
  - Diamagnetic atoms are repelled by a magnet.

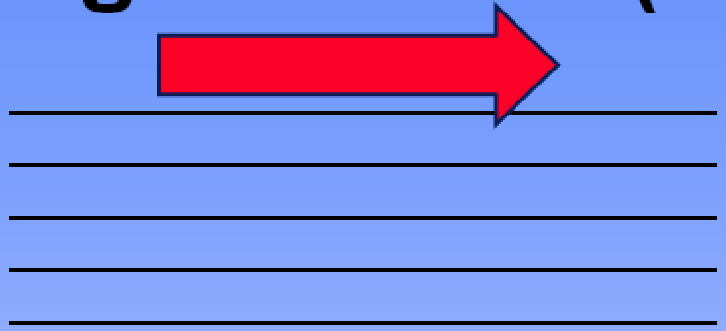
The next two slides show;

First slide: diagram of a paramagnetic compound aligns itself within a magnetic field.

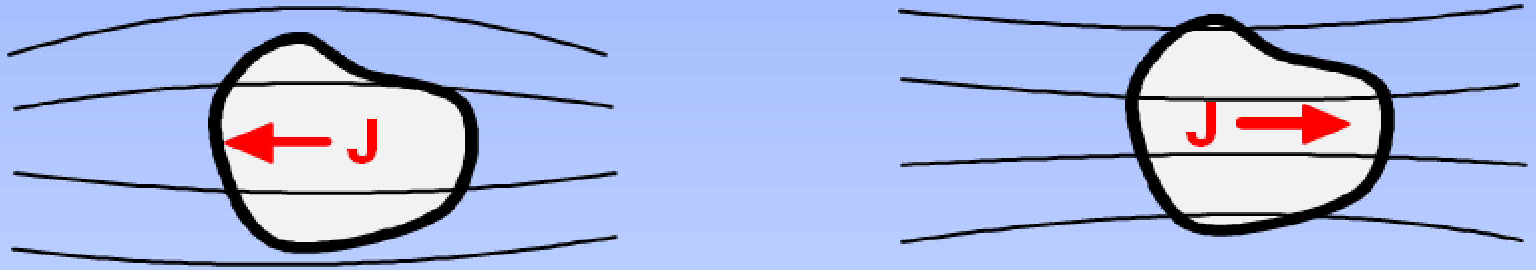
Second slide: shows a comparison of diamagnetic and paramagnetic compounds aligning to an external magnetic field.


PARAMAGNETIC
H=0
H →

Magnetic field (B_o)



Diamagnetic | **Para/Ferromagnetic**



$\chi < 0$ | $\chi > 0$

- A substance contains no unpaired electrons and is not attracted to a magnetic field.
- Diamagnetism is a quantum mechanical effect that is found in all materials.
- For a substance to be termed "diamagnetic" it must be the only contribution to the matter's magnetic effect.
- It is caused by the orbital motion of electrons in the atoms of the material and is unaffected by temperature.

MORE ON DIAMAGNETISM

Diamagnetism

- The value of B is smaller in the region of the diamagnetic material than it would be if the material were absent
- The origin of diamagnetism is Lenz's law

When the flux through an electrical circuit is changed, an induced current is set up in such a direction as to oppose the flux change.

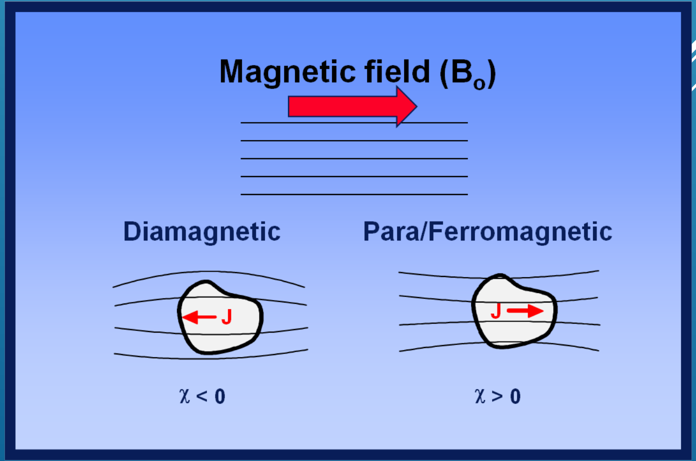
WHEN COMPARED TO PARMAGNETISM.

You noticed that the magnetic field is repulsed by the diamagnetic material.

For the paramagnetic material is aligns itself to the field.

However, there is a means to convert a diamagnetic material into a paramagnetic one without any chemical change.

More of how this can be will be discussed later on.



INTERMOLECULAR FORCES

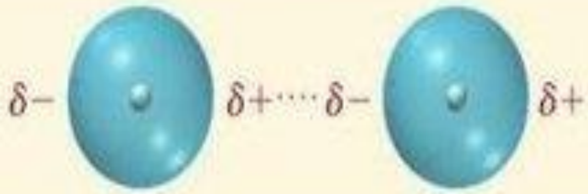
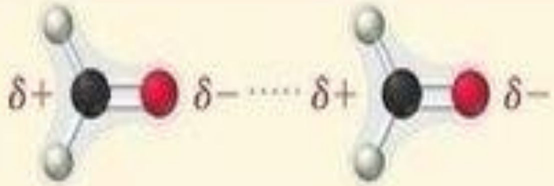
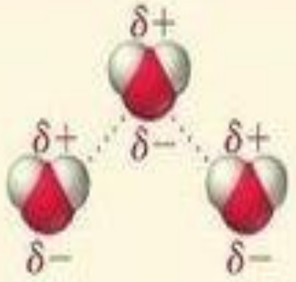
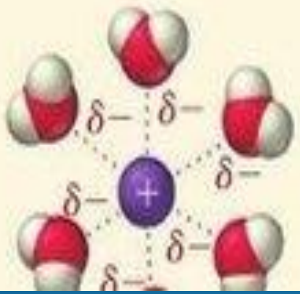
Difference between intramolecular and intermolecular.

Intramolecular forces (bonding forces) exist within molecules and influence the chemical properties.

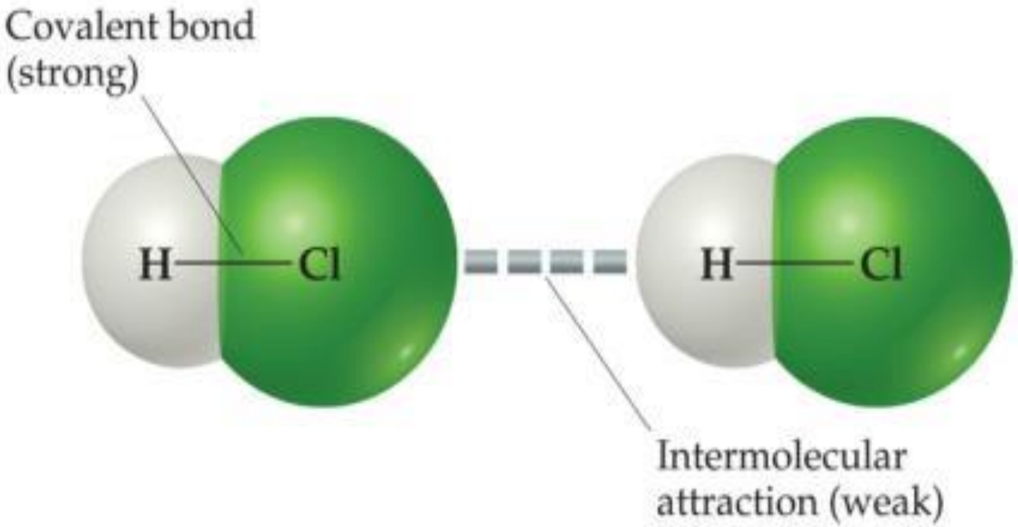
Intermolecular forces exist between molecules and influence the physical properties.

In the next two slides; the first show a chart of the types of intermolecular forces, the show shows a diagram of the Van der Waals intermolecular forces.

TABLE 11.4 Types of Intermolecular Forces

Type	Present in	Molecular perspective	Strength
Dispersion	All molecules and atoms		
Dipole–dipole	Polar molecules		
Hydrogen bonding	Molecules containing H bonded to F, O, or N		
Ion–dipole	Mixtures of ionic compounds and polar compounds		

Intermolecular Forces



These intermolecular forces as a group are referred to as van der Waals forces.

London Dispersion Forces

The IMF that exist between **non-polar** atoms or molecules and due to attractions between opposite charges.

Attractive forces are due to **instantaneous dipole moments**.

Figure on the next slide represents a "snapshot" of two helium atoms.

At this particular instant, both valence electrons on the atom on the right are on the same side of the nucleus.

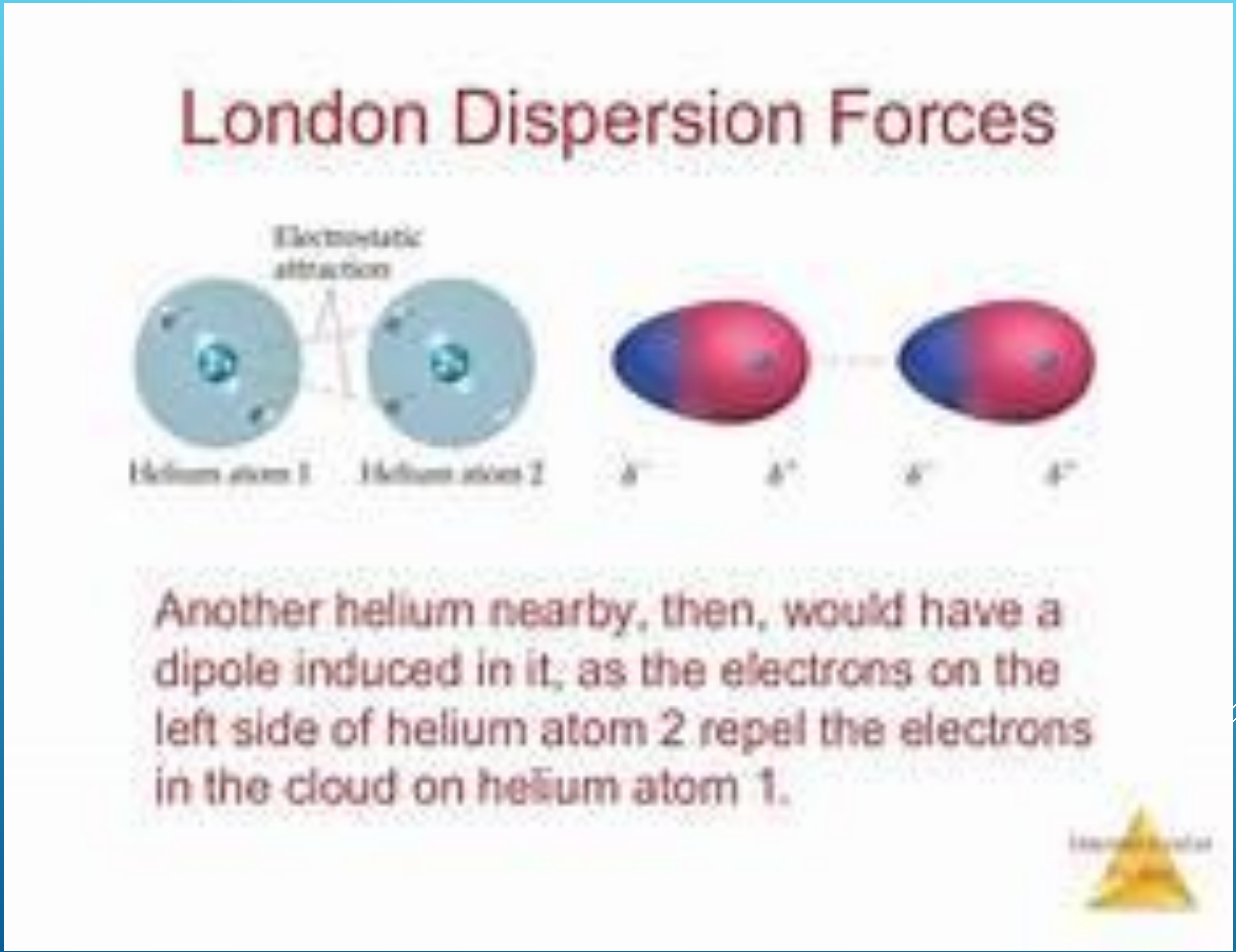
This will create an instantaneous dipole moment in that helium atom.

There will be an attraction between this area of negative charge and the nucleus of an adjacent helium atom.

Electrons on the second atom will be repelled by the electrons on the first.

Then will also form an "induced" dipole in the second atom.

The picture on the right shows the induced dipole moments and the attraction between them. These are the London Dispersion Forces.


London Dispersion Forces
Electrostatic attraction
Helium atom 1
Helium atom 2
Another helium nearby, then, would have a dipole induced in it, as the electrons on the left side of helium atom 2 repel the electrons in the cloud on helium atom 1.

MOLECULAR CLUSTERS

It is ensemble of bound atoms or molecules that is immediate in size between a molecule and a bulk solid.

It exists of diverse stoichmetries and nuclearities.

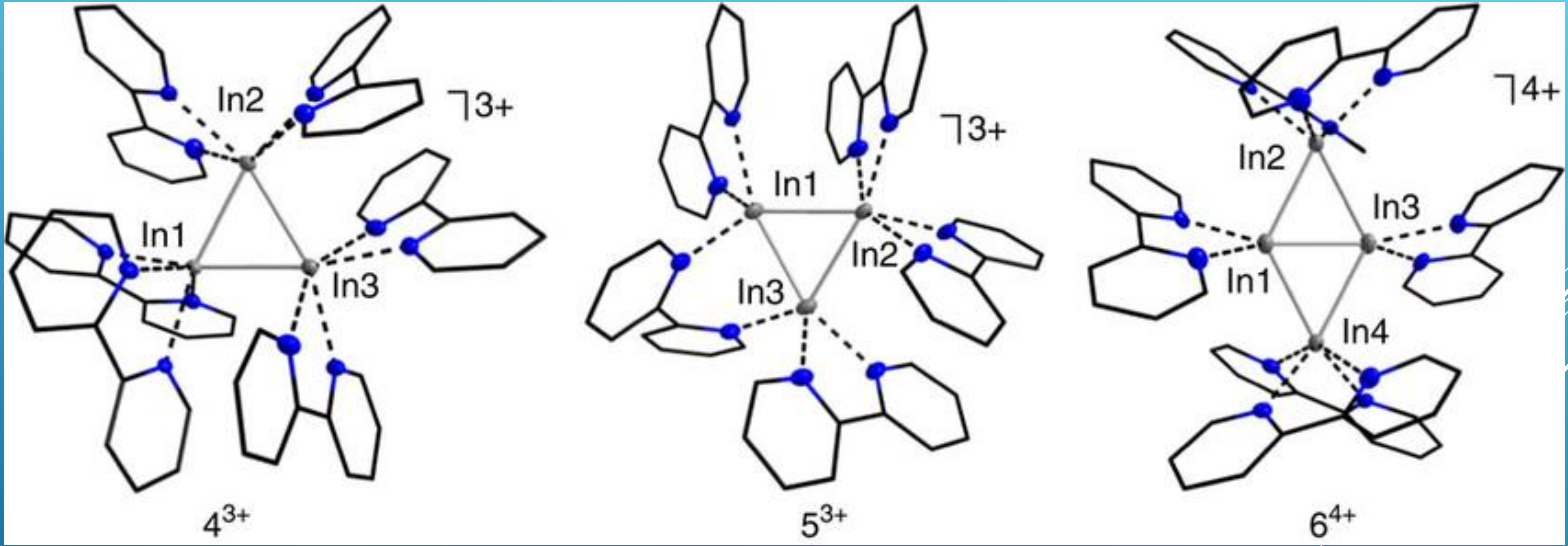
They are aggregates of 5- 10^5 atomic or molecular units.

Classified according to the forces binding them together.

One type which is in this discussion is Van der Waals clusters.

The attraction is between induced electric dipoles and repulsion between electron cores of closed electron configurations.

The next slide shows a cluster of Dicyclohexane molecules with a cyclopropane molecule .


In2
3+
In1
In3
4^3+
In1
3+
In2
In3
5^3+
4+
In2
In3
In1
In4
6^4+

Cluster system properties come from the size and composition (that contributes to the binding forces) which determines:

- Number of dimensions of the phase spaces.
- The range of accessible positions and velocities of the atomic compounds.

There is a gradual transition that occurs between the properties of the molecules and that of the corresponding bulk mass.

They exhibit physical and chemical properties specific to their configuration space only.

They’re strongly atom-count dependent and have specific qualities compared to the bulk mass.

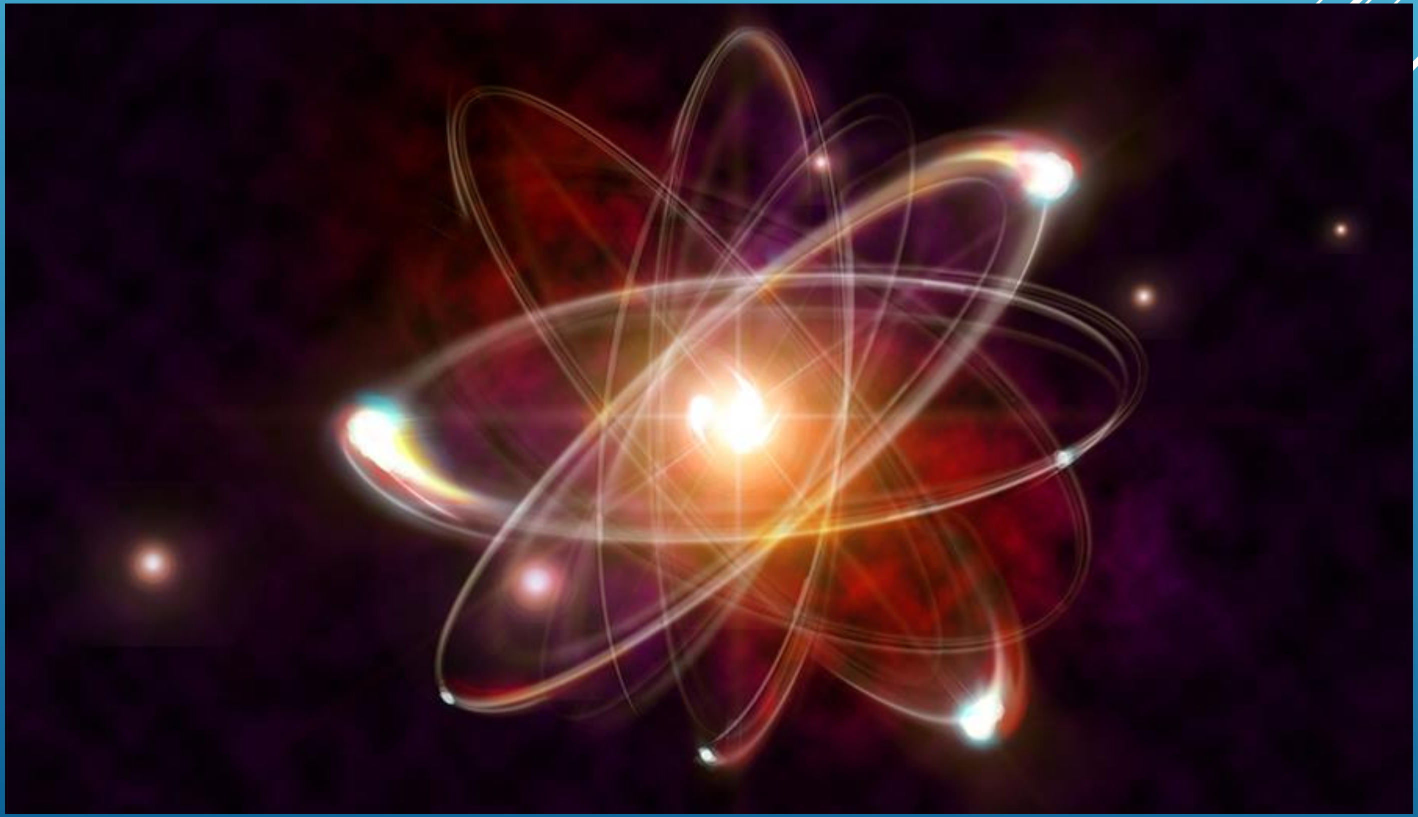
Are metastable in respect to one of the following evolution classifications;

- Elimination or absorption at cluster surface as cause for growth or decay.
- Switches among set of stable configuration structures which is accessible to all clusters of the same or similar type.

QUANTUM PRINCIPLES; ELECTRON COUPLING INTERACTIONS

Practically all of these phenomenon are based on the movement of the electrons in the atoms.

The study of electrons orbiting and interacting in an atom and in chemical bonds is called Quantum Mechanics.



An electron being a charged particle exhibits an electric field.

When in motion creates a magnetic field that is perpendicular or orthro orientation to the electric field.

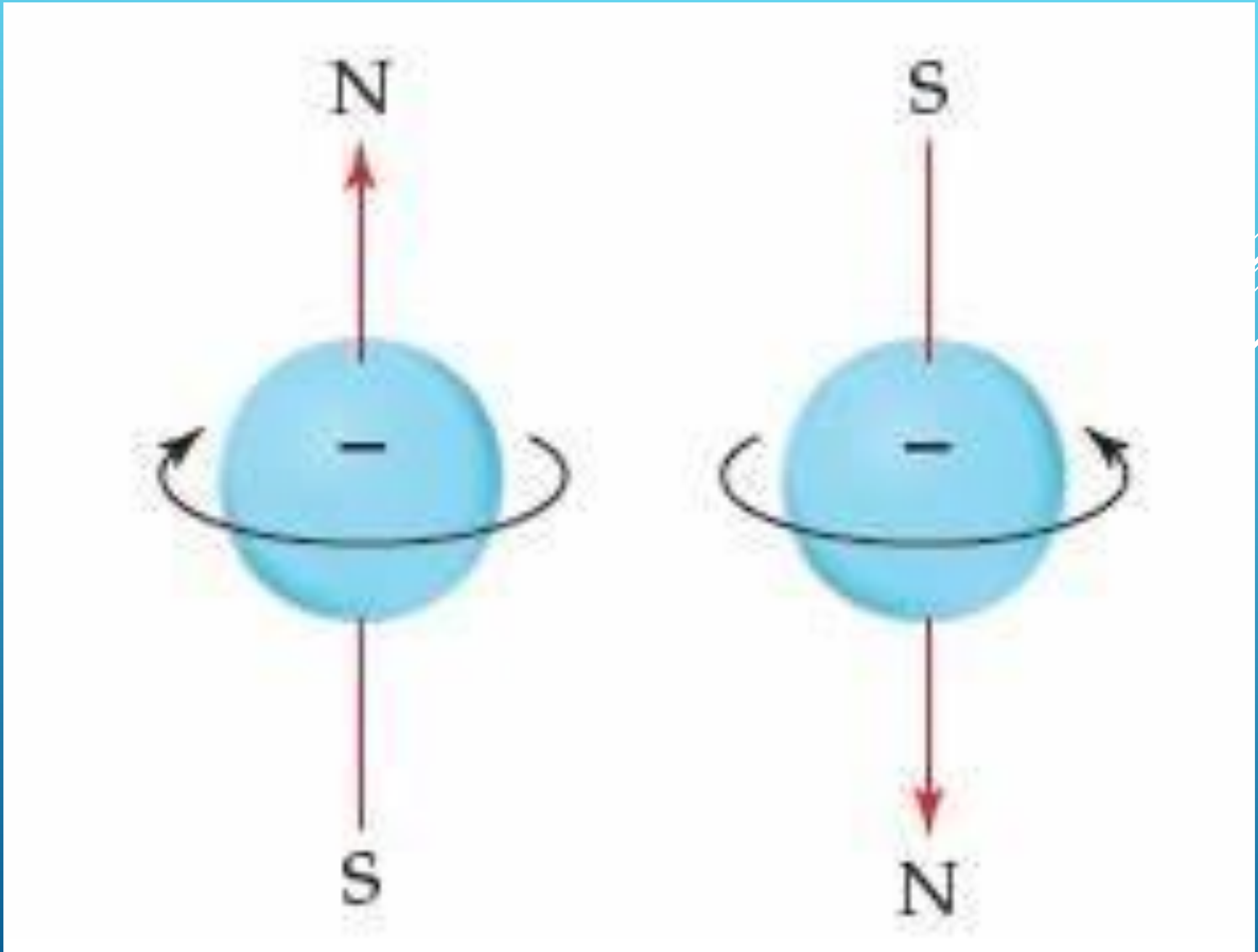
The attractive or intermolecular force itself is a combination both the electric and magnetic fields of the electrons.

That orbit nucleus of the atom itself.

When orbiting the nucleus the electron can have two magnetic orientations call **spin**.

This is so the electron’s magnetic field doesn’t repel the others orbiting the nucleus.

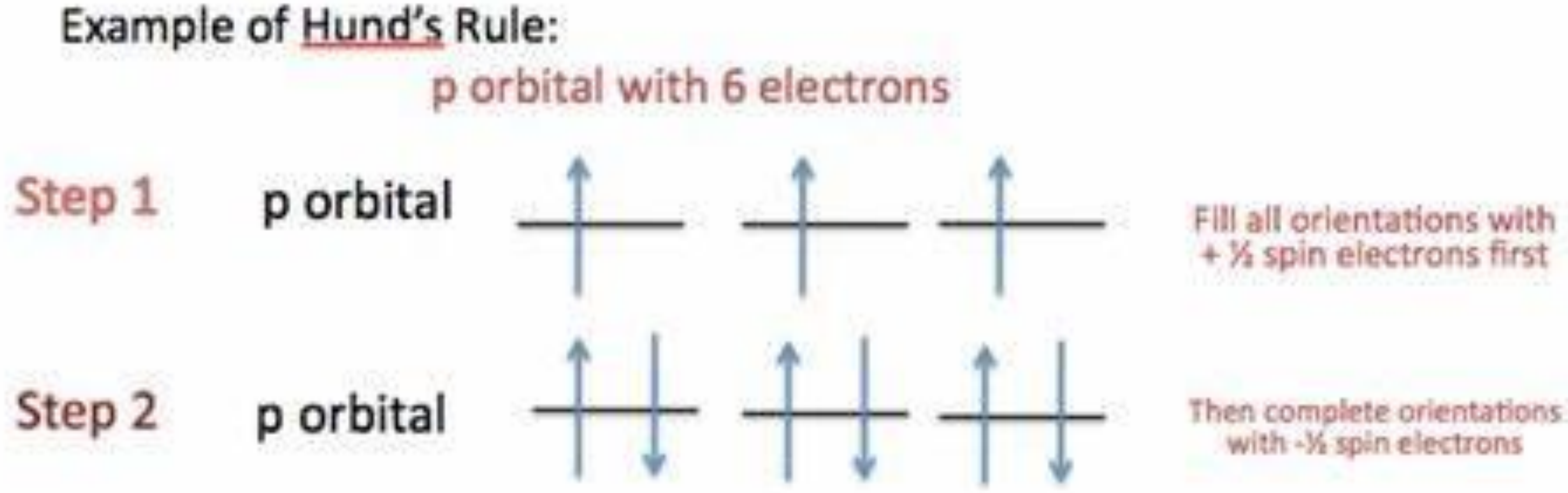
The next slide shows the two types spin an electron can have



N
S
S
N

In the atom the electrons are arranged in a particular order which is call …

Hund's rule: every orbital in a subshell is singly occupied with one electron before any one orbital is doubly occupied, and all electrons in singly occupied orbitals have the same spin.



- Going hand in hand with Hund’s rule is Pauli's exclusion principle which is …
- the quantum mechanical principle which states that two or more identical particles (particles with half-integer spin) cannot occupy the same quantum state within a quantum system simultaneously.
- In other word, it mean that each electron must have it’s own place in orbiting the nucleus.
- The next slide show an example of this.

Element	Total Electrons	Orbital Diagram				Electron Configuration
		1s	2s	2p	3s	
C	6	↑↓	↑↓	↑ | ↑ |		$1s^2 2s^2 2p^2$
N	7	↑↓	↑↓	↑ | ↑ | ↑		$1s^2 2s^2 2p^3$
Ne	10	↑↓	↑↓	↑↓ | ↑↓ | ↑↓		$1s^2 2s^2 2p^6$
Na	11	↑↓	↑↓	↑↓ | ↑↓ | ↑↓	↑	$1s^2 2s^2 2p^6 3s^1$

SPIN ORBIT INTERACTIONS

It is a relativistic interaction of a particle's spin with its motion inside a potential(electric.)

Example- spin-orbit interaction leading to shifts in an electron's atomic energy levels.

This is due to electromagnetic interaction between;

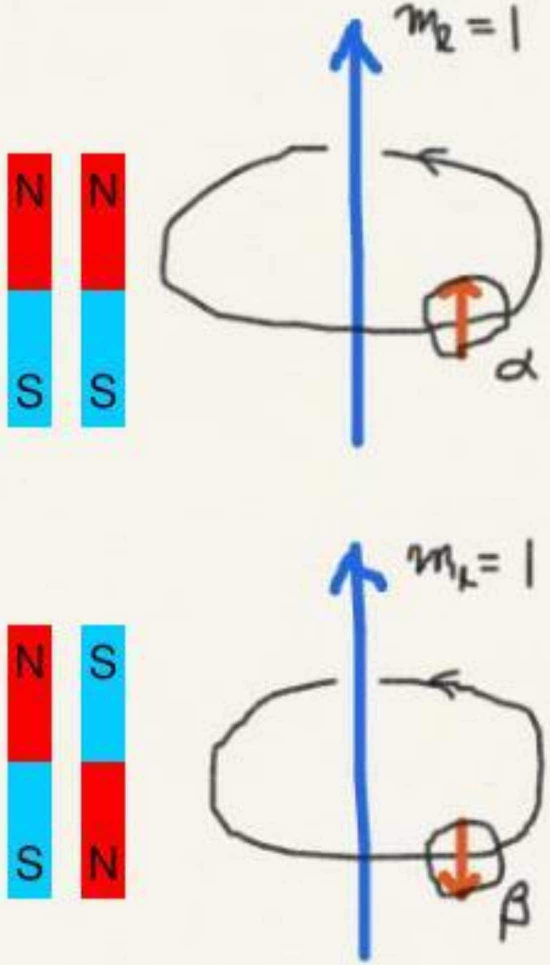
an electron's orbital motion,

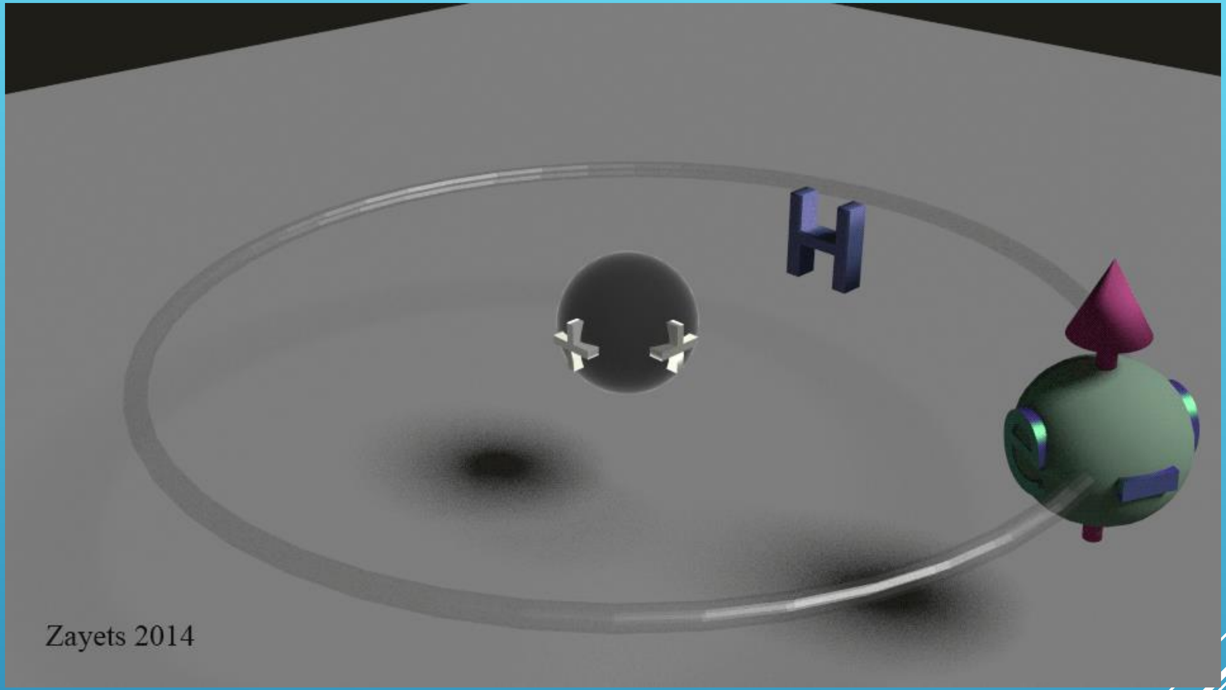
magnetic dipole,

and the nucleus's positively charged electrostatic field.

Spin-orbit coupling

- Spin of an electron makes it a magnet. Orbital motion of the electron also makes it a magnet. These two magnetic moments can interact or "couple" (**spin-orbit coupling**) and cause energy level splitting.





This is detectable as a spectral line splitting that can be thought of a Zeeman Effect of 2 relativistic effects; (that will be discussed later on)

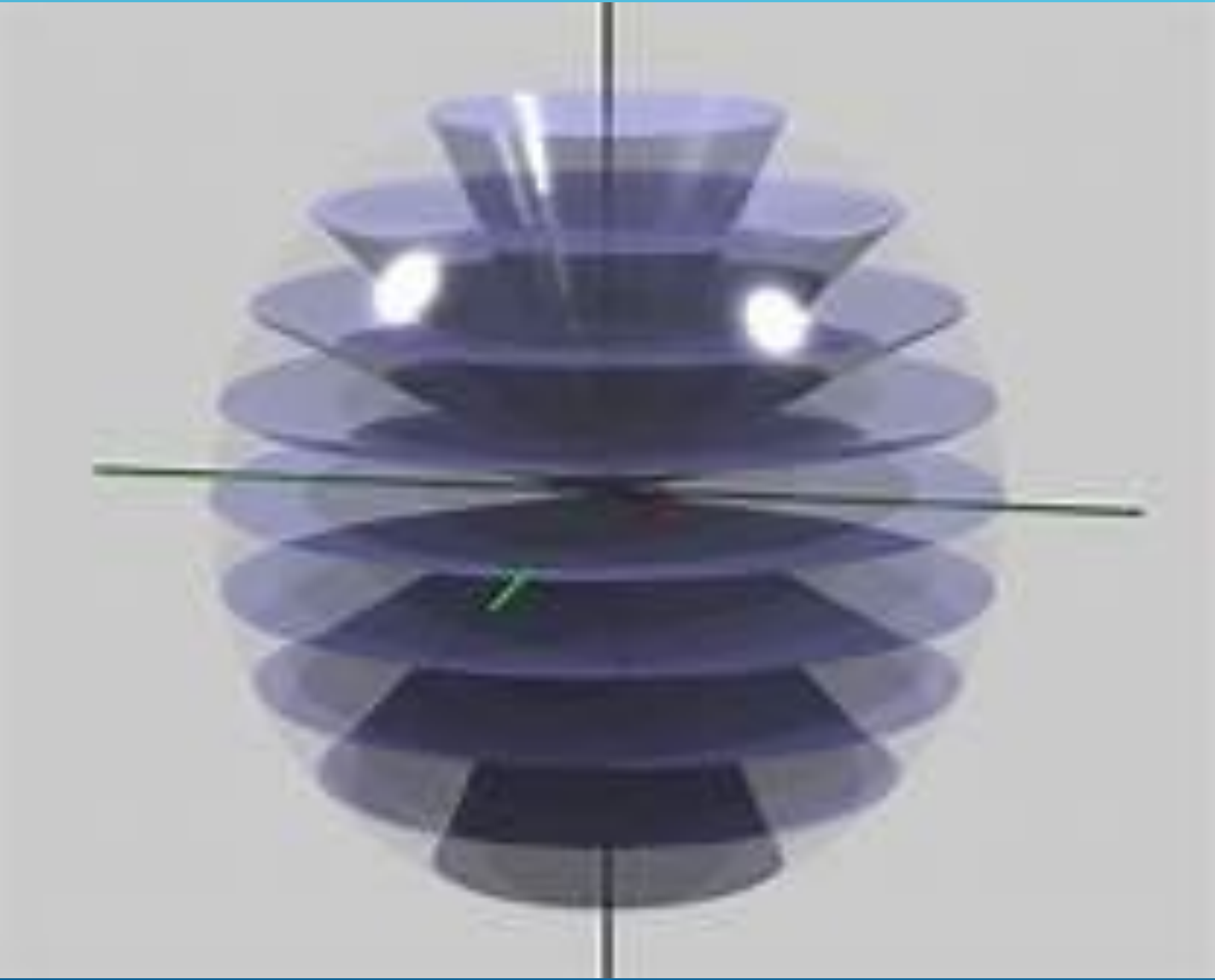
The apparent magnetic field from the electron's perspective.

The magnetic moment of the association of the electron with it's spin.

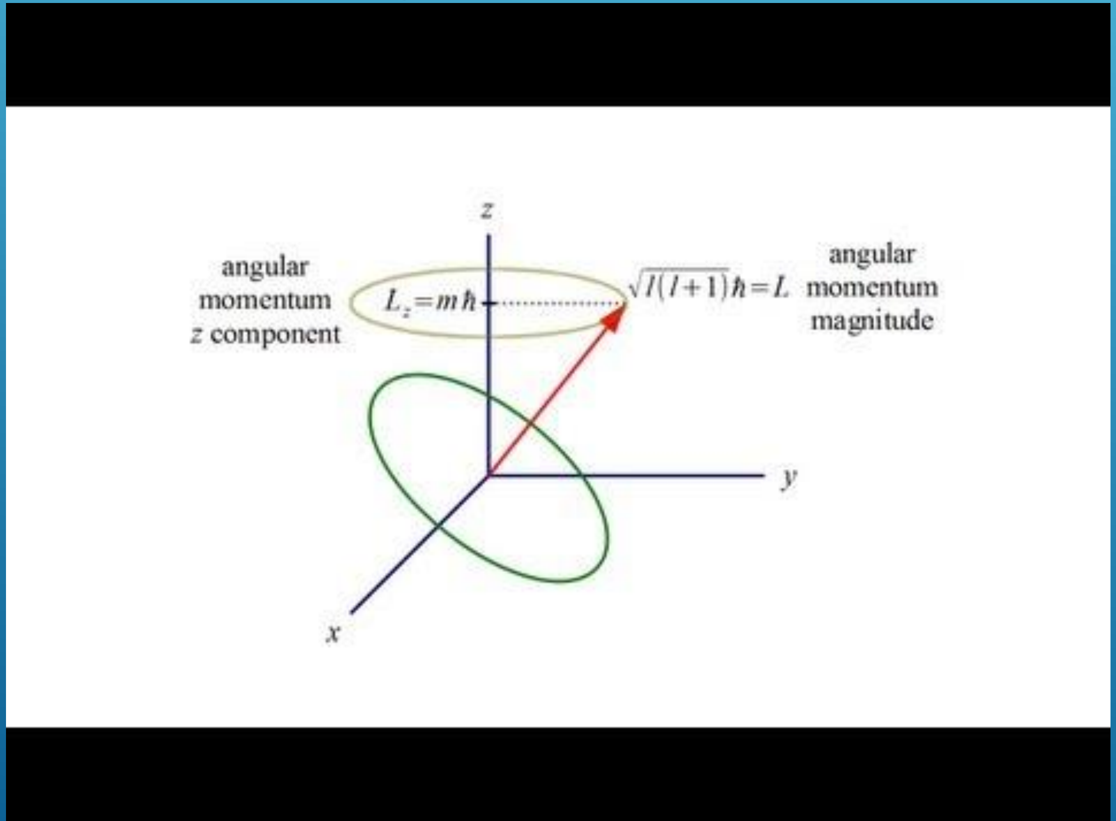
- The electron individual spins are denoted with the quantum number s_i
- Their interactions summed up(s_i + . . .)forming the total angular Spin Number **S.**
- The orbital individual orbits are denoted with the quantum number l_i
- Their interactions summed up(l_i + . . .)forming the total angular Orbital Number **L.**
- **The next slide show the equations for sums of L and S.**

$$\mathbf{L} = \sum_i \ell_i, \quad \mathbf{S} = \sum_i \mathbf{s}_i.$$

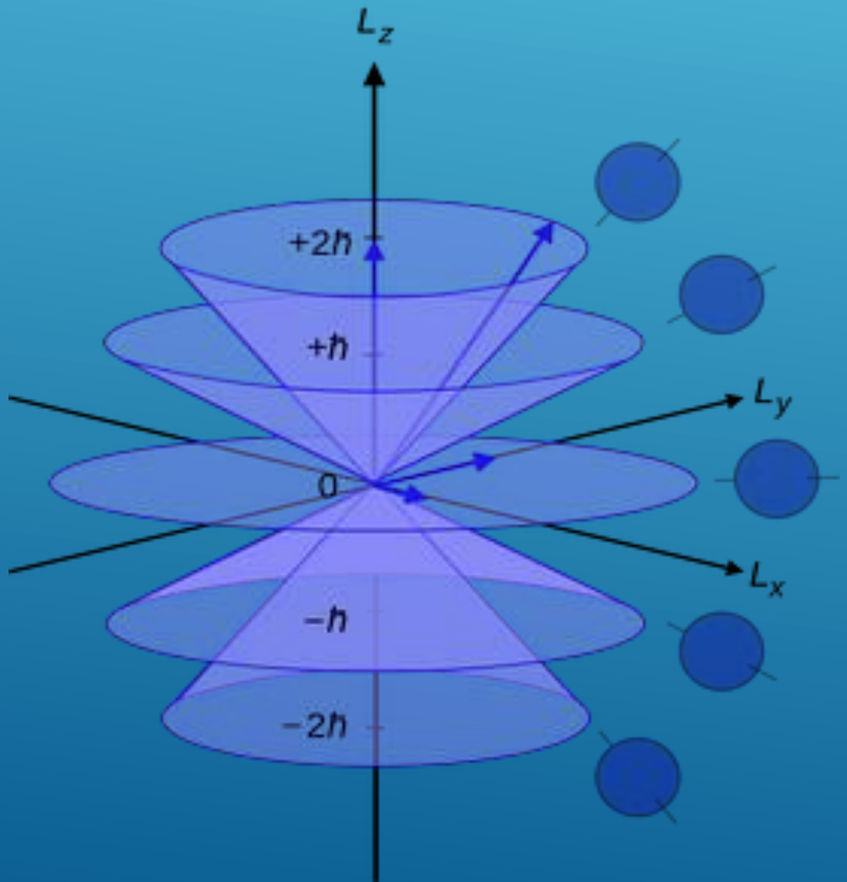
ANGULAR MOMENTUM



- In quantum mechanics a technique in combining eigenstates (that is spin-orbit interactions)of total angular momentum out of separate one is call angular momentum coupling.
- For example, The orbit and spin of a single particle can interact though spin – orbit interaction that the complete physical model has to include spin – orbit coupling on 2 charged particles with each having a well defined angular momentum that can interact by coulomb force in which the coupling of the two one particle angular momenta to a total angular momenta

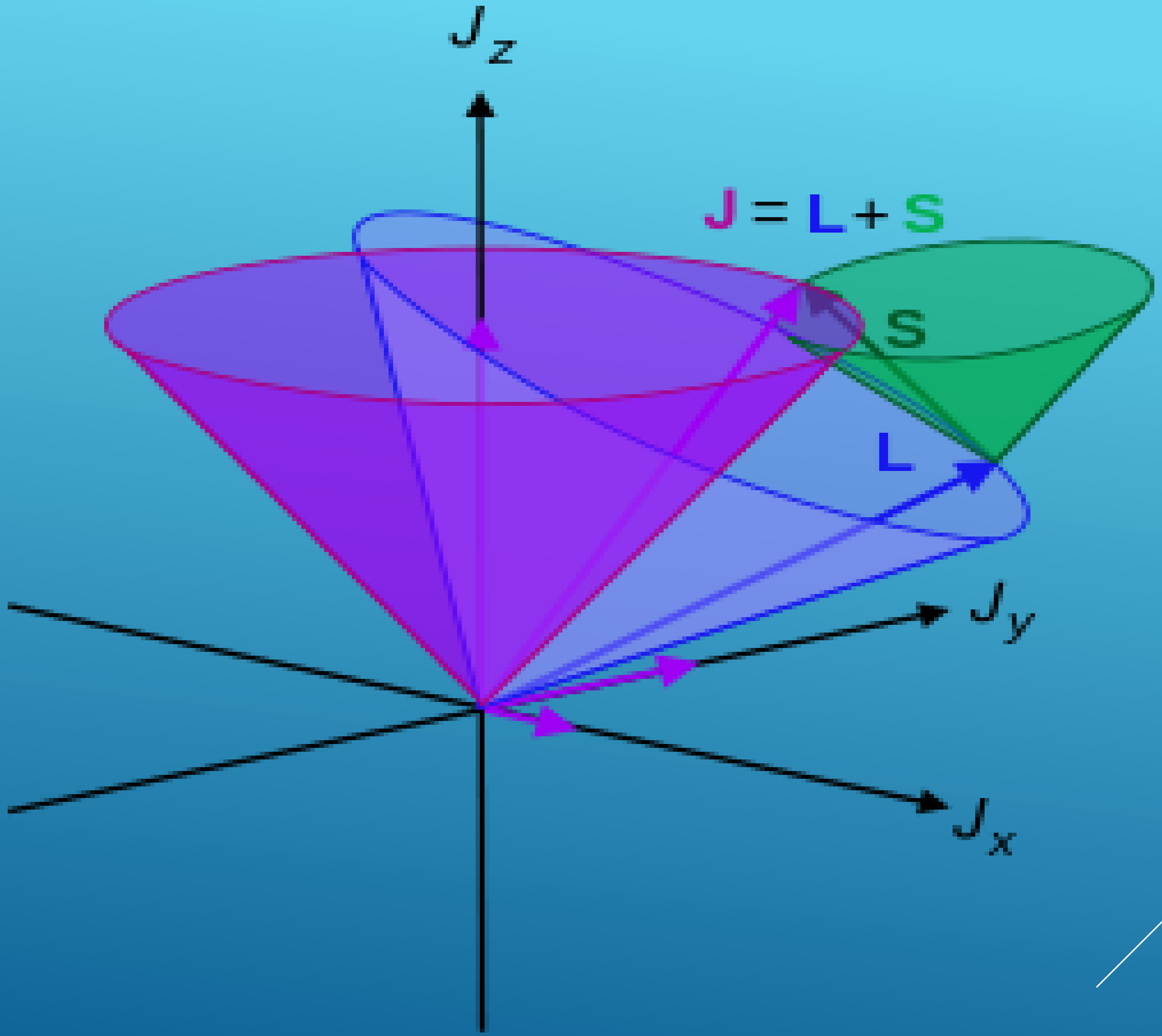


- It is the property of a physical system that is in constant motion.
- It is a conserved property, time- independent, and well defined.
- In 2 cases;
  - 1. system experiences spherically symmetric potential field
  - 2. System moves "quatumly" in isotopic space.



- Generally, angular momentum conservation implies full rotational symmetry and conversely spherical symmetry implies angular momentum conservation.
- If 2 or more systems have conserved angular momentum, it is useful in combining them.
- For example, 2 electrons in a atom

- **L S c**oupling – pertains to atomic with an atomic mass of less than 30 amu.
- The electron spins s_i interact among themselves and combine to a total angular momentum **S.**
- The same happens with l_i the orbital angular momentum combining to form **L.**
- This interaction is called the Russel- Sanders approximation.
- This approximation is good as long as the external magnetic field is weak.
- Stronger fields the 2 momenta decouple giving rise to a different energy level splitting pattern.
- The next slide show a pictorial representation of this and the following is a quantative explanation.
- The following that is a simplification of what was discussed.


J_z
J = L + S
S
L
J_y
J_x

Total Angular Momentum

- If j and m_j are quantum numbers for the single electron (hydrogen atom).

$$J = \sqrt{j(j+1)}\hbar$$
$$J_z = m_j\hbar$$

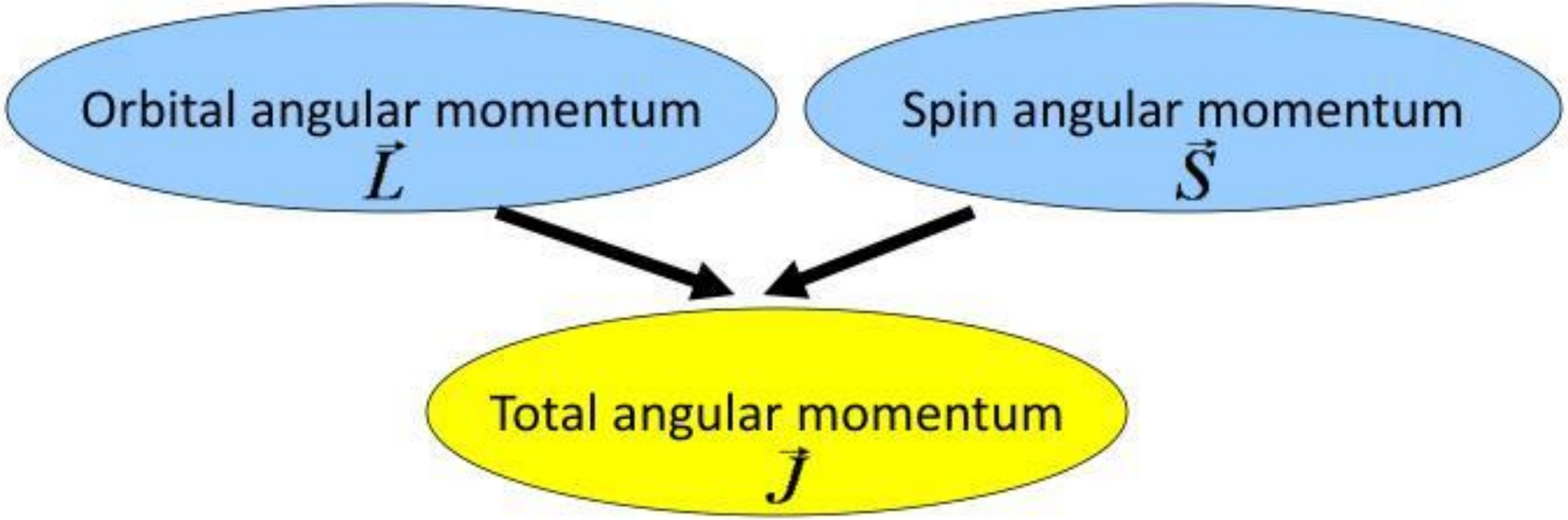
- Quantization of the magnitudes.

$$L = \sqrt{\ell(\ell+1)}\hbar$$
$$S = \sqrt{s(s+1)}\hbar$$
$$J = \sqrt{j(j+1)}\hbar$$

- The total angular momentum quantum number for the single electron can only have the values

$$j = \ell \pm s$$

Total Angular Momentum



$$\vec{J} = \vec{L} + \vec{S}$$

L, L_z, S, $S_z J$ and J_z are quantized

- Now for some other facts.
- Spin-spin coupling is the coupling of the intrinsic angular momentum of different particles.
- Such coupling between pairs of nuclear spins is an important feature of nuclear magnetic resonance (NMR) spectroscopy
- It can provide detailed information about the structure and conformation of molecules.

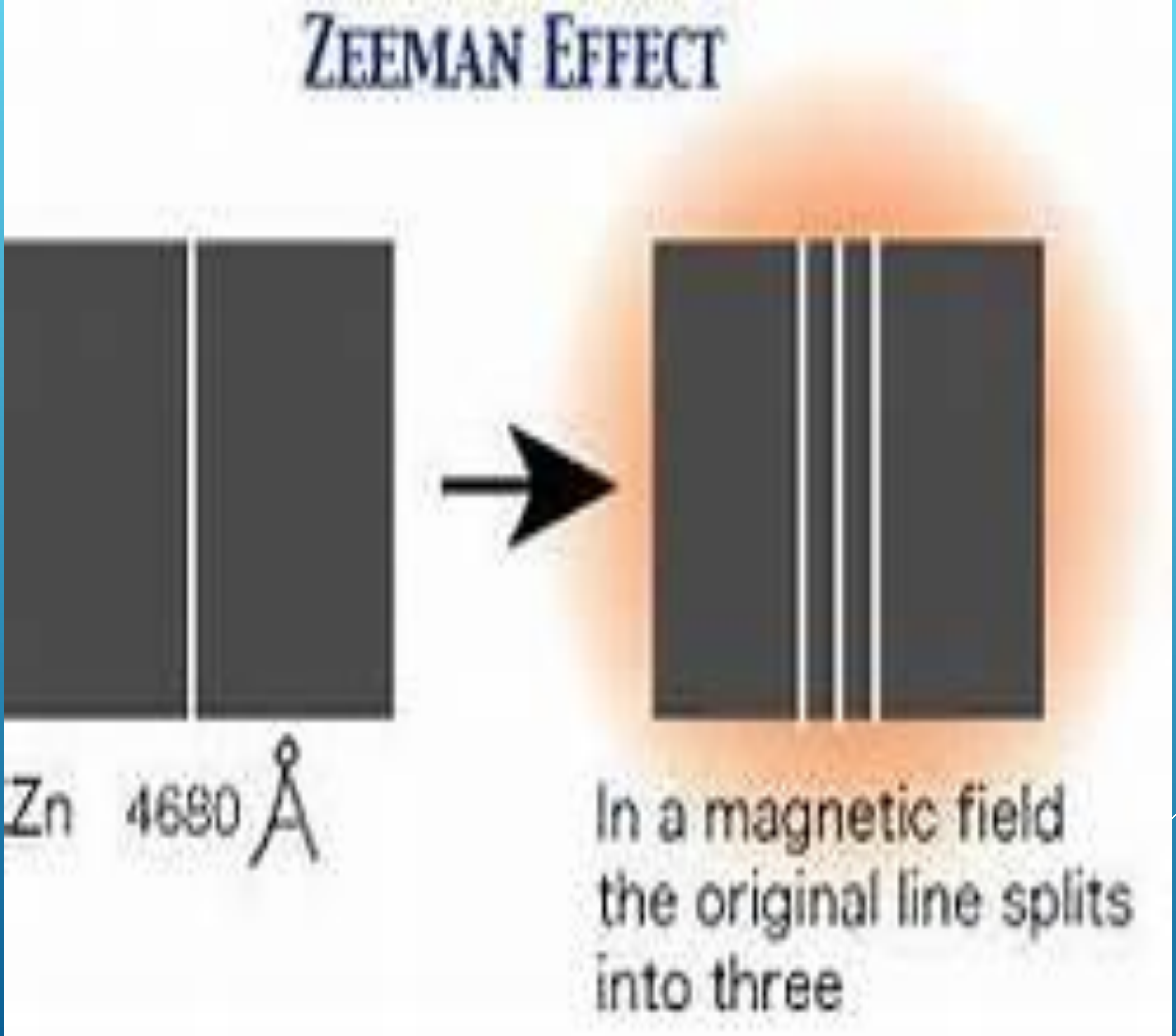
Zeeman effect

It is the splitting of a spectral line into two or more components of slightly different frequency when a light source is placed in a magnetic field.

For our purposes it is the splitting effect of a spectral line from an electron into several components in the presence of a static magnetic field.

It was first observed in 1896 by the Dutch physicist Pieter Zeeman

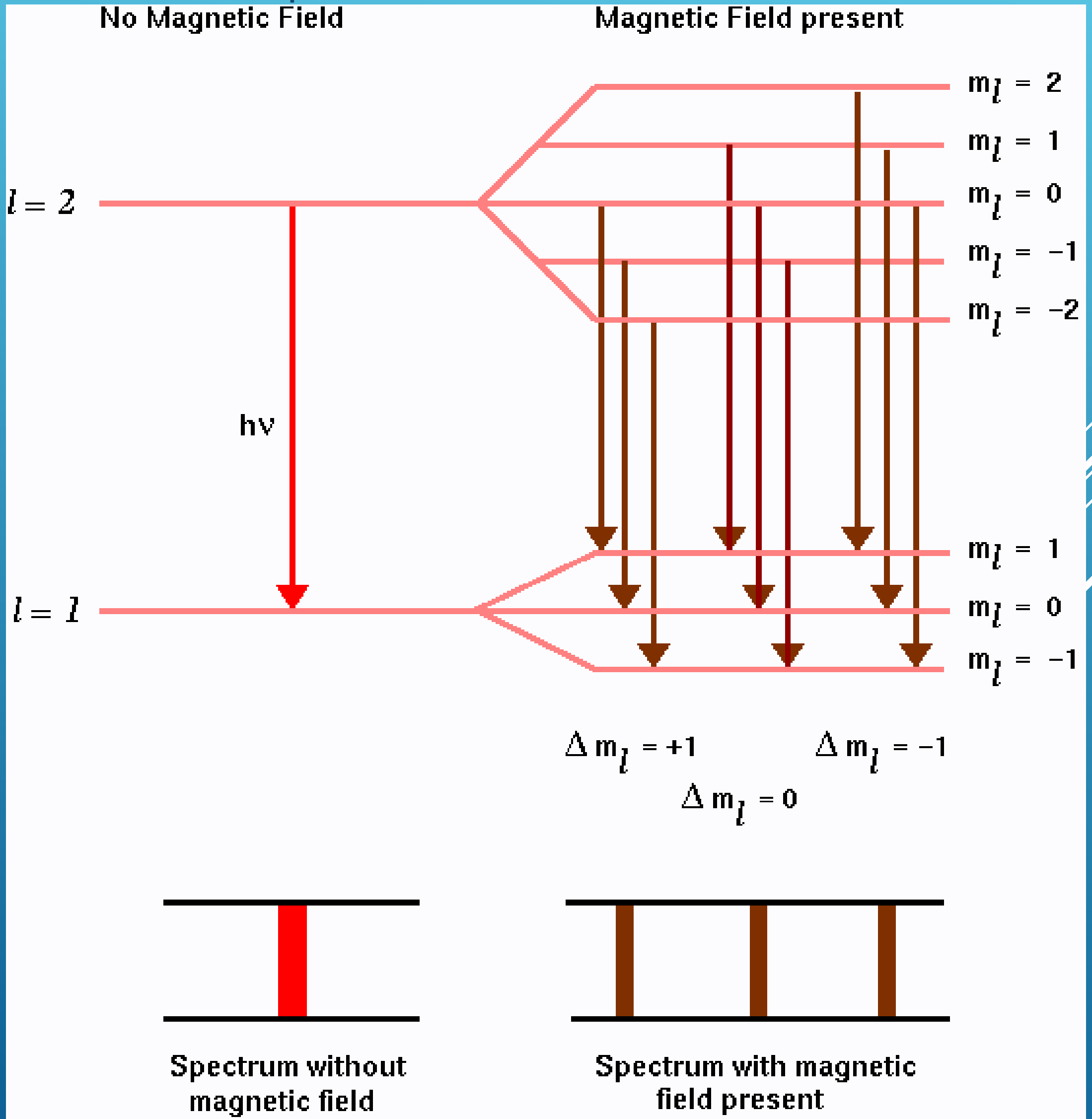
THE NEXT SLIDE SHOW A VISUAL EXAMPLE OF THIS EFFECT.


ZEEMAN EFFECT
Zn 4680 Å
In a magnetic field
the original line splits
into three

Distance between the Zeeman sublevels (lines) is a function of magnetic field strength.

-Can be used to measure magnetic field strength.

When the spectral lines are absorption line it is called the inverse Zeeman effect.



Normal and anomalous Zeeman Effects

Anomalous effect appears on transitions where the net spin is an odd ½ integer.

So, the number of Zeeman Levels is even. (This sound similar to the nitrogen rule for mass Spectroscopy.)

It was discovered that when electron spin was included with the total angular momentum actually show that it was part of the normal Zeeman effect.

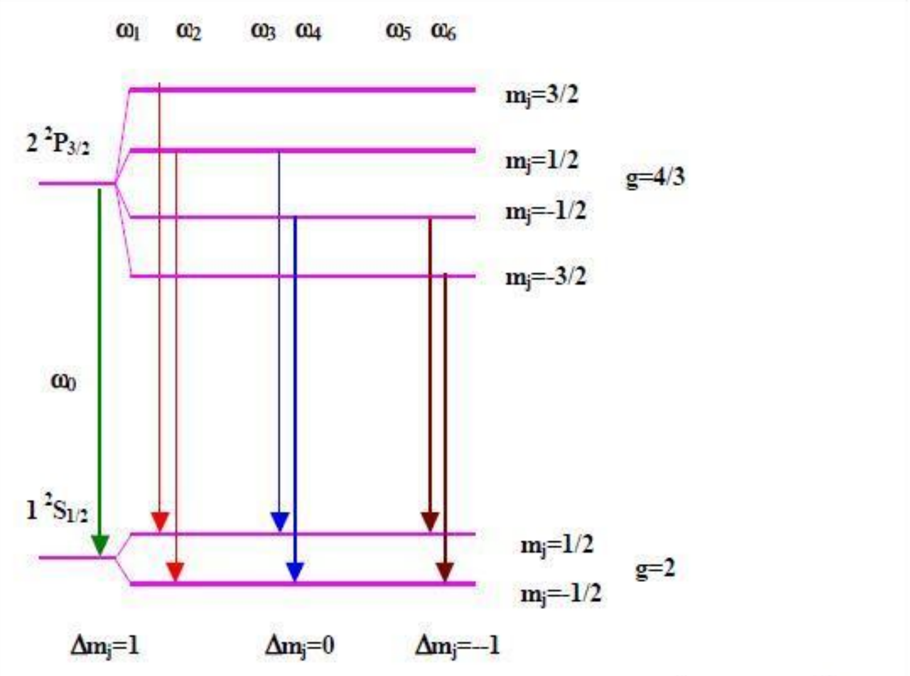


Figure 2. Anomalous Zeeman transitions between $1\,^2S_{1/2}$ and $2\,^2P_{3/2}$.

- At higher magnetic field strength the effect becomes nonlinear.
- At much higher field strength where it is equal to the atom's own internal field, the electron coupling is disturbed and the spectral line rearrange.

  It is called the Paschen – Back effect.

EXPERIMENTAL RESULTS

Here 3 separate studies using a Magnetic Field will be discussed.

- Hydrocarbon Fuel Viscosity and Engine Performance.
- Fuel Consumption and Exhaust Emissions in a 2 stroke Engine.
- Performance and emission of Single cylinder 4 stroke diesel engine.

HYDROCARBON FUEL VISCOSITY AND ENGINE PERFORMANCE.

- There were 2 major parts to this;
  - One for a diesel engine; plus a sub test on viscosity.
  - Another for Petrol or gasoline engine.

- Hydrocarbon fuels are made of covalently bonded carbon and hydrogen atoms.
  - 2 electrons in each covalent bond which are balanced spin-wise.
  - Diesel has large number of large molecules that are incipient solids in a liquid mix.
    - When put in a strong magnetic field, the field's energy will make the electrons spins parallel to each other instead of opposing each other.
    - Also they are raised to a higher energy level.
    - This makes the molecules repulsive to each other and solid one can't solidify,
    - They're ionized which reacts with oxygen more quickly when combusting.
    - Tests showed less fuel use for given horsepower.

- Experiment setup: magnetic field effects on petrol viscosity.
- 1. The Petrol was place in a bottle.
- 2. It was hung to a certain height with a pipe going down into a flask.
- 3. When the value was opened the time was measured to see how long it would take to fill 20 ml.
- 4.The test was repeated 3 times.
- 5. 1st run was without magnetic field. The following run was with a magnetic field with an increase on the following run.
- 6. The setup was all nonmetal to ensure no residue magnetization.

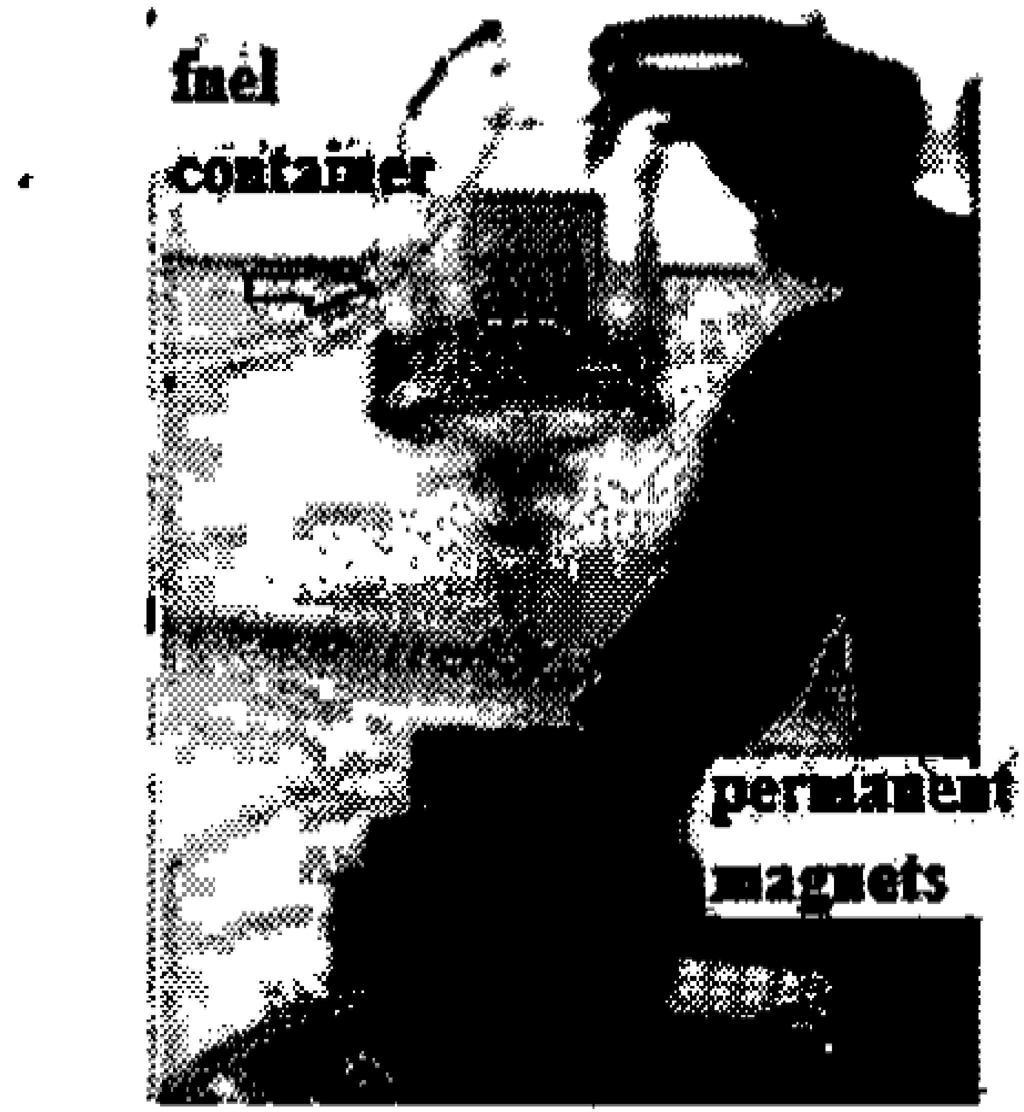
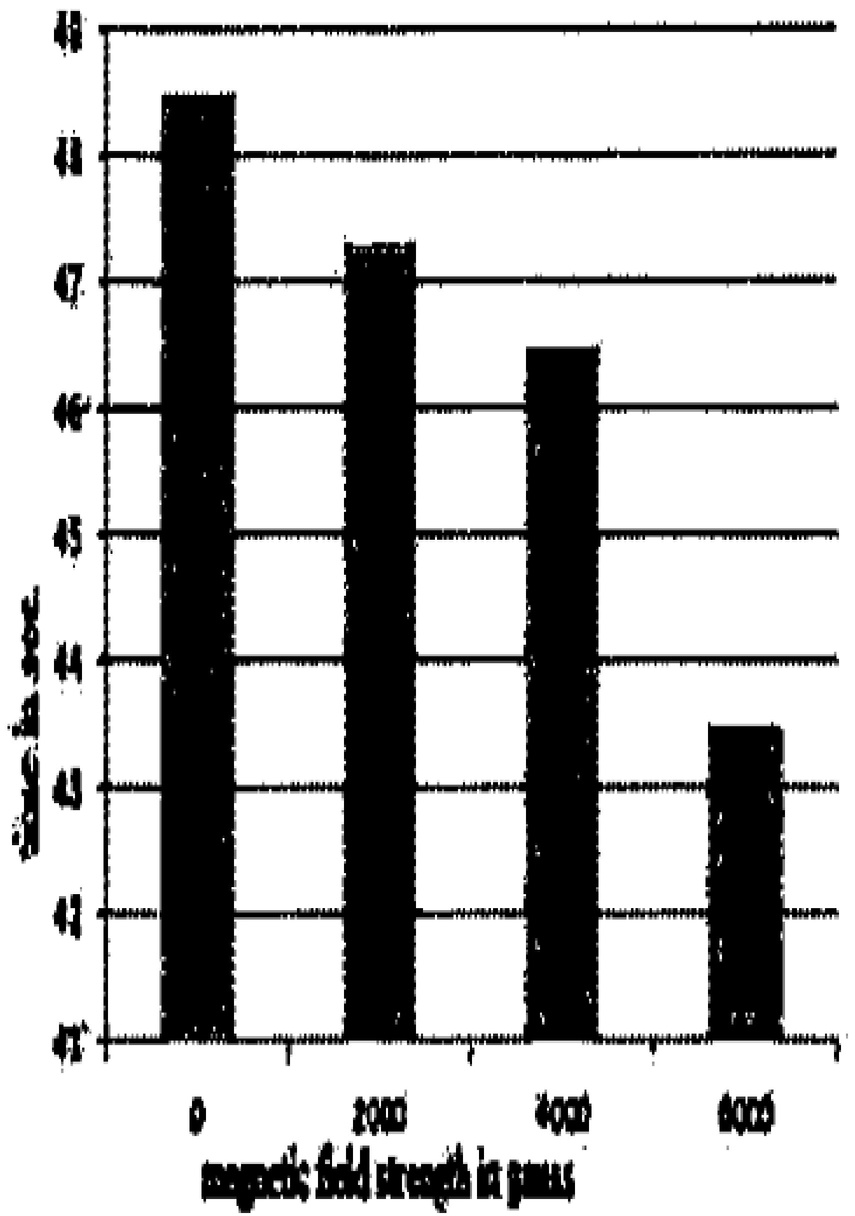


Figure 2 Experimental setup for analysis of effect of magnetic field on the viscosity of petrol

- Experimental results for Viscosity.
- Crude oil - mix of various sized hydrocarbons.
- Largest sized solid suspensions.
- Oil viscosity – related to the suspensions.
- When put in the magnetic field the cluster size of the solid suspensions was reduced while the fraction percentage of solids remained the same.



Graph 1. Magnetic field strength vs. fuel flow time

SR.NO	magnetic field strength (in gauss)	time in sec. to collect 20 ml of petrol in flask			average time
1	0	48.2	48.5	48.4	48.5
2	2000	47.5	47.3	47.4	47.3
3	4000	46.4	46.4	46.7	46.5
4	6000	43.6	43.5	43.5	43.5

Table 1.Time required to collect 20 ml petrol in a flask for different magnetic fields.

- Diesel Engine performance.
- Fuel consumption rate measured was found to reduce with a magnetic field on a load.
- Due to better mixing.
- Engine Specifications:
  - 1 cylinder 4 stroke
  - Power rating; 5.2 Kw
  - Speed: 1500 rpms

Figure 4.Diesel engine testing setup

- Procedure and results
- 1 Test on fixed load.
  - - only frictional power from mechanical parts.
- 2 3 readings were taken for same condition.
- 3 1st set without magnetic field.
- 1st magnetic pair 2000 gauss on fuel line.
- 4 Procedure repeated for fields of 4000, 6000, and 8000 gauss.
  - Time measured for consumption of 10 ml fuel.
  - 2nd run time increases for consumption as field increases. (that is the rate decreased)
    - Max amt. of change observed at 4000 gauss.

3rd run show consumption rate decreased up to 4000 gauss, then it increased over 4000 gauss.

Possibly due to viscous heating.

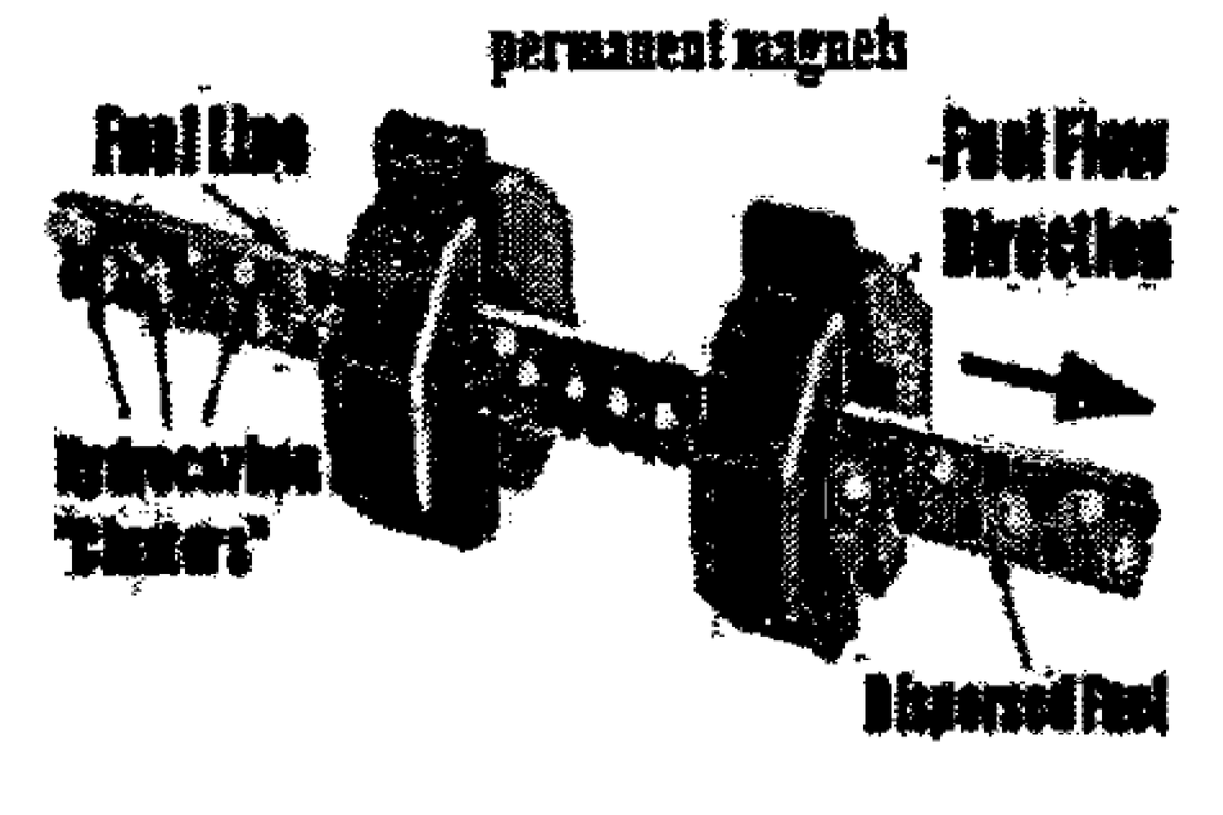
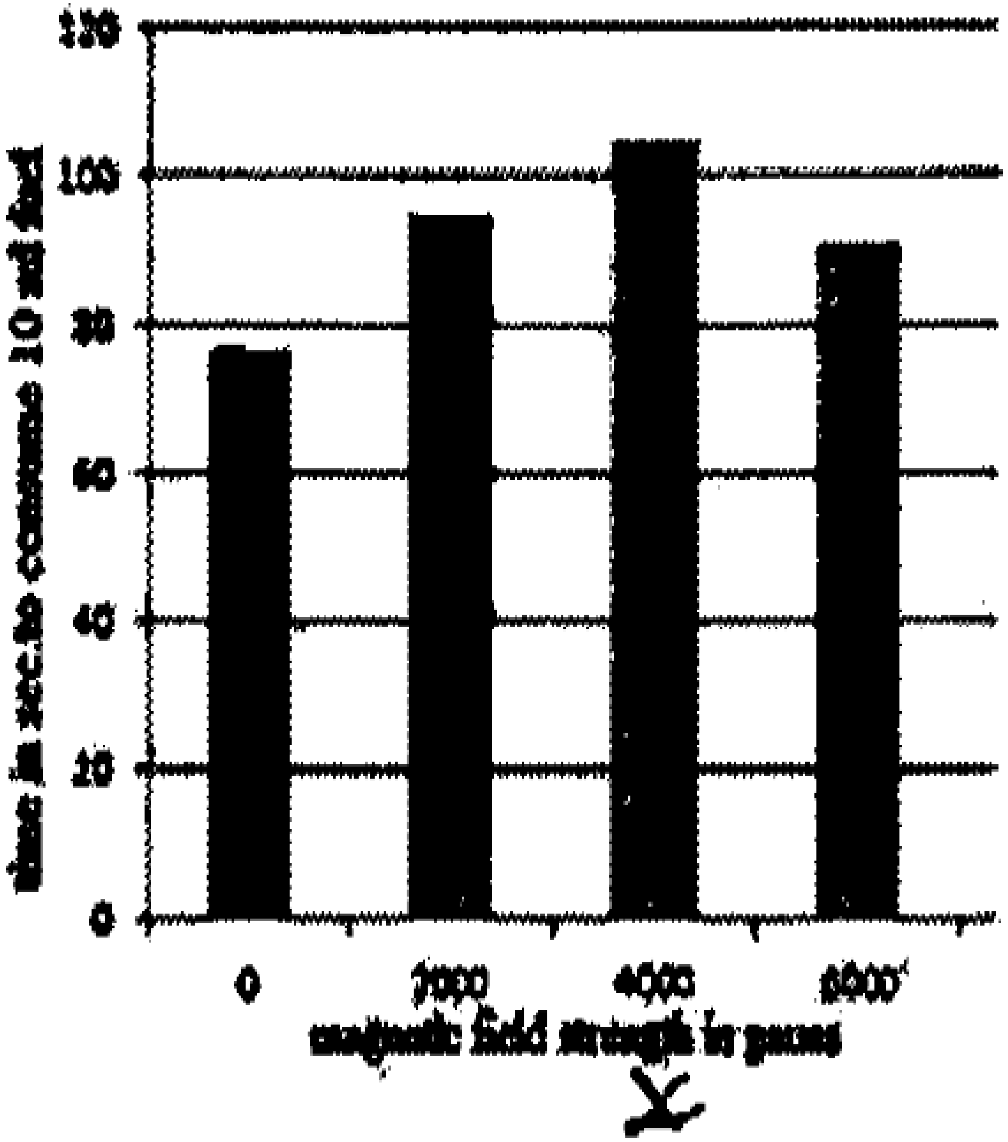


Figure 1 Declustering of hydrocarbon molecules

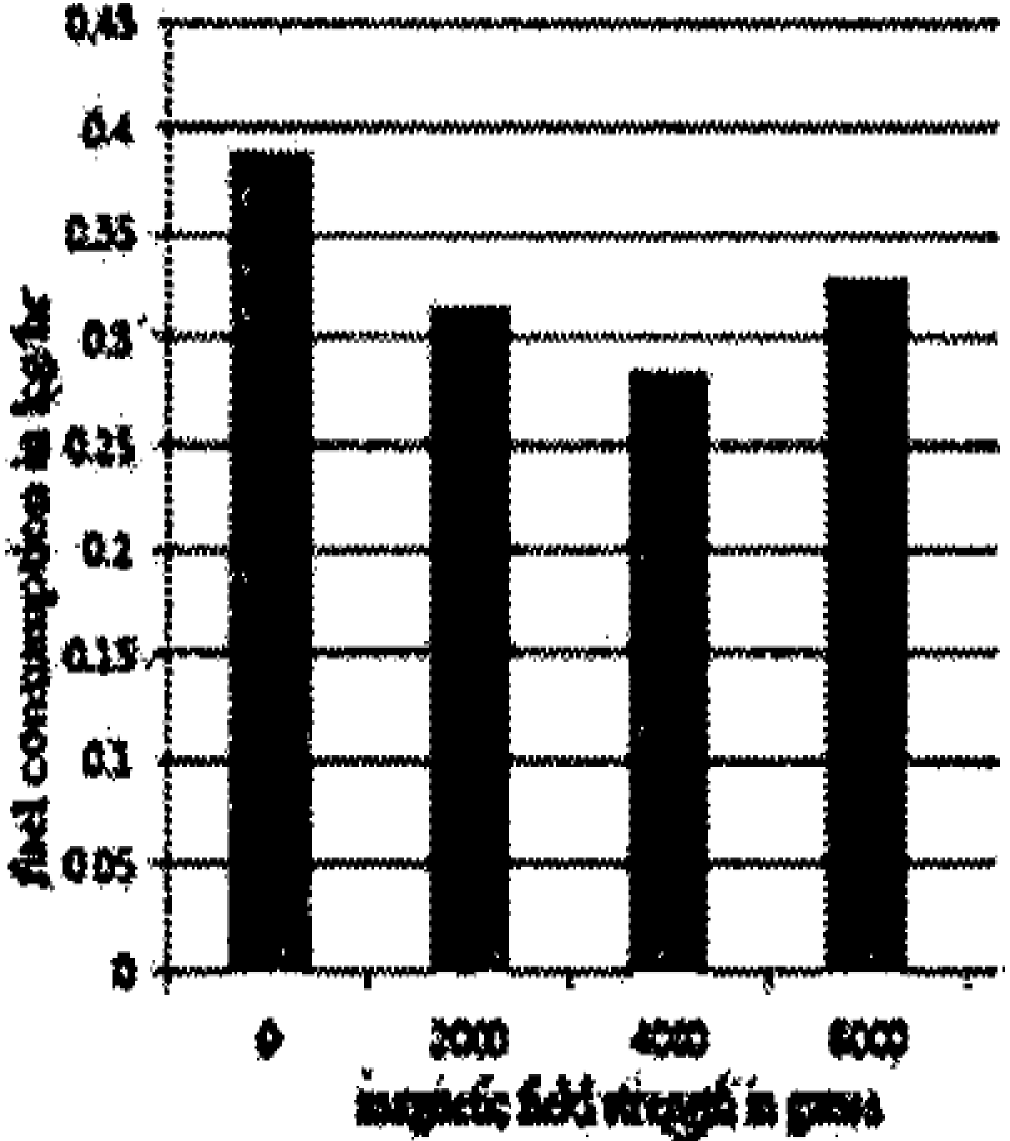
THIS SHOWS THE MAGNETIC PLACEMENT FOR THE EXPERIMENT.

Sr.No	magnetic field strength (in gauss)	time in sec to consume 10 ml of fuel	fuel consumption in kg/hr	% saving of fuel
1	0	77	0.348	0
2	2000	95	0.314	19.07
3	4000	105	0.284	25.8
4	6000	91	0.323	15.46

Table 2.Effect of magnetic field on time required for consumption of 10 ml of diesel in diesel engine for fixed engine load.



Graph 2. Magnetic field strength vs. Fuel consumption time



Graph 3.Magnetic field strength vs. fuel consumption in kg/hr.

- Petrol Engine Performance

Engine Specifications;

1 cylinder 4 stroke engine.

Air cooled.

Power; 15.4 PS

Cylinder displacement; 159.7 cc

Torque 13.1 Nw

Procedure:

1. Motor bike with an external tank where 100 ml of fuel was put int.
2. A line from tank to bike is attached.
3. Bike ran with constant speed and gear until fuel was consumed with no magnetic field applied to fuel line. Initial and final reading were taken to determine total distance.
4. Ascending magnetic field strength applied to fuel line.
5. Distance traveled was recorded with and without magnetic field.

Results

As the magnetic field increased, mileage increased.

At 6000 gauss, the mileage increased to 7 miles more than without the magnetic field.

Figure 5.Separate fuel supply system attached to bike

Figure 6.location of permanent magnet and fuel line

Sr. No.	magnetic field strength (in gauss)	gravimeter reading	[illegible]	[illegible]	improvement of profit
1	0	[illegible]	42	42	0
2	2000	[illegible]	43	43	1
3	4000	[illegible]	43	45	6
4	6000	[illegible]	49	48	7

FUEL CONSUMPTION AND EXHAUST EMISSIONS IN A 2 STROKE ENGINE.

Here petrol fuel is used; emissions and fuel consumption were tested.

Results showed a reduction of 9-14% fuel consumption with 14% being the highest at 6000 gauss.

Exhaust gases; each were reduced accordingly; CO 30%, HC 40%, with the exception of CO2 which increased up to 10%.

Also, UV-Vis and Infrared spectra were taken showing an absorption change in physical/chemical properties of gas affected by the magnetic field.

Fuel surface tension exposed was at different magnetic field intensities were measured and compared to measurement without magnetization.

Introduction.

- Magnetic moments that exist in fuel molecules having positive and negative charges.
- Yet aren't realigned and can't fully combust with oxygen. Thus they must be ionized to be realigned by using a magnetic field.
- Experimental studies show evidence of this that;
  - Can enhance oil recovery, prevent wax deposits, and improve crude oil fluidity.

- From the experiment present here will show that hydrocarbons can be polarized by magnetic field exposure.
- That will create magnetic moments from the outer (valent) electrons of the hydrocarbon (hydrogen) atoms which will put into a higher quantum state.
  - It does this by breaking down fixed valence electrons partaking in bonding of fuel components.
  - Such as the fuel becomes aligned which doesn’t create any new hydrocarbon chains. But more explainable aligns with the conduced magnetic moment into a dipole relationship within itself.
  - Magnetic alignment permits quick bonding with oxidizing media.
  - Thus more quick and complete fuel combustion.
  - This actually improves emissions of CO_2, CO, HC, etc.

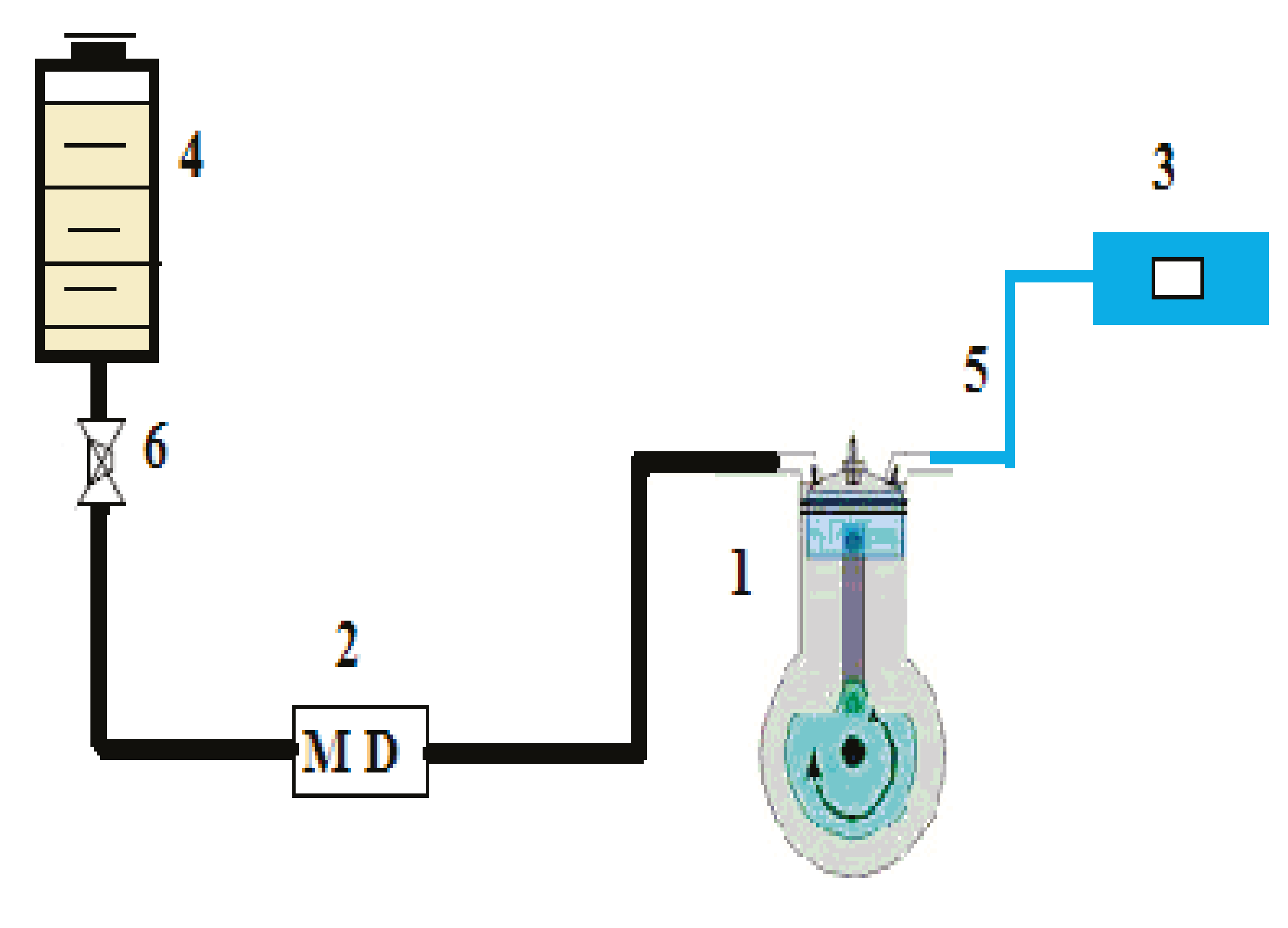
- <u>Declustering of fuel</u>
- Hydrocarbons have a "cage-like" structure which is the reason oxidizing the inner structures of clusters is hindered.
  - Binding into large pseudo – compound groups.
  - Oxygen is unable to access the cluster interior to combust.
  - When magnetized, the fuel becomes declusters – making smaller particles that more readily react with oxygen.
  - This is in accordance with the Van der Waal discovery of weak clustering force, thus there is an overly strong binding of fuel with oxygen.

- <u>Method</u>
- Magnetic devices used;
- Made by water research center ministry of Science and Technology.
- Each device contains a number of permanent magnets arranged alternatively in multiple stages.
- Magnetic field intensities of 2000, 4000, 6000, 9000 gauss.

- Method continued;
- Engine:
- 2 –stroke spark ignition Chinese origin 5.5 hp.
- External tank includes a volumetric scale and value connected instead of the main tank on engine to measure amount consumed during operation.
- Fuel; gasoline or petrol.

- Procedure;
- 1. Periodic inspection of parts for each experiment.
- 2. Accelerated engine rpm (3500, 4500, 5000) taken.
- 3. Engine start-up set select speed. Continued operating for 2 hours for each test which exhaust was measured several times for accuracy.
- 4. Repeated process for 2nd speed to know amount of fuel consumed and amount of exhaust.
- 5. Repeated process with magnetic device and the again at higher magnetic intensity.

- Test and measuring equipment
- Up to 100 ml of fuel used before and after magnetization taken for each intensity and to measure Infrared absorption spectrum using IR presge-21 SHIMADZU range (400-4000)1/cm.
- Similar sample measuring UV absorption spectrum using UV-1650PC/UV-Vis SHIMADZU.
- Surface tension taken and examined by KSV Instruments LTD-series SIGMA 70 using Wilhelm Plate
- Exhaust Gases measured by AVL Device made in Australia.


4
6
2
M D
1
5
3

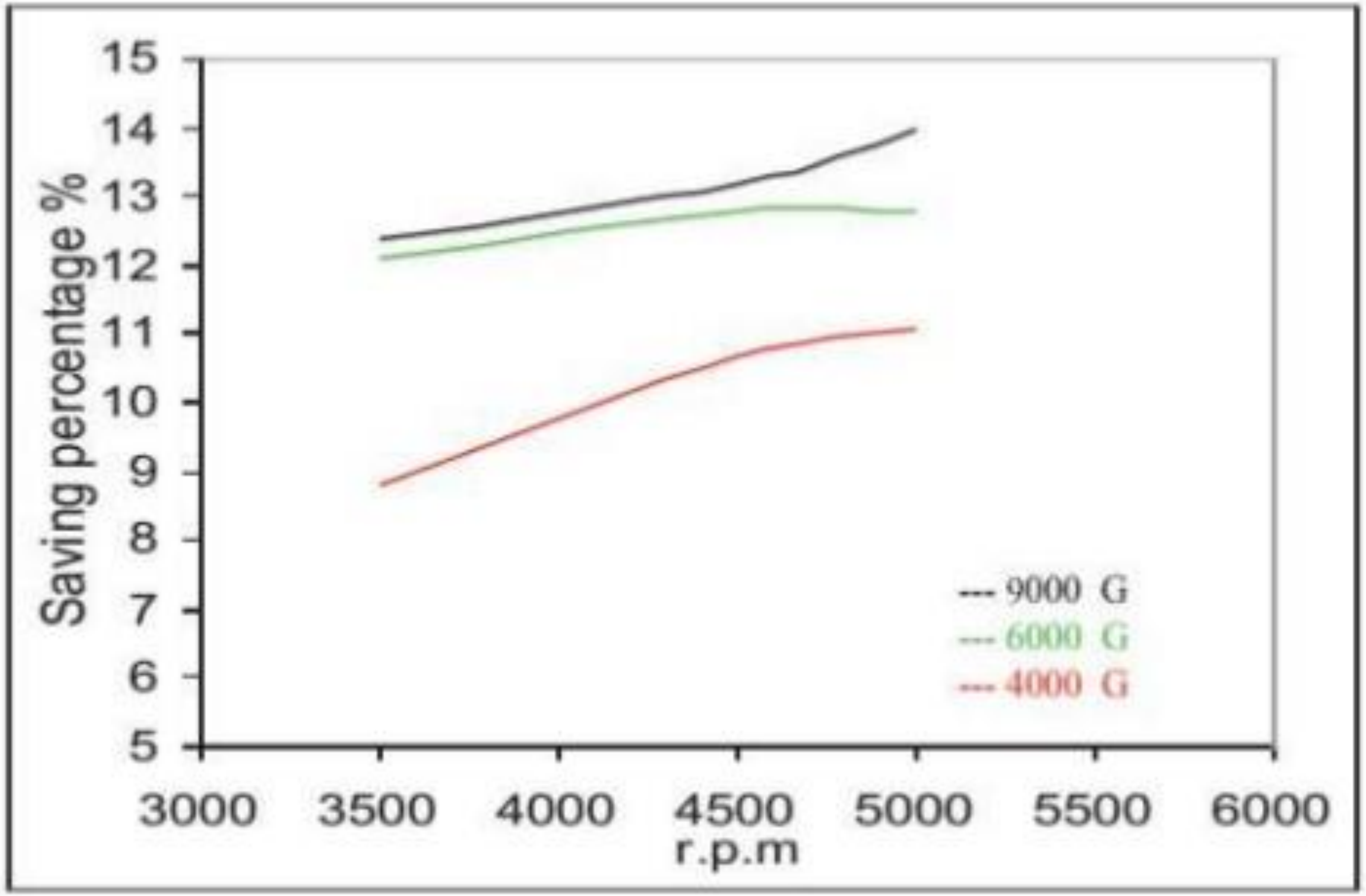
- <u>Results</u>
- Magnetic field effects on consumption and exhaust.
- The magnetic field broke down the bonds between the hydrocarbon chains resulting in decreased density, surface tension, and smaller droplets during fuel injection into the combustion chamber.
  - The smaller particles and droplets caused increased evaporation rates and improved mixing of fuel with oxygen.
  - Net increases with combustion rate and power.
  - Reduced pollutants.

- Magnetic effects on microstructures
- Magnetic effect on fuel; 500 ml samples were taken and exposed to field with intensities of 2000, 4000, 6000, and 9000 without retention time within the magnetization system.
- 100 ml of the mentioned samples were taken besides the magnetized ones to be examined by infrared spectra (FITR.)
- Due to nonpolar hydrocarbon attraction energy by vibrational frequencies, it can be shown that the higher frequency the lower the absolute attraction energy value or group attraction energy.
- Thus the attraction forces among hydrocarbons decreases after magnetization and why hydrocarbon properties indices such as viscosity surface tension based on attractive forces decrease after going through the magnetic field.

- UV-Vis radiated by matter is related to transition of energy levels and changes of electron states.
- In studying spectra features of UV-Vis Spectra of fuel, useful in revealing properties and mechanisms of magnetic influence on electron motions and atomic structure.
- UV absorption strength remarkably increases after aromatic hydrocarbons are magnetized meaning the transition probability of pi electrons in conjugated systems among different energy levels is higher.
- It may enhance splitting of carbon double bonds in aromatic rings during combustion under intense light and heat actions.
- Thus, aromatic oxidation is accelerated and complete.

- Surface tension rates decreased under magnetization.
- Yet, the rates don’t increase accordingly well as field strength increases.
- For some certain fields surface tension decreased considerably, other it comparatively decreases unnoticedly.
- So, surface tension decreases fluctuates with increase of field intensity.

Increased rate of fuel saving with increasing magnetic field intensity



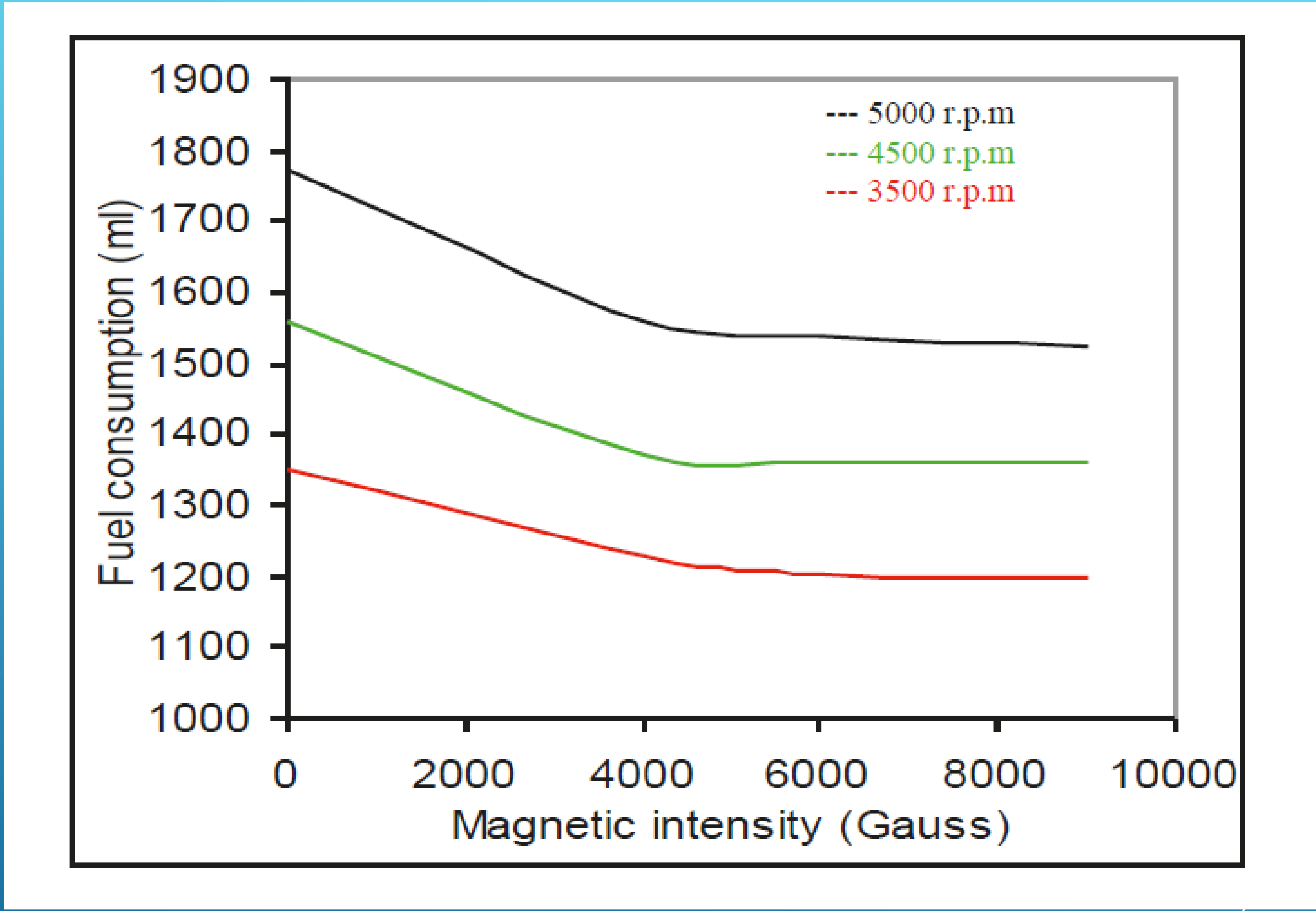


FIG. 3. REDUCING THE AMOUNT OF CONSUMED FUEL WITH INCREASING MAGNETIC FIELD INTENSITY

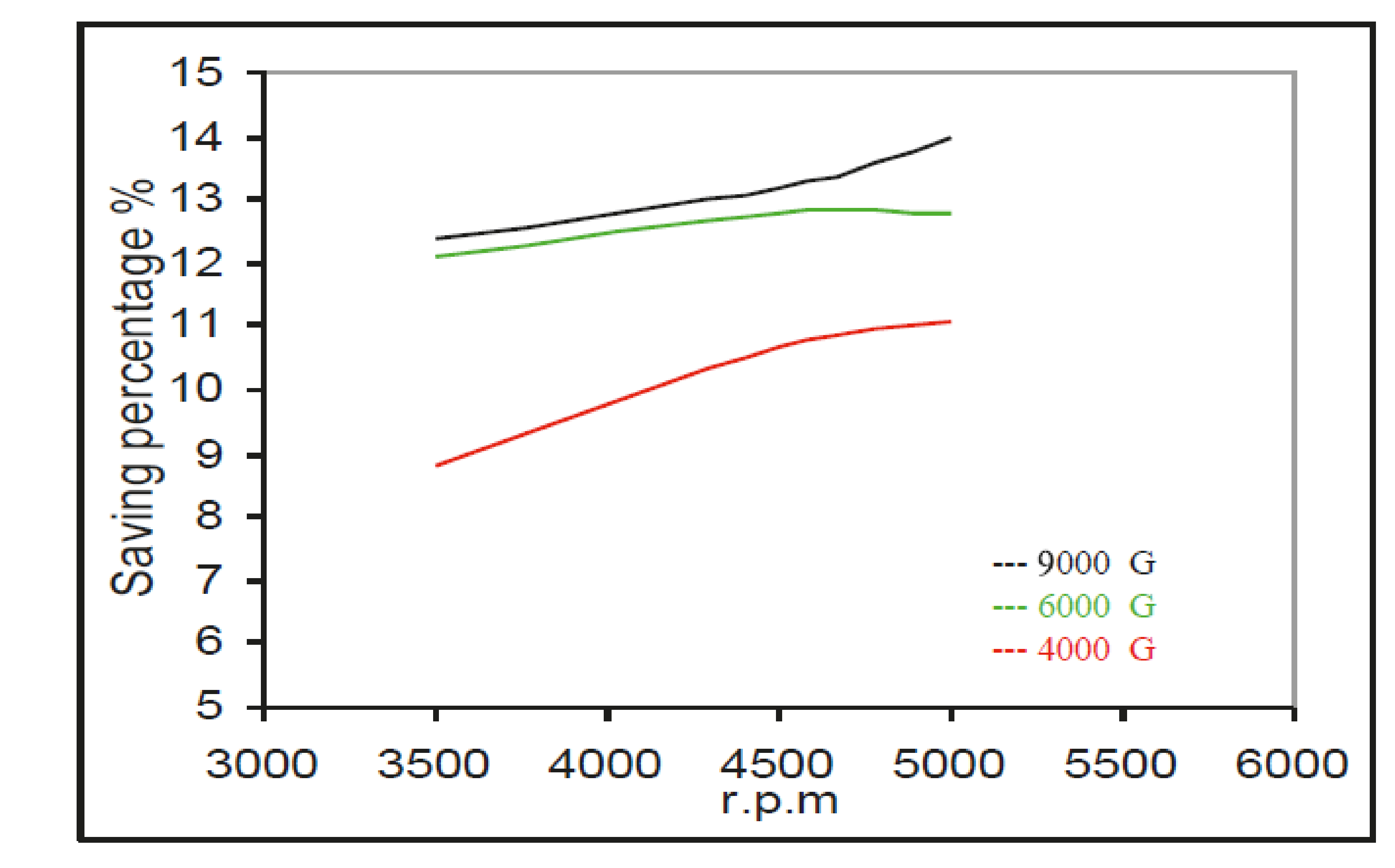


FIG. 4. INCREASED RATE OF FUEL SAVING WITH INCREASING MAGNETIC FIELD INTENSITY

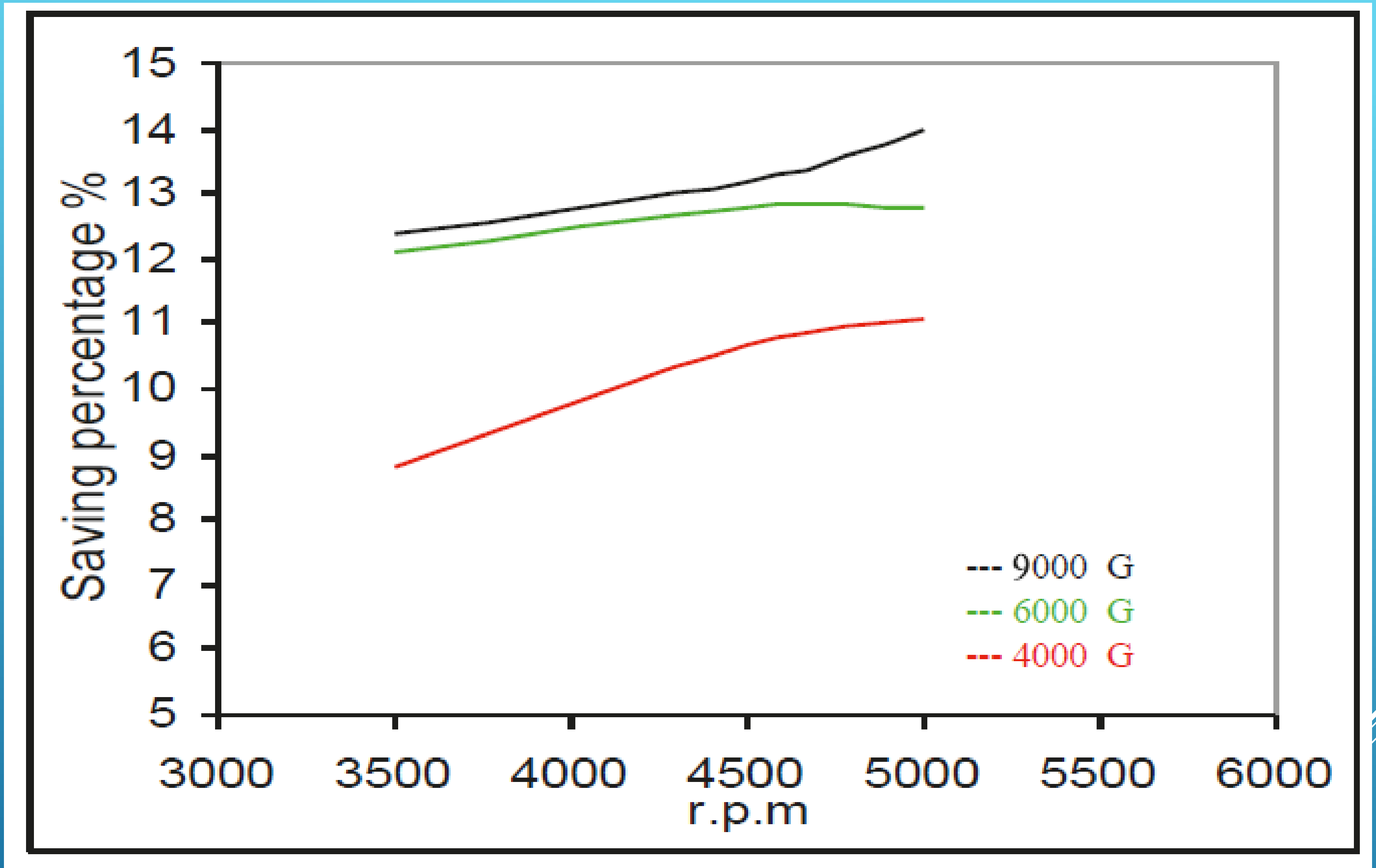


FIG. 5. INCREASED RATE OF FUEL SAVING WITH INCREASING ENGINE SPEED

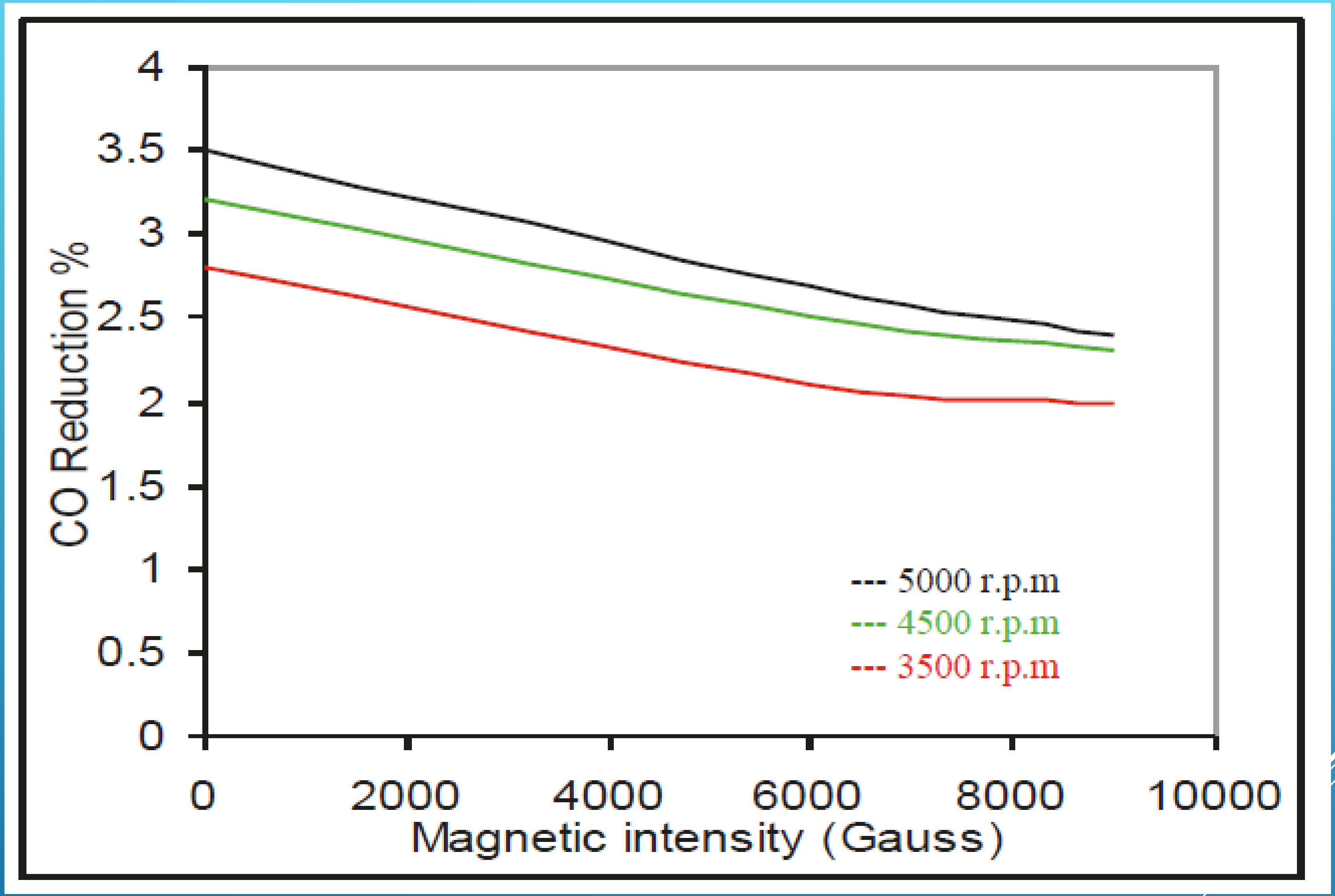


FIG. 6. DECREASE RATE OF CO GAS WITH MAGNETIC INTENSITY

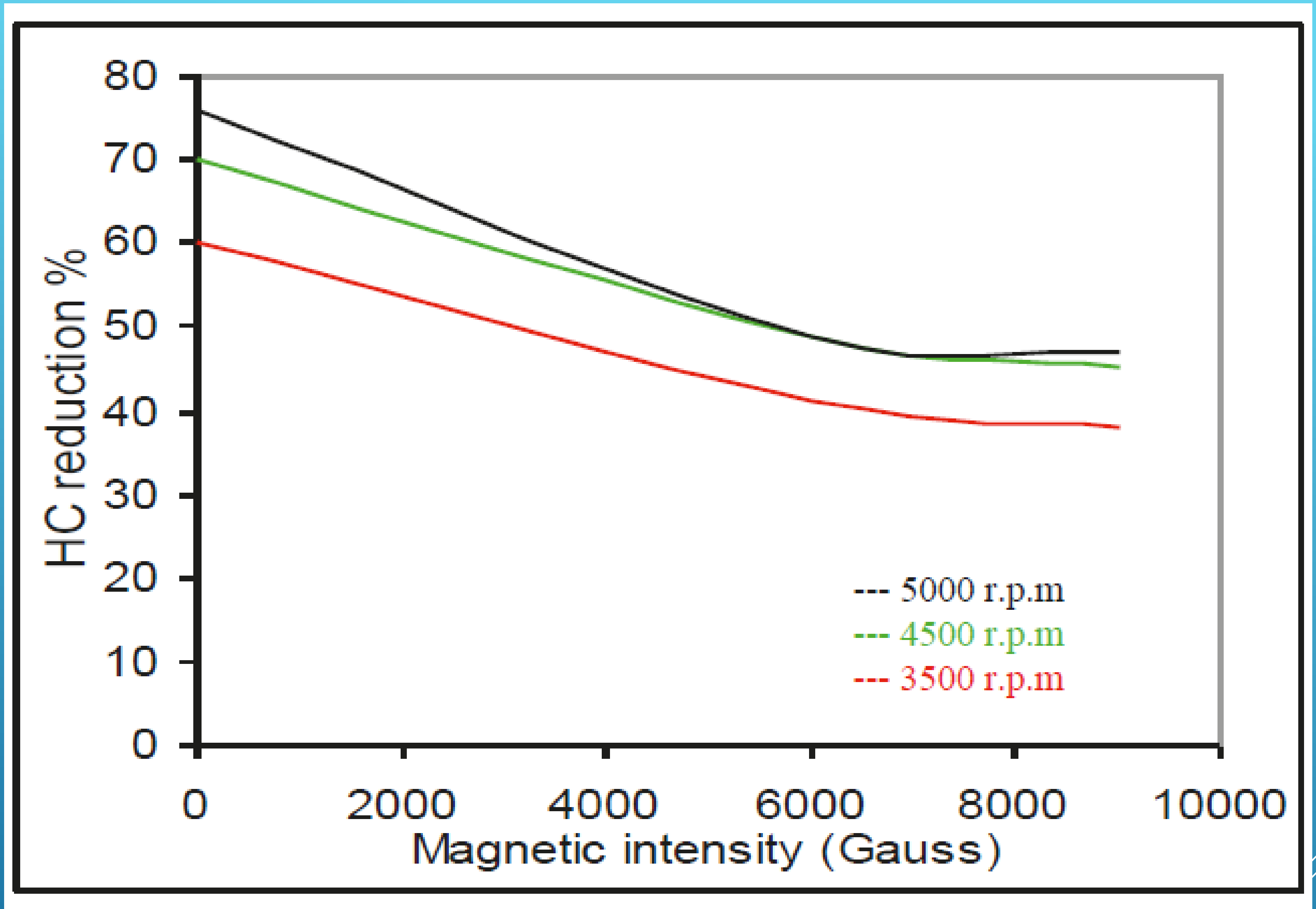


FIG. 7. DECREASE RATE OF UNBURNED HYDROCARBONS HC WITH MAGNETIC INTENSITY

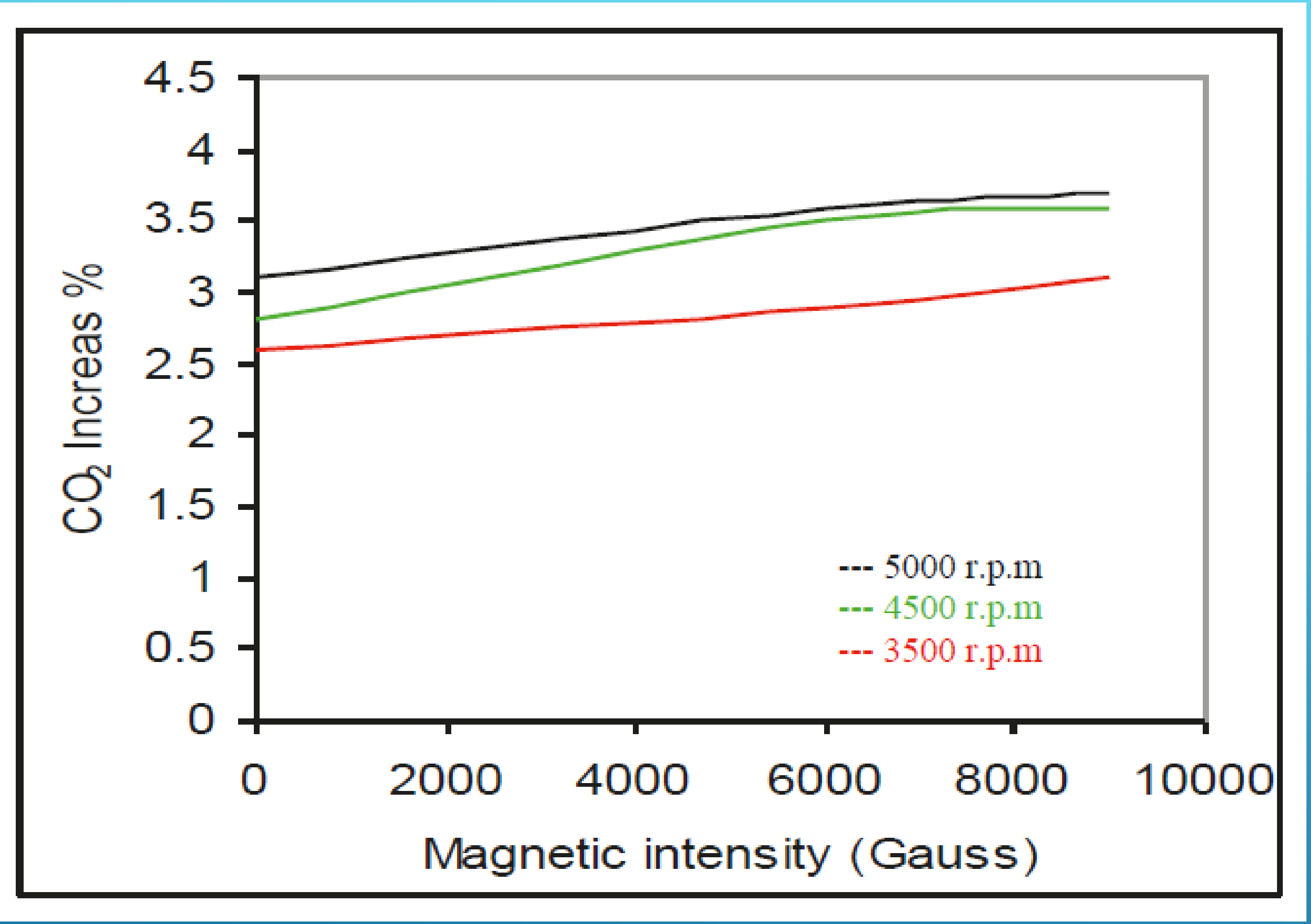


FIG. 8. INCREASE RATE OF CO2 GAS WITH MAGNETIC INTENSITY

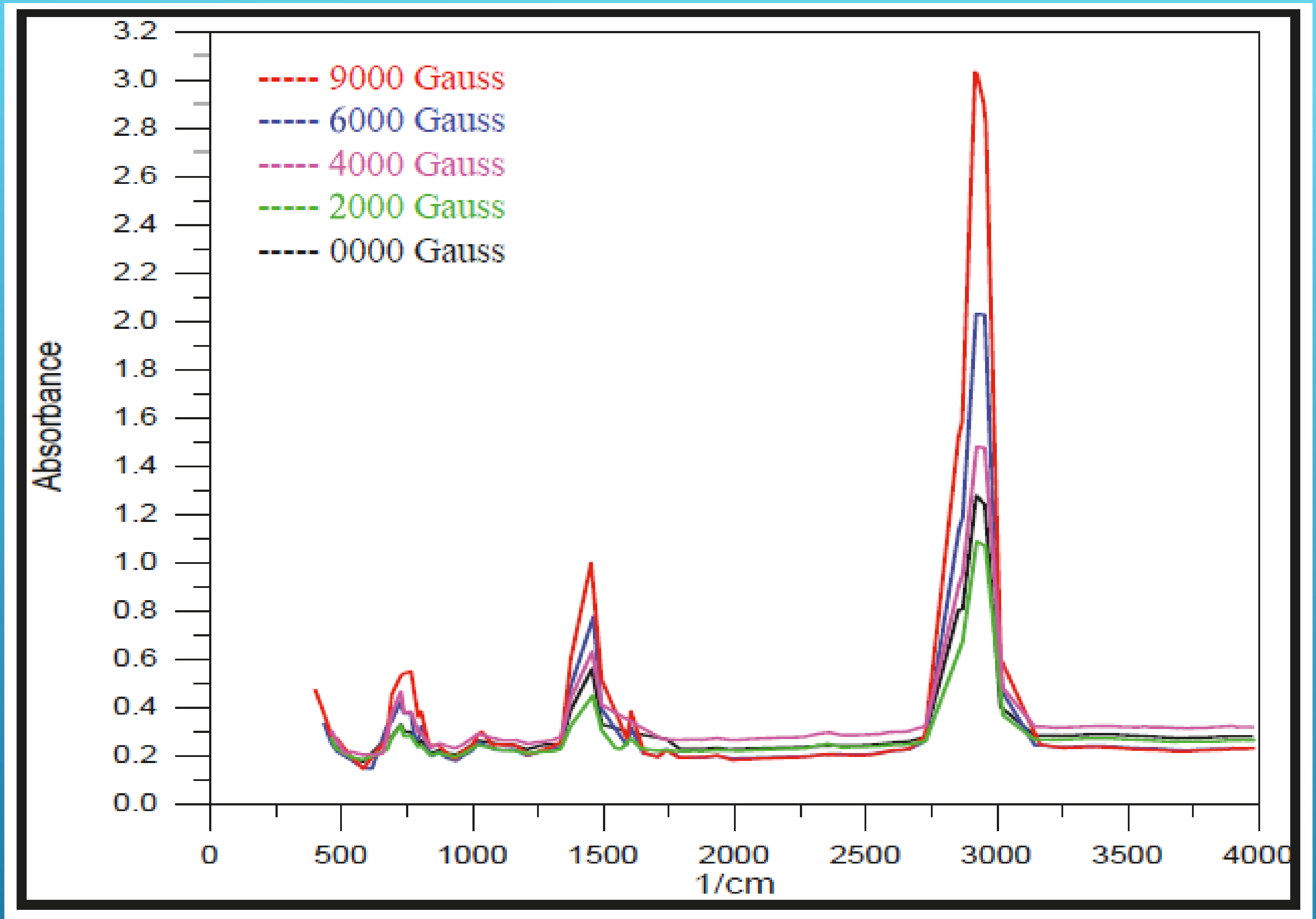


FIG. 9. VARIATION OF STRENGTHS OF INFRARED ABSORPTION PEAKS OF FUEL WITH MAGNETIC INTENSITY

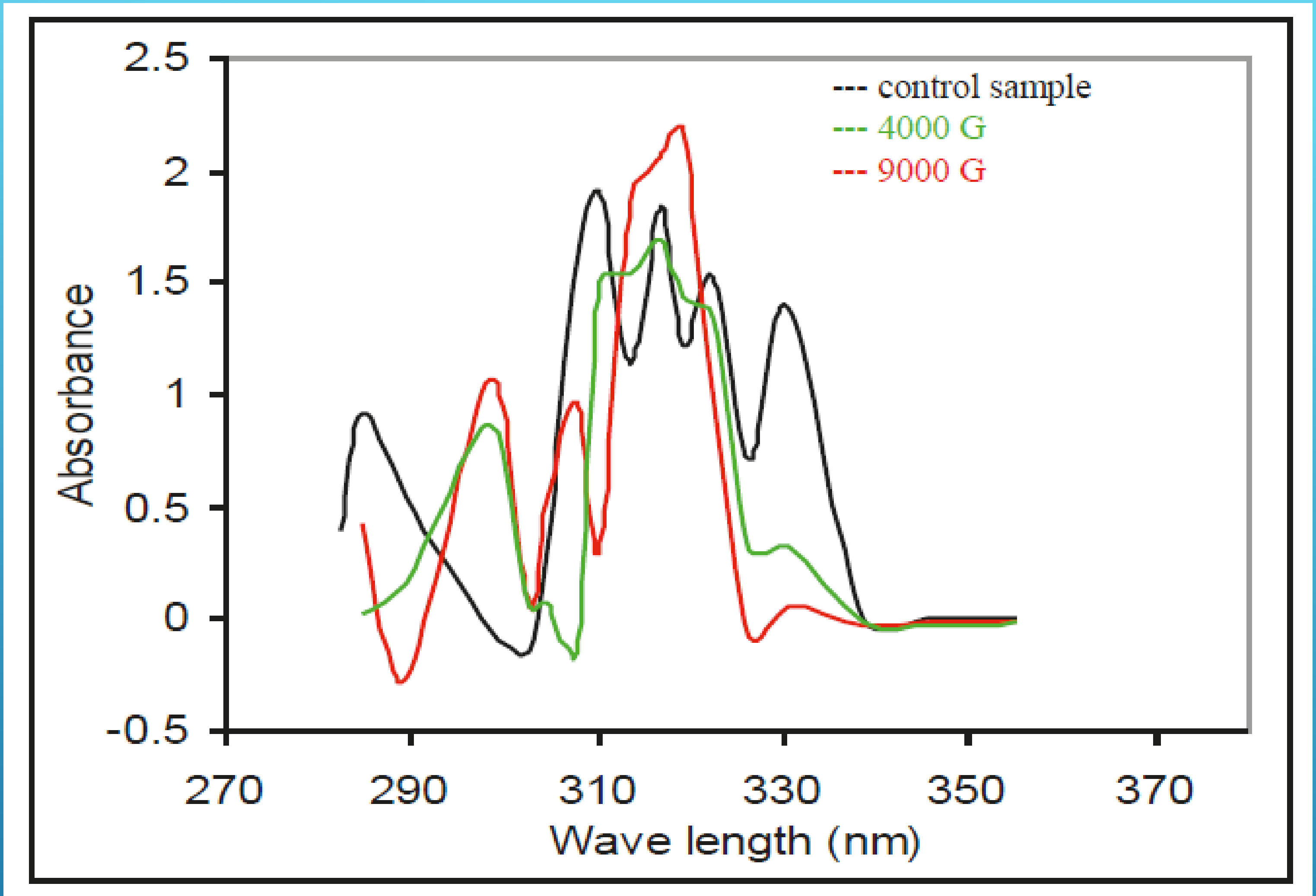


FIG. 10. ABSORPTION SPECTRUM OF ULTRAVIOLET LIGHT FOR FUEL MAGNETIZED WITH DIFFERENT MAGNETIC INTENSITIES

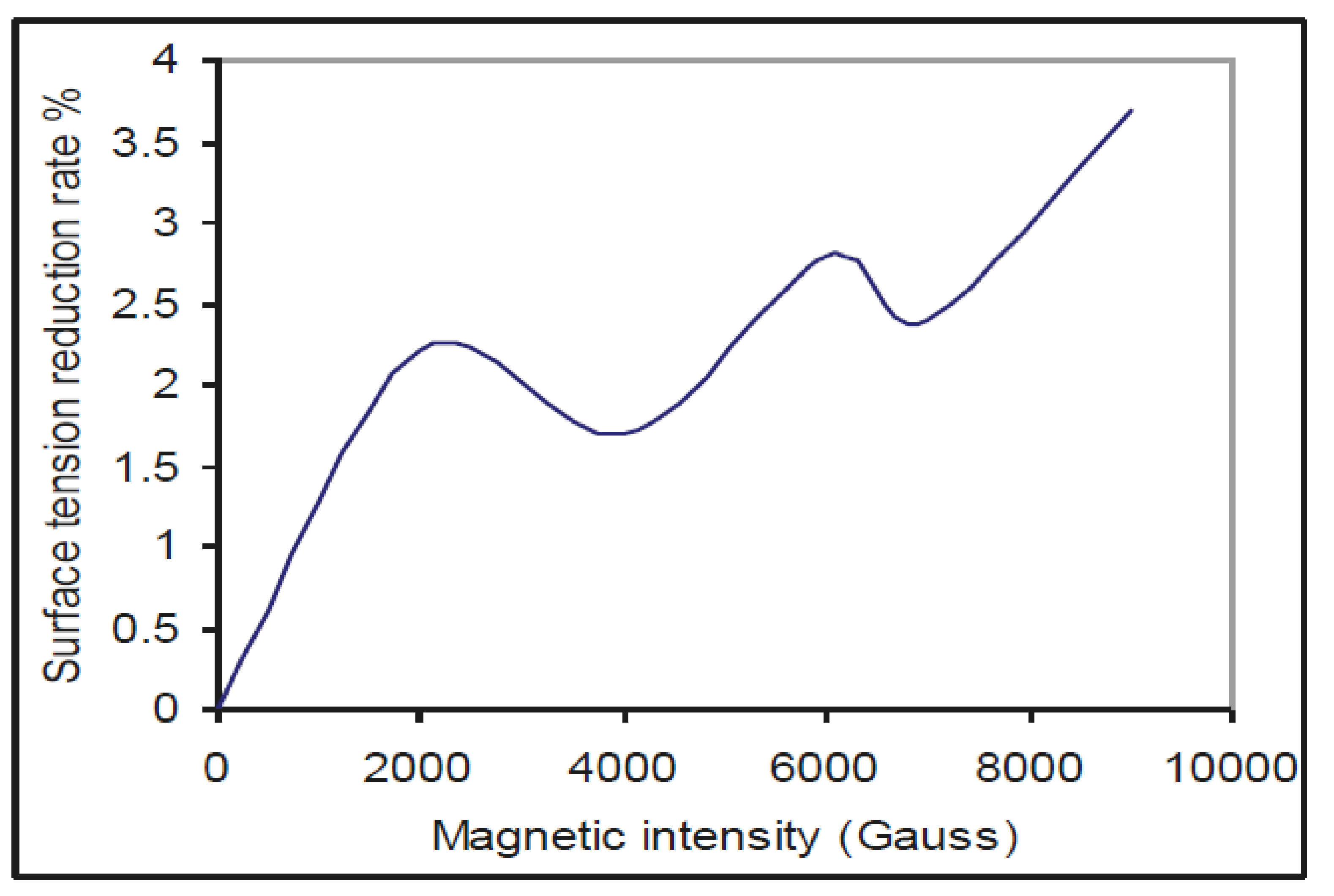
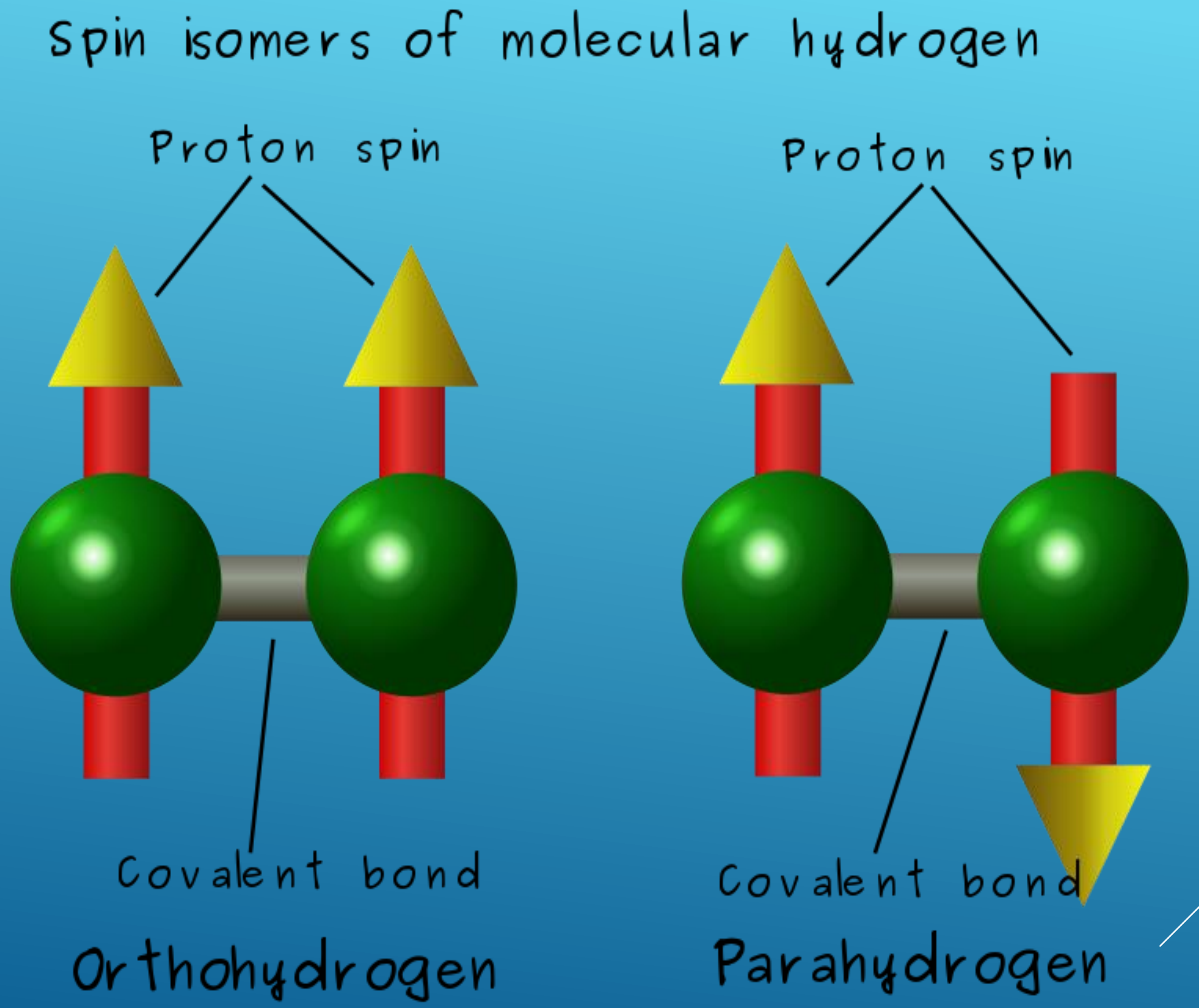


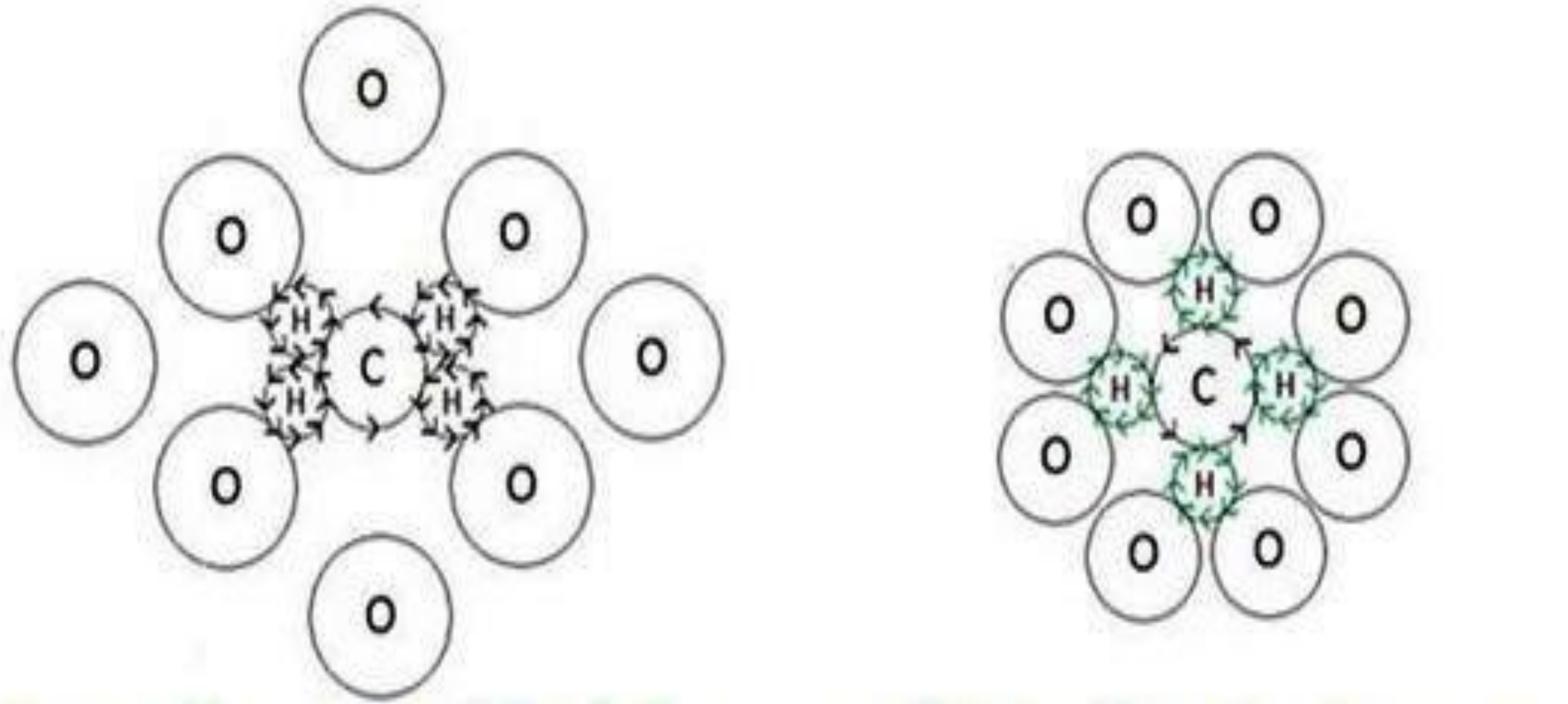
FIG. 11. CHANGE IN SURFACE TENSION OF THE FUEL WITH THE INTENSITY OF THE MAGNETIC FIELD.

PERFORMANCE AND EMISSION OF SINGLE CYLINDER 4 STROKE DIESEL ENGINE.

- Introduction
- Fuel is ionized by magnetic field by principle of magnetic field mutual action with hydrocarbon fuel and oxygen.
- Various attraction forces between fuel molecules which forms densely packed structures which are stable.
- That oxygen can't penetrate.
- External magnetic field polarizes fuel , being the fuel molecules change orientation and increase space between them.
- Thus better reaction with oxygen and more complete combustion.
- When the fuel passes through the field it changes the molecular orientation converting it from a para form to an ortho form.


Spin isomers of molecular hydrogen
Proton spin
Proton spin
Covalent bond
Covalent bond
Orthohydrogen
Parahydrogen

- In the ortho state the intermolecular force is reduced considerably and space is increased between them.
- This magnetic field also helps to disperse oil particles, becoming finely divided.



Para-Hydrogen at Time of Combustion

Ortho-Hydrogen at Time of Combustion

- Set up and procedure.
- A diesel engine was used for all tests.
- Designed for accurate flow rate.
- Fuel consumption was measured directly by using the burette method.
- Measurement was taken at different loading times.
- Exhaust was measured by a gas analyzer, measuring HC, CO, CO2, and NOx AT each load.
- Procedure was done twice with and without magnets and results were compared.

THE ENGINE USED

Technical Specifications Model	TV1
Make	Kirlosker Oil Engines
Type	Four stroke, Water cooled, Diesel
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Combustion principle	Compression ignition
Cubic capacity	0.661 liters
Compression ratio 3 port	17.5:1
Lubrication system	Forced feed system

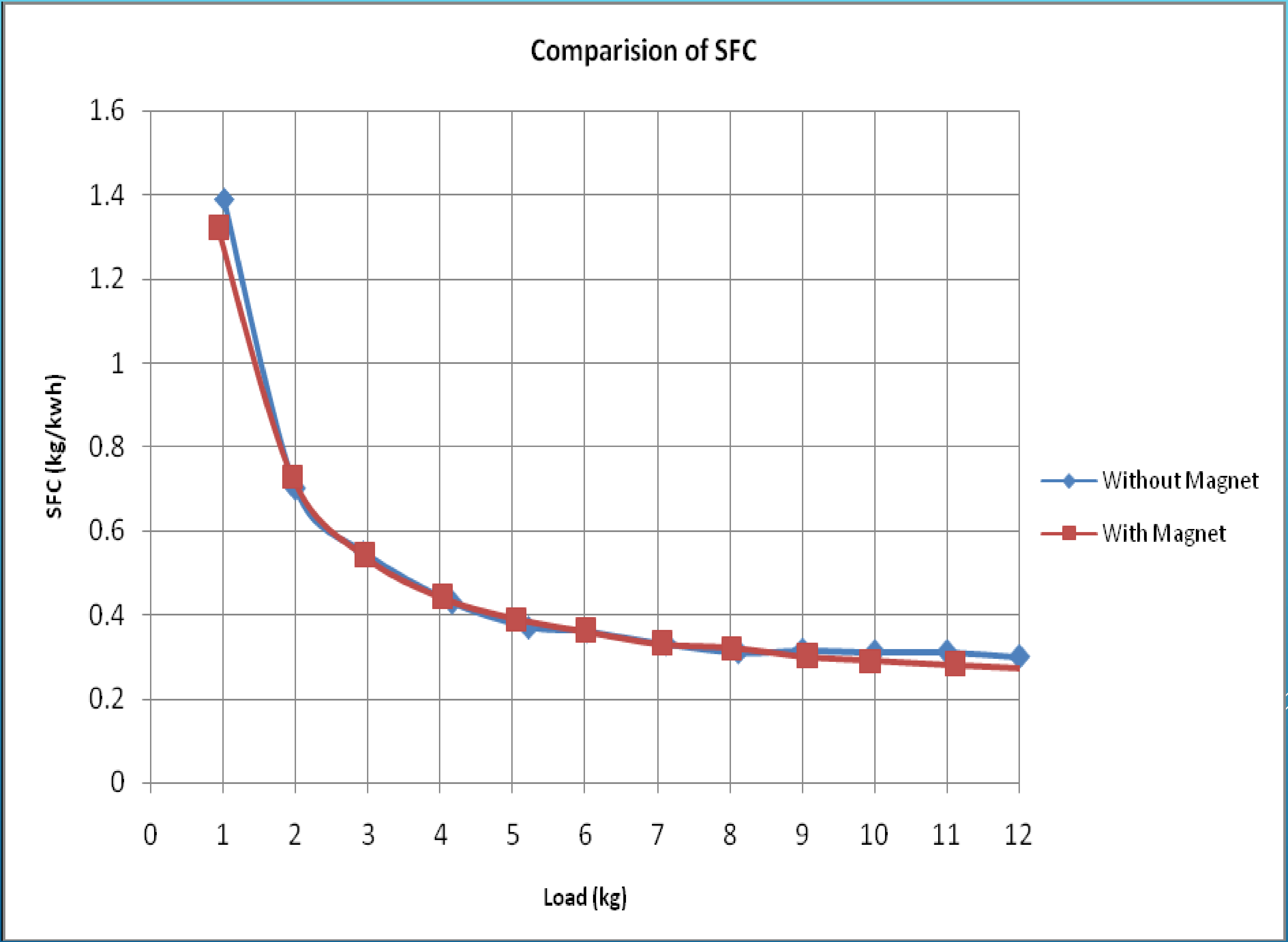
THE ENGINE SPECIFICATIONS

PHOTOGRAPHIC VIEW OF EXHAUST GAS ANALYZER

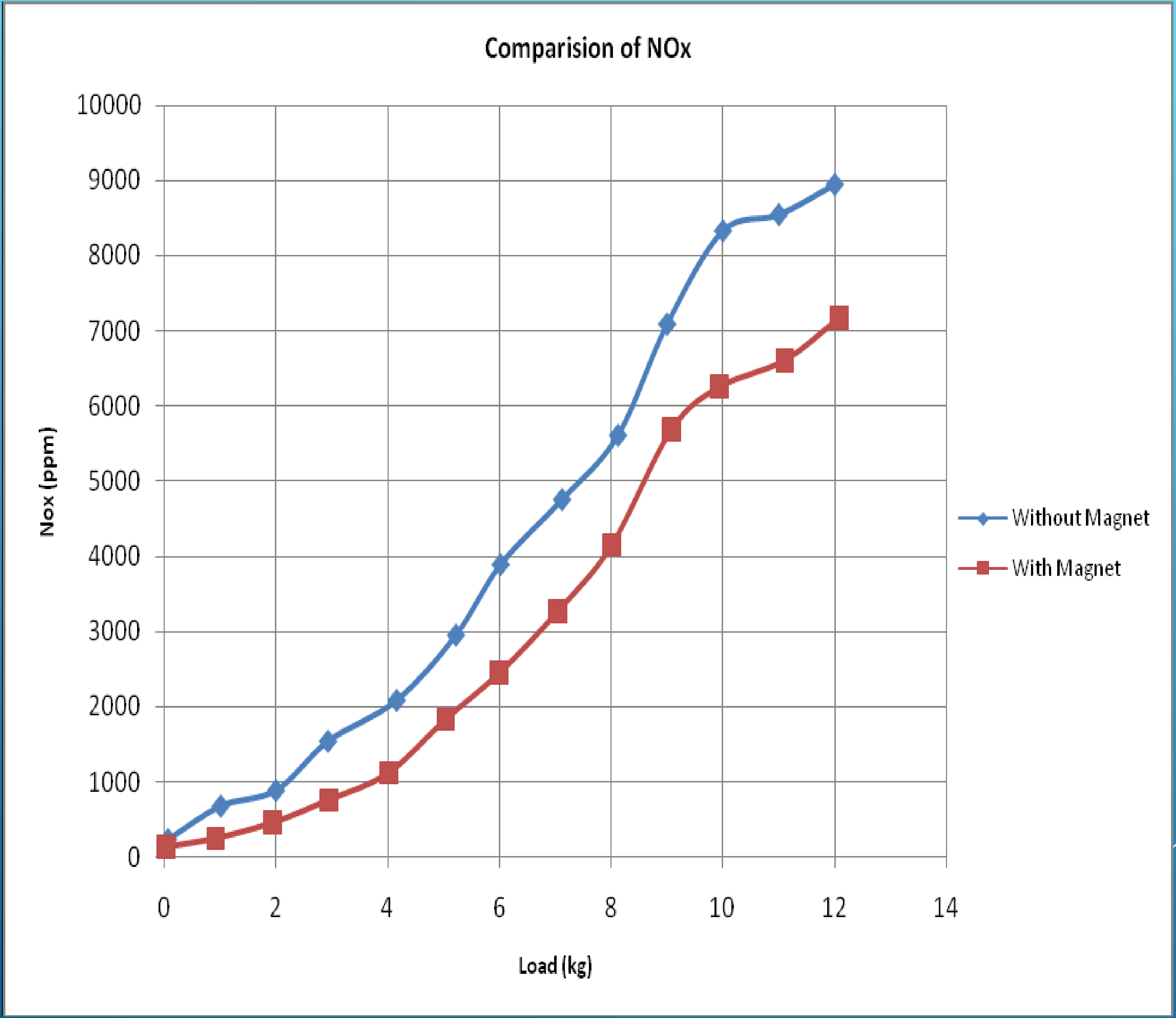
- Magnet properties
- A ferrite magnetic was used.
- It was a ceramic and iron oxide type.
- It was installed just before the injector for maximum alignment and effect.

PHOTOGRAPHIC VIEW OF FERRITE MAGNETS

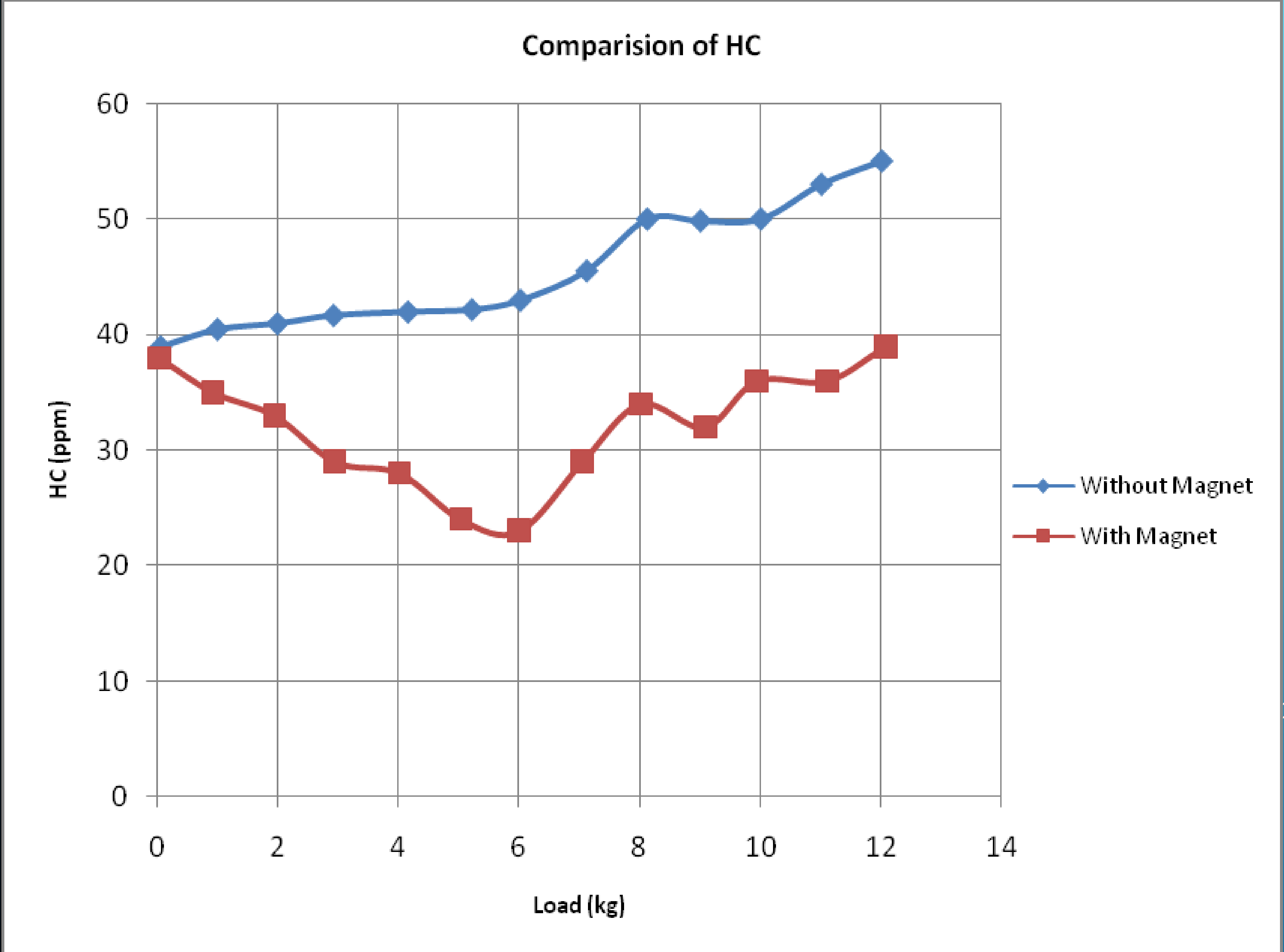
- <u>Results</u>
- Fuel(SFC) consumption was less with the magnet.
- Brake(BTE) power was less, up to 2%.
- Emission show the greatest change!
- Nox decreased 27.7%
- HC decreased 30%
- CO showed a significant decrease then an increase then back down again.
- CO2 decreased 9.72%

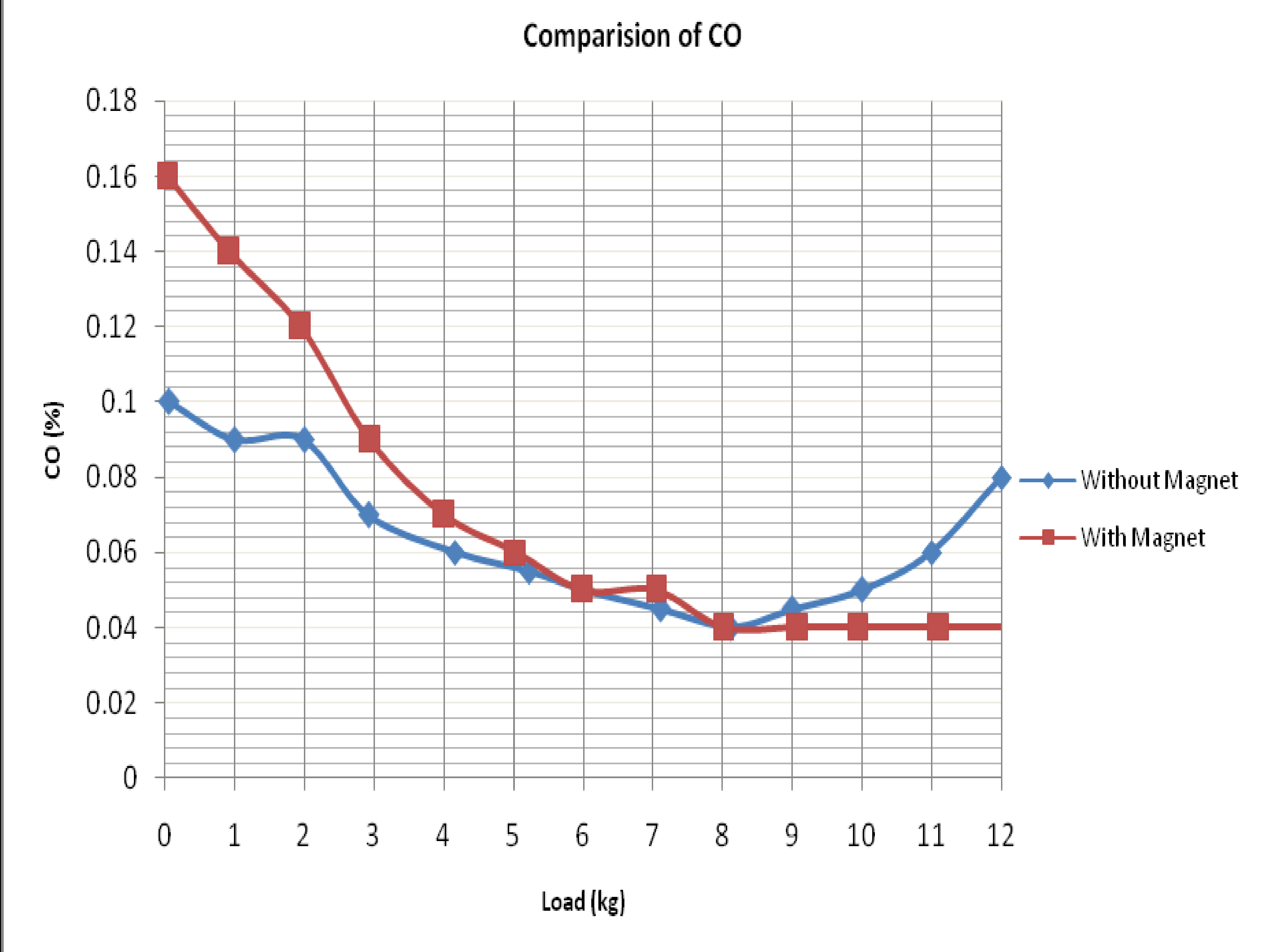


Comparision of SFC
SFC (kg/kwh)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Load (kg)
Without Magnet
With Magnet

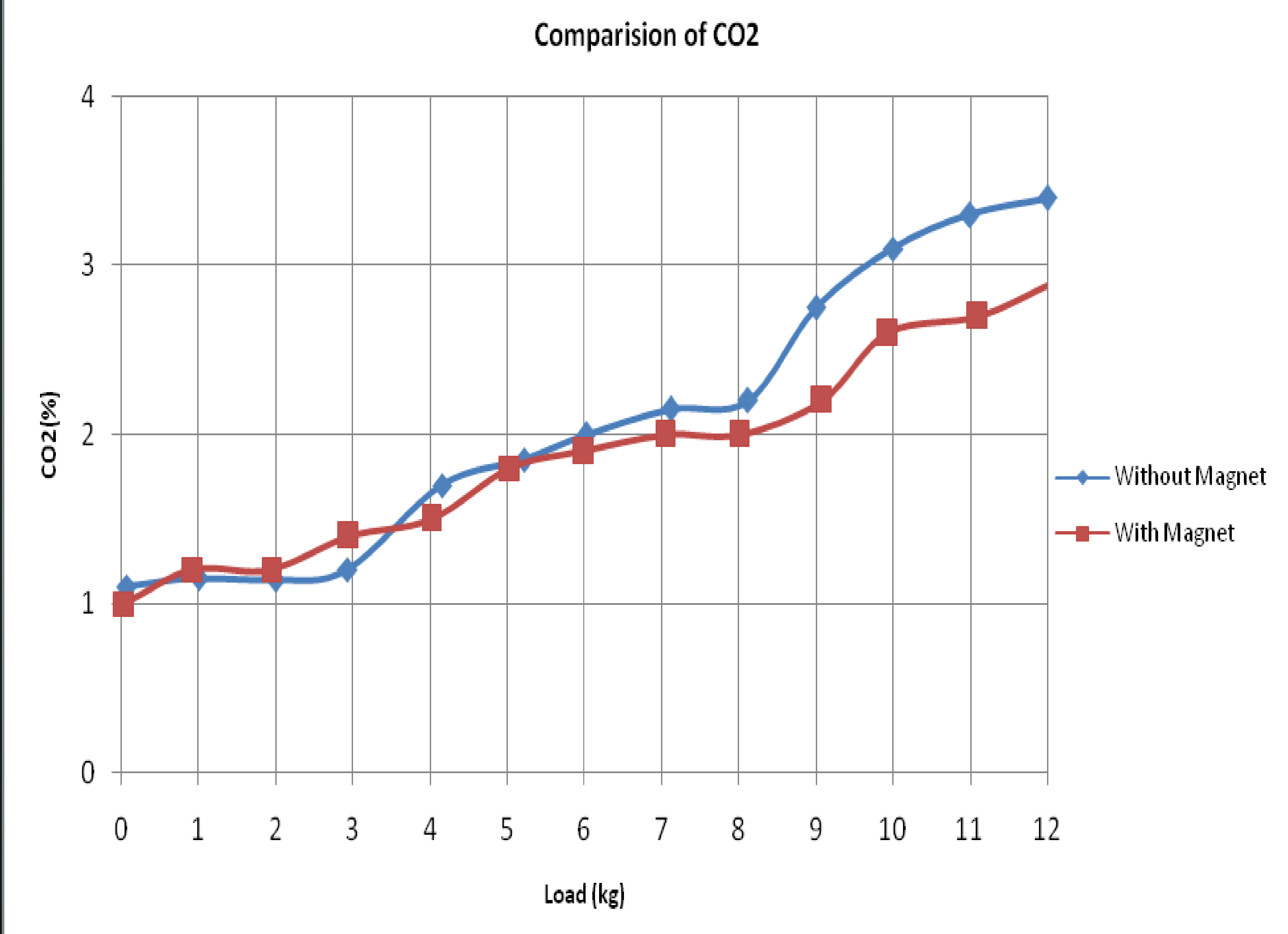


Comparision of NOx
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Nox (ppm)
0
2
4
6
8
10
12
14
Load (kg)
Without Magnet
With Magnet

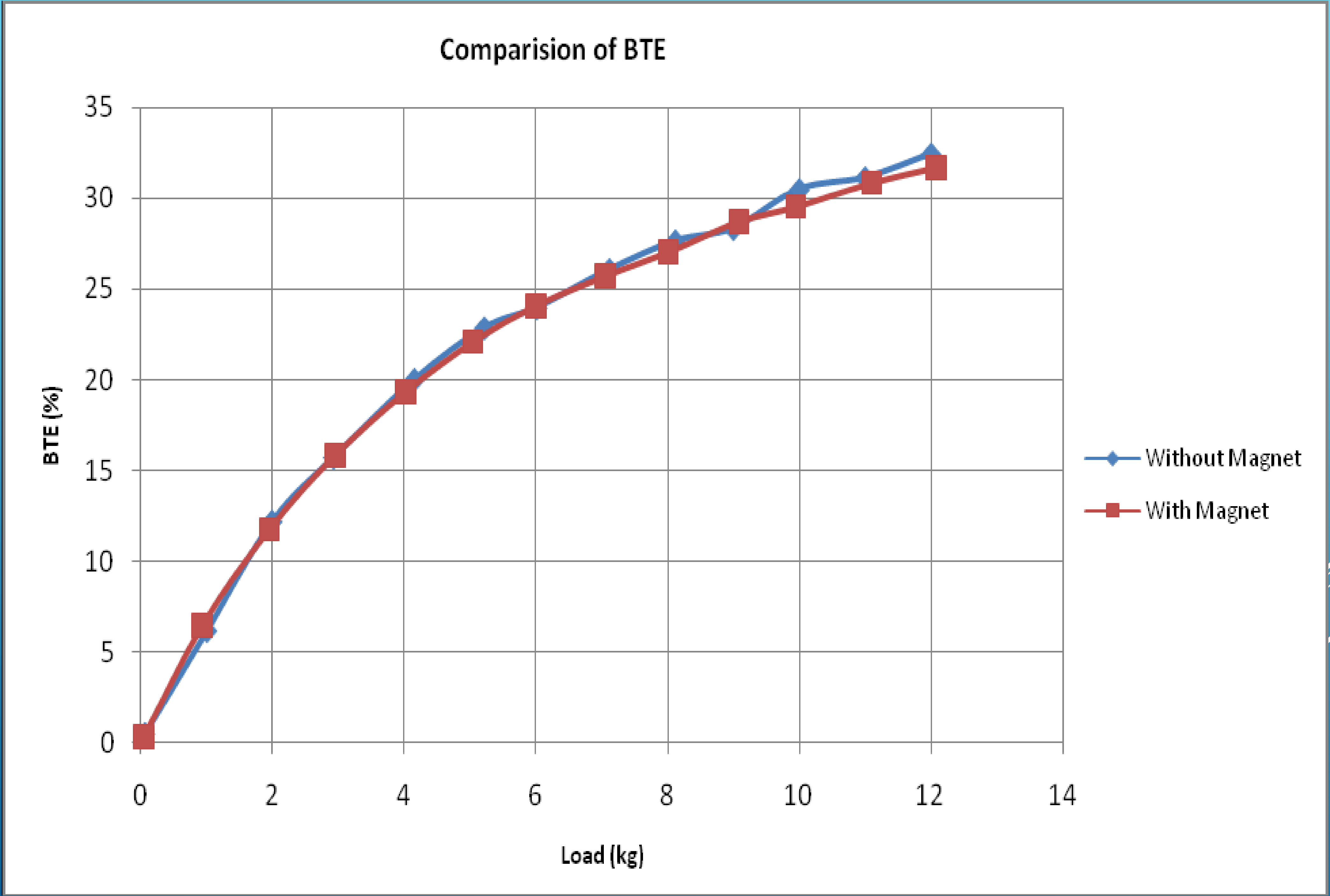

Comparision of HC
HC (ppm)
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
Load (kg)
Without Magnet
With Magnet



Comparision of CO
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
CO (%)
0 1 2 3 4 5 6 7 8 9 10 11 12
Load (kg)
Without Magnet
With Magnet



Comparision of CO2
CO2(%)
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Load (kg)
Without Magnet
With Magnet


Comparision of BTE
BTE (%)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
Load (kg)
Without Magnet
With Magnet

- Conclusion
- Brake thermal efficiency similar in both cases with and without magnetic field.
- Yet, indicated power improved at low load conditions.
- Fuel consumption decreased.

APPLYING THE RESULTS

These are based on the 3 experiments dealing with the effect of applying a magnetic field on hydrocarbon fuels.

1st part explains how using a magnetic field can enhance Infrared and UV-Vis spectroscopy.

2nd part explains how using a magnetic field to reduce surface tension and viscosity can be a benefit for HPLC and GC Spectroscopy.

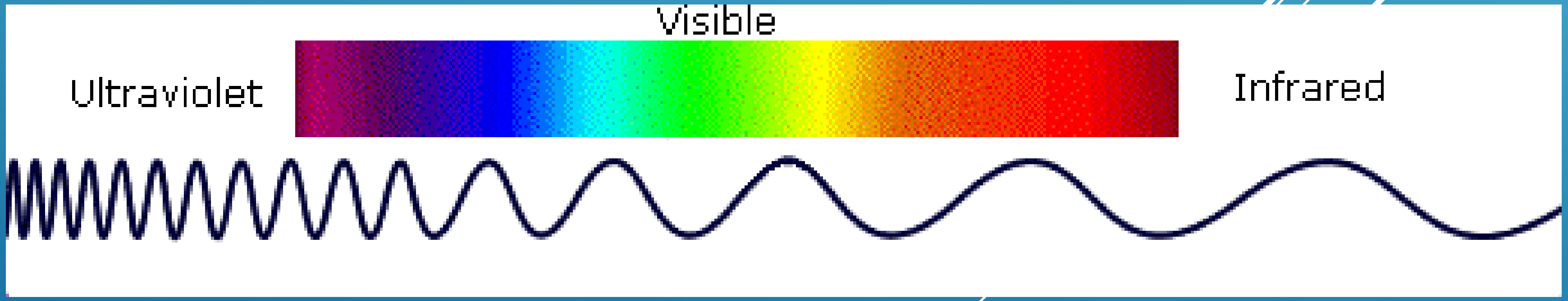
3rd part explain how this can be implemented into the current system available.

INFRARED SPECTROSCOPY

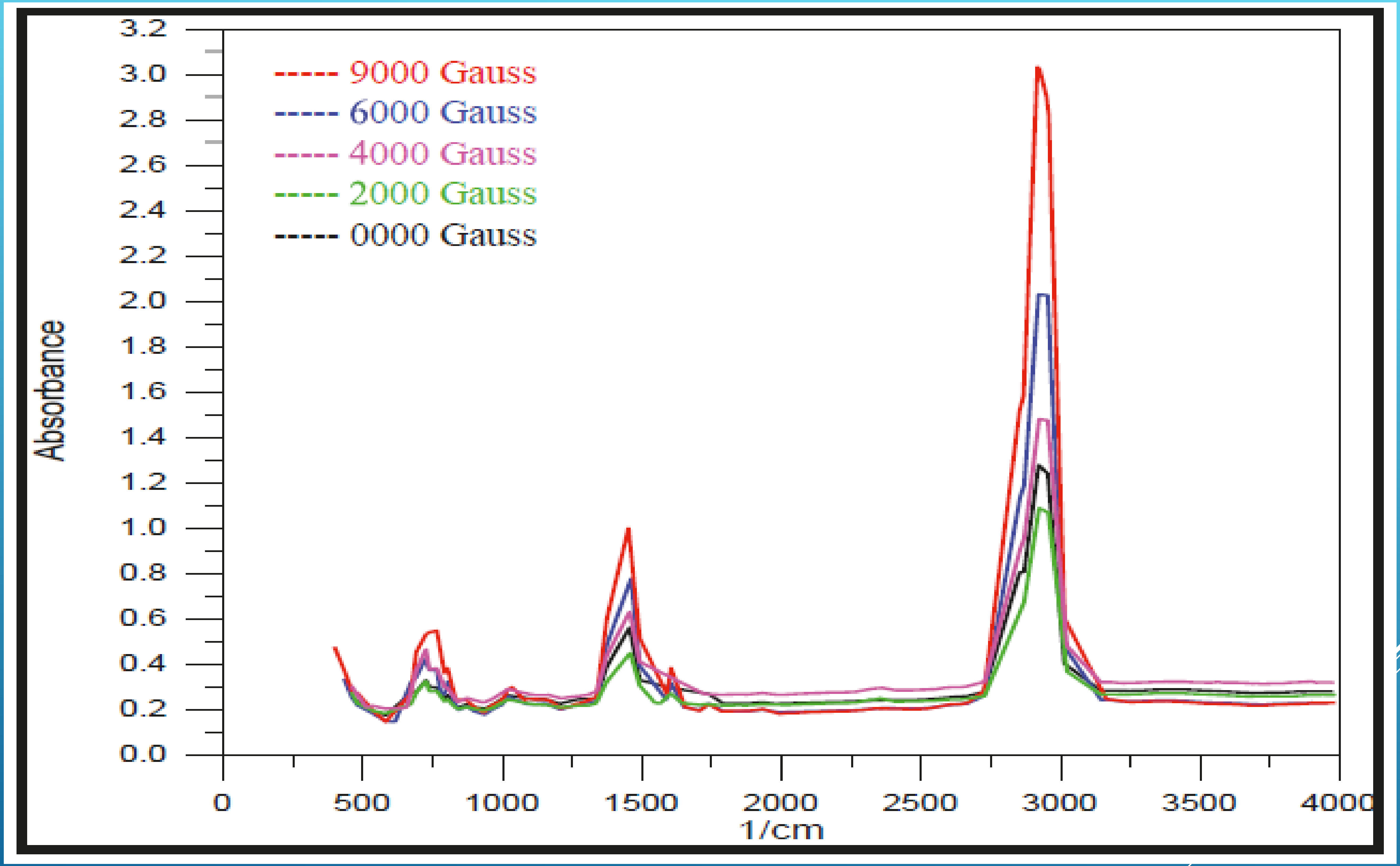
Infrared spectroscopy (**IR spectroscopy** or **vibrational spectroscopy**) is the interaction of infrared radiation with matter.

It covers a range of techniques, mostly based on absorption spectroscopy.

From the diagram below the wavelengths used are towards the red end of the spectrum.



- As shown earlier the absorption spectra physical and chemical properties of the fuel are changed by the magnetic fields effect.
- In the petrol experiment 100 ml of fuel samples that were magnetized and those that were not were examined by infrared spectroscopy.
- Because of the non-polar hydrocarbon attraction force is determined by vibrational frequencies, it was determined that the higher the frequency the lower the absolute molecular attraction forces.
- Thus it was concluded the attraction of hydrocarbon intermolecular forces are decreased after magnetization.
- The next slide show variation of strengths of infrared absorption peaks of fuel with magnetic intensity from the petrol experiment.



9000 Gauss
6000 Gauss
4000 Gauss
2000 Gauss
0000 Gauss
Absorbance
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
2000
2500
3000
3500
4000
1/cm

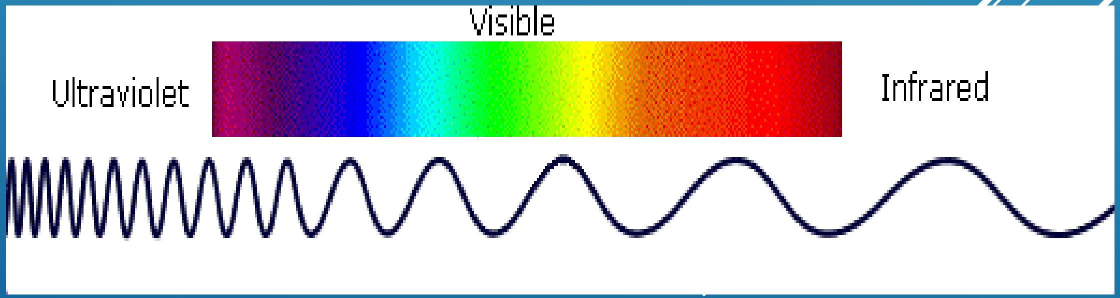
UV-VIS SPECTROSCOPY

Ultraviolet–visible spectroscopy refers to absorption spectroscopy or reflectance spectroscopy in part of the ultraviolet and the full, adjacent visible spectral regions.

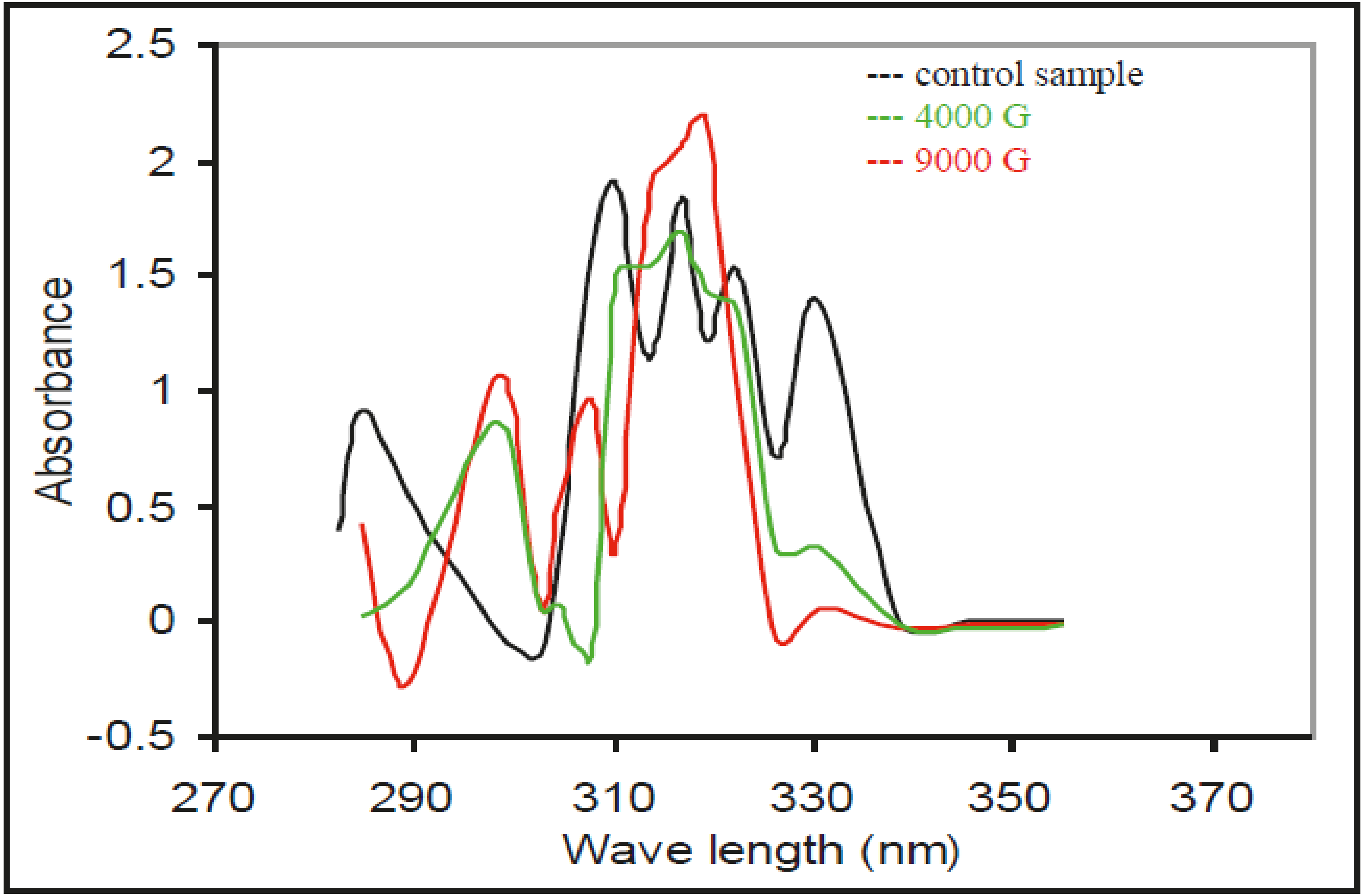
Molecules containing bonding and non-bonding electrons (n-electrons) can absorb energy in the form of ultraviolet or visible light to excite these electrons to higher anti-bonding molecular orbitals.

The more easily excited the electrons the longer the wavelength of light it can absorb.

On the spectrum below the UV-vis wavelengths are on the left side.



- In studying the spectral features of UV-Vis spectra showed that it was useful in showing properties and magnetic effects on electron motions and atomic structure.
- The petrol experiment showed that magnetized aromatic compounds remarkably increased indicating the transition probability of pi electrons in conjugated compound is higher.
- On the next slide shows the absorption spectrum of ultraviolet light for fuel magnetized with different magnetic intensities from the petrol experiment.



--- control sample
--- 4000 G
--- 9000 G
Absorbance
2.5
2
1.5
1
0.5
0
-0.5
270
290
310
330
350
370
Wave length (nm)

DISADVANTAGES WITH INFRARED SPECTROSCOPY

Based on the experimental results discussed, it is obvious that using a strong magnetic can greatly enhance Infrared spectra.

For the case of Infrared spectroscopy, there are some disadvantages that magnetization could solve.

One disadvantage is it requires very sensitive and properly tuned instruments.

The ability to focus well enough to make out what's being seen requires a well tuned instrument.

Also, the more tuned and better the instrument, the more expensive it will be in terms of purchasing and maintaining.

The next two slides show the advantages and more of the disadvantages.

Advantages:

- Non-Optical Spectroscopy
- No Spectral Temperature Dependence
- Minimal Sampling Requirements
- Spectral Response to Hydrogen Concentration is Linear
- Comparatively Large Sample Volumes
- Water is in Distinct Spectral Region
- Detailed Hydrocarbon Information is readily Quantifiable
- Fundamental Chemical Information can be Derived Directly from Spectrum.
- Colored/Black Samples Readily Observed

Disadvantages:

- Solids Cannot be Observed
- Spectra are "composite averages" of all components in the sample. Individual Molecular Component Identification may not be directly observed
- Low Sensitivity to Impurities – Quantitative > 1000 ppm
- Spectral Degradation may result from Presence of Ferro-Magnetic Species
- Excessive Sample Viscosity impacts Spectral Resolution
- Non-Hydrogen Containing Species are Not Observed

Disadvantages of FT-IR

- Cannot detect atoms or monoatomic ions - single atomic entities contain no chemical bonds.
- Cannot detect molecules comprised of two identical atoms symmetric-such as N_2 or O_2.
- Aqueous solutions are very difficult to analyze - water is a strong IR absorber.
- Complex mixtures - samples give rise to complex spectra.

WHAT MAGNETIZATION CAN DO FOR IR

For Infrared spectroscopy, magnetization can greatly enhance, depending the strength of the field as show in slide 140, the spectra reading.

At 9000 gauss show how greatly enhanced it can be. Thus it can overcome low sensitivity compounds.

For Ferromagnetic species spectral degradation, a applied field can be used to filter out the species.

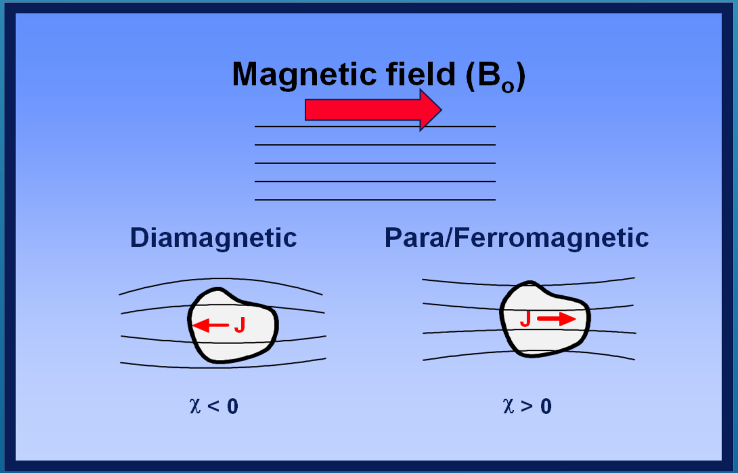
It depends on the whether the anayltes of interest are diamagnetic or paramagnetic.

Also, by varying the strength of the field to properly filter out problem species.

What is suggested here is based on the findings of the three experiments and what was discussed.

As for viscosity, it does decrease under magnetization, this will depend on in part with surface tension.

More of this will be in the discussion about viscosity and surface tension.

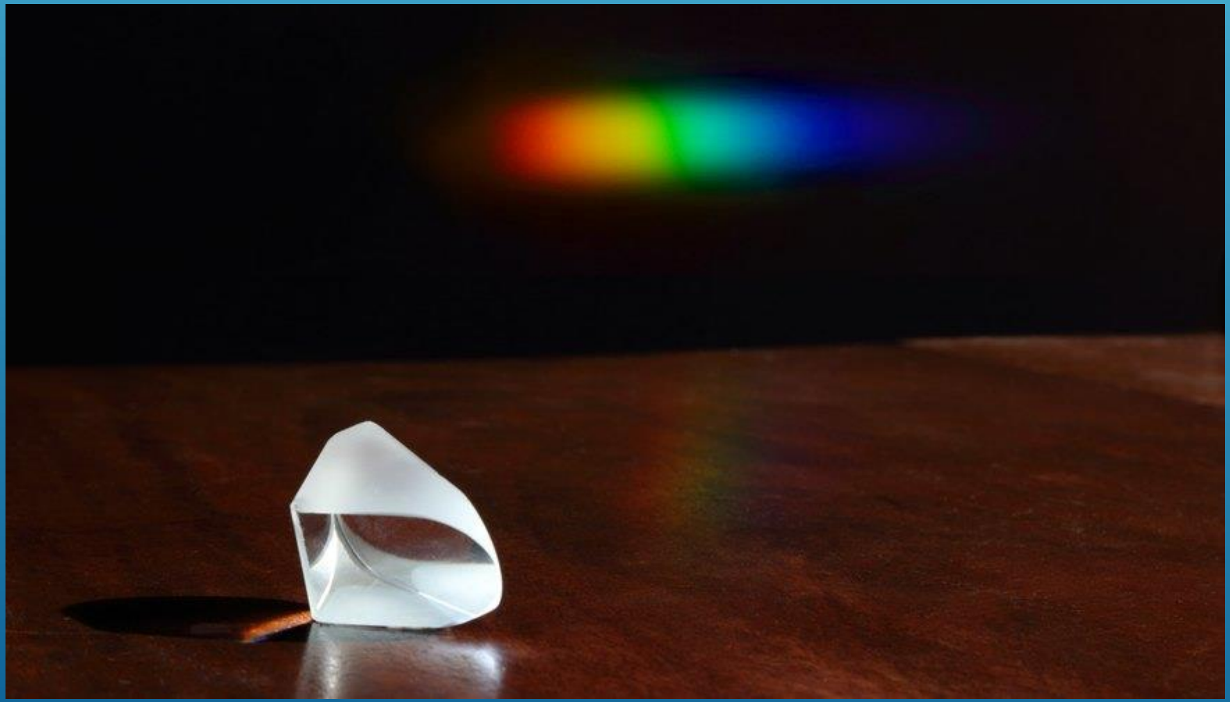


DISADVANTAGES WITH UV-VIS SPECTROSCOPY

As with Infrared Spectroscopy, UV-Vis has it's own advantages and disadvantages.

From the sources found its seems there is less disadvantages with UV-Vis than with Infrared.

However, there is one interesting disadvantages that will be generally addressed.

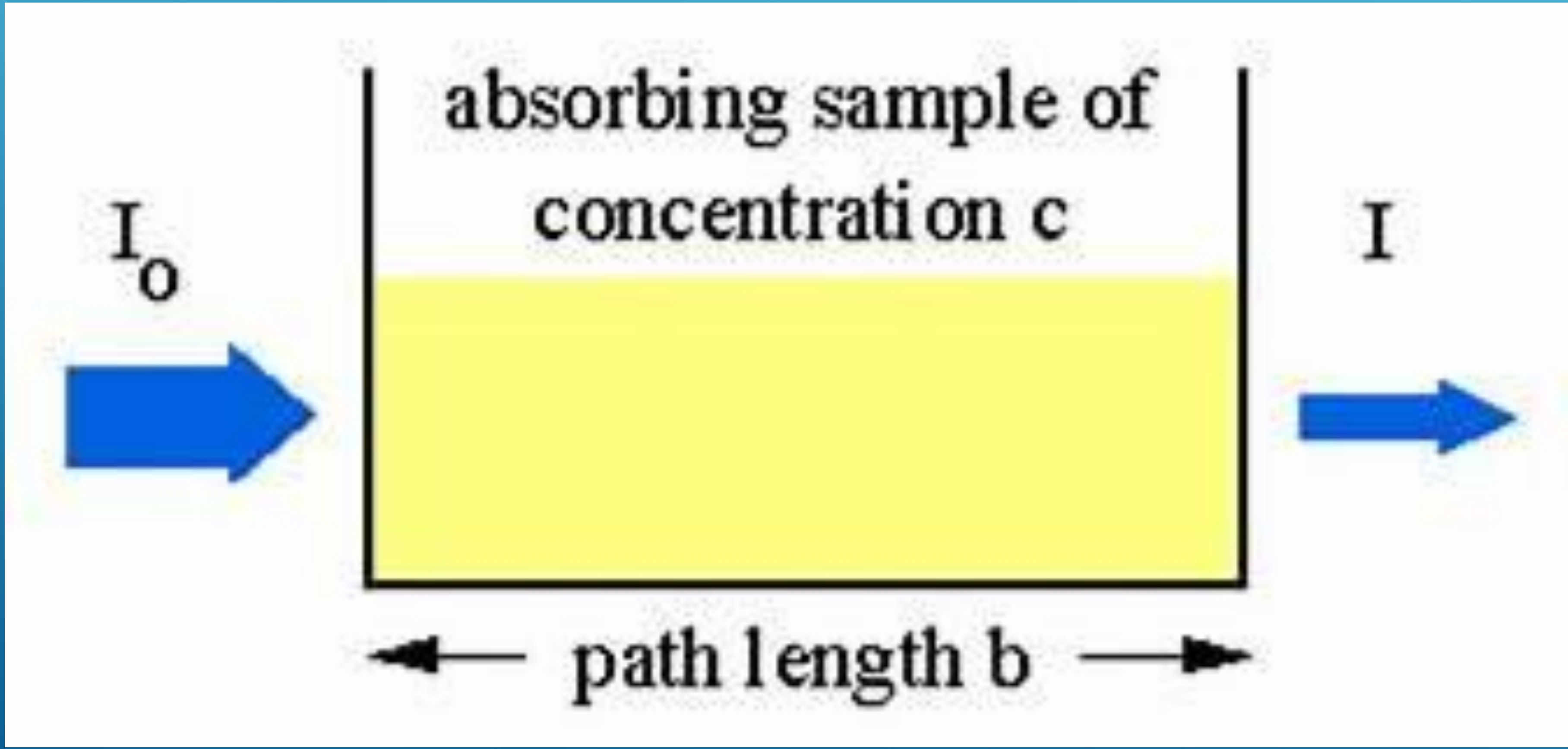


UV/Visible

- Advantages
  - high sensitivity
  - small sample volume required
  - linearity over wide concentration ranges
  - can be used with gradient elution
- Disadvantage
  - does not work with compounds that do not absorb light at this wavelength region

- The other disadvantage of UV-Vis spectroscopy is the deviations with the Beer-Lambert Law.
- These deviations are:
- **Real Deviations** – These are fundamental deviations due to the limitations of the law itself.
- **Chemical Deviations**– These are deviations observed due to specific chemical species of the sample which is being analyzed.
- **Instrument Deviations** – These are deviations which occur due to how the absorbance measurements are made.

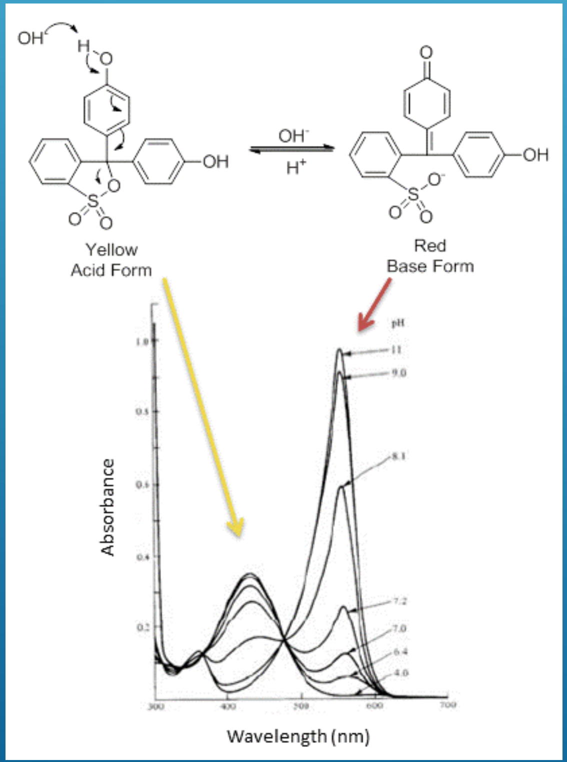
- Beer law and Lambert law only capable of describing absorption behavior of solutions containing relatively low amounts of solutes dissolved in it (<10mM).
- When the analyte concentration is high (>10mM), it begins to behave differently.
- Due to interactions with the solvent and other solute molecules.
- At times even due to hydrogen bonding interactions.



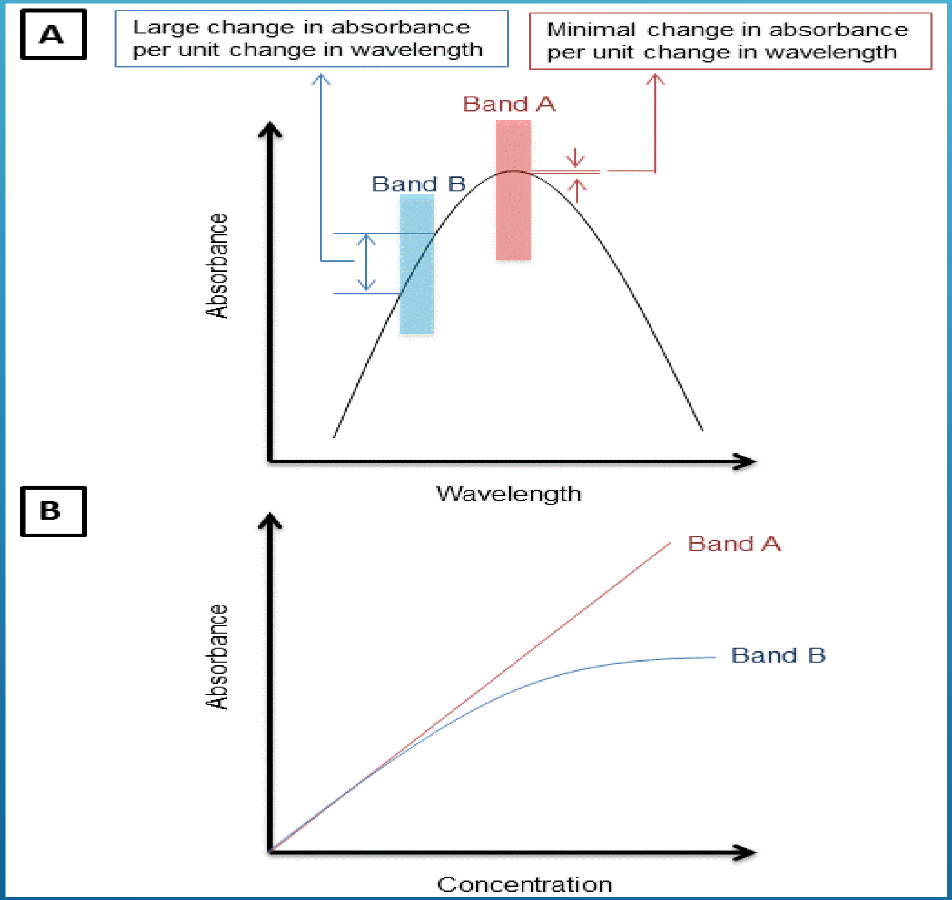
$$A = \varepsilon c l$$

A	Absorbance	
ε	Molar absorption coefficient	$M^{-1}cm^{-1}$
c	Molar concentration	M
l	optical path length	cm

- Chemical deviations occur due the analyte molecules involved with the solvent in association, dissociation and interaction producing a product with different absorption characteristics.
- For example, phenol red undergoes a resonance transformation when moving from the acidic form (yellow) to the basic form (red).
- Due to this resonance, the electron distribution of the bonds of molecule changes with the pH of the solvent in which it is dissolved.
- Since UV-visible spectroscopy is an electron-related phenomenon, the absorption spectrum of the sample changes with the change in pH of the solvent.



- Beer-Lambert law is for monochromatic radiation source.
- However, the use a polychromatic radiation source with continuous wavelength distribution. with a filter or a grating unit (monochromators) to create a monochromatic beam from this source.
- This has lead to taking the reading at the maximum absorption point only.
- As the graph below shows why.

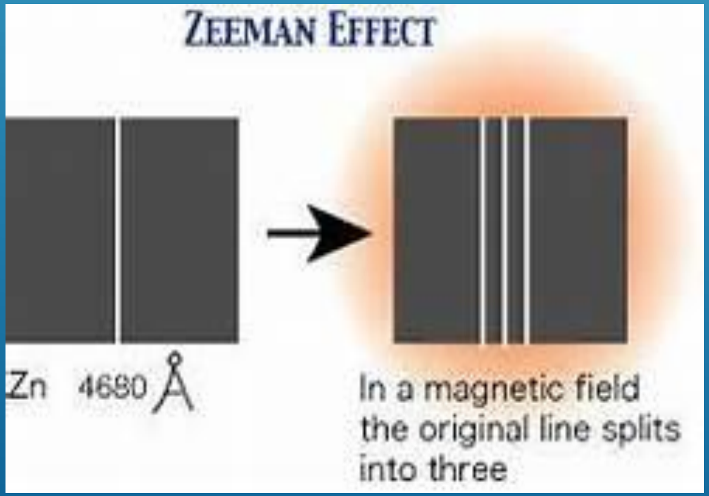


WHAT MAGNETIZATION CAN DO FOR UV-VIS

For compound that don't absorb the light spectrum region which are don't have unconjugated and/or no pi bonds. Magnetization though the principles of the Zeeman effect could and probably convert them to absorb in this region.

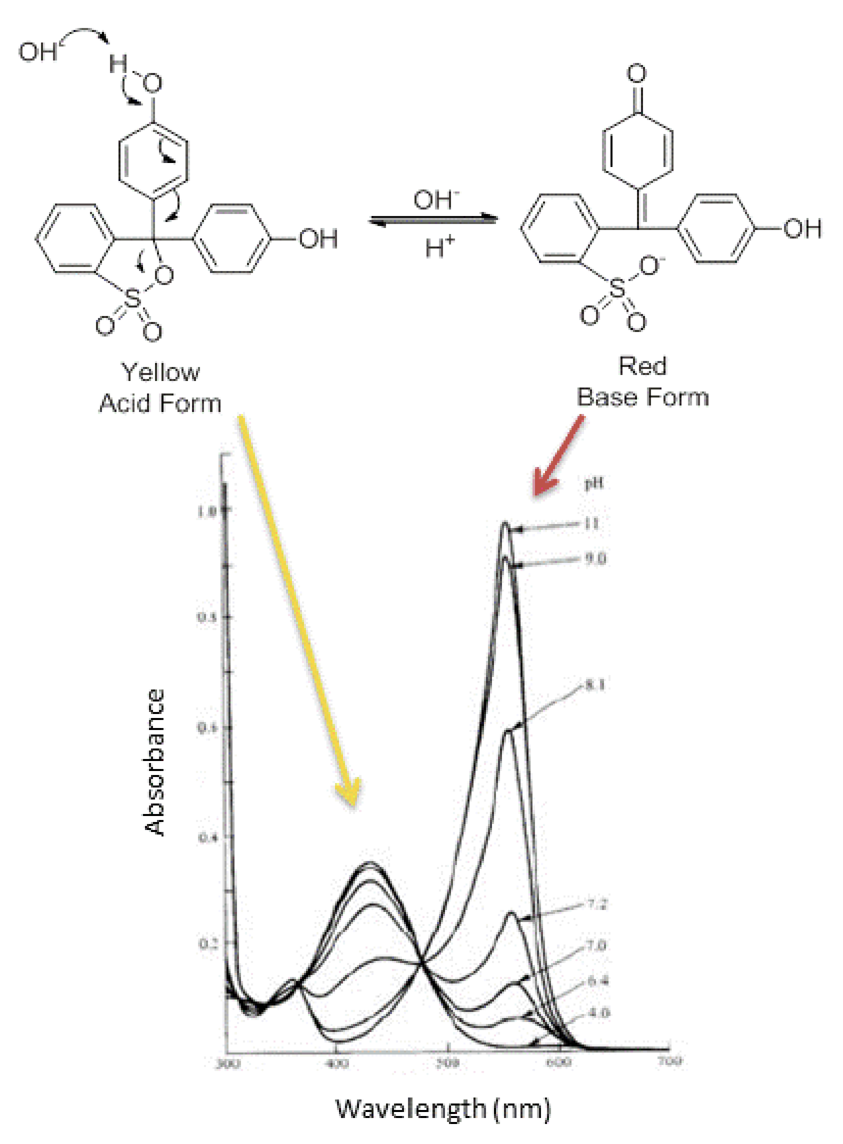
Because the with the Zeeman effect, the valence electrons can become unpaired breaking up any electron orbital and angular momentum couplings in a strong enough magnetic field.

As shown in the example for Zinc.

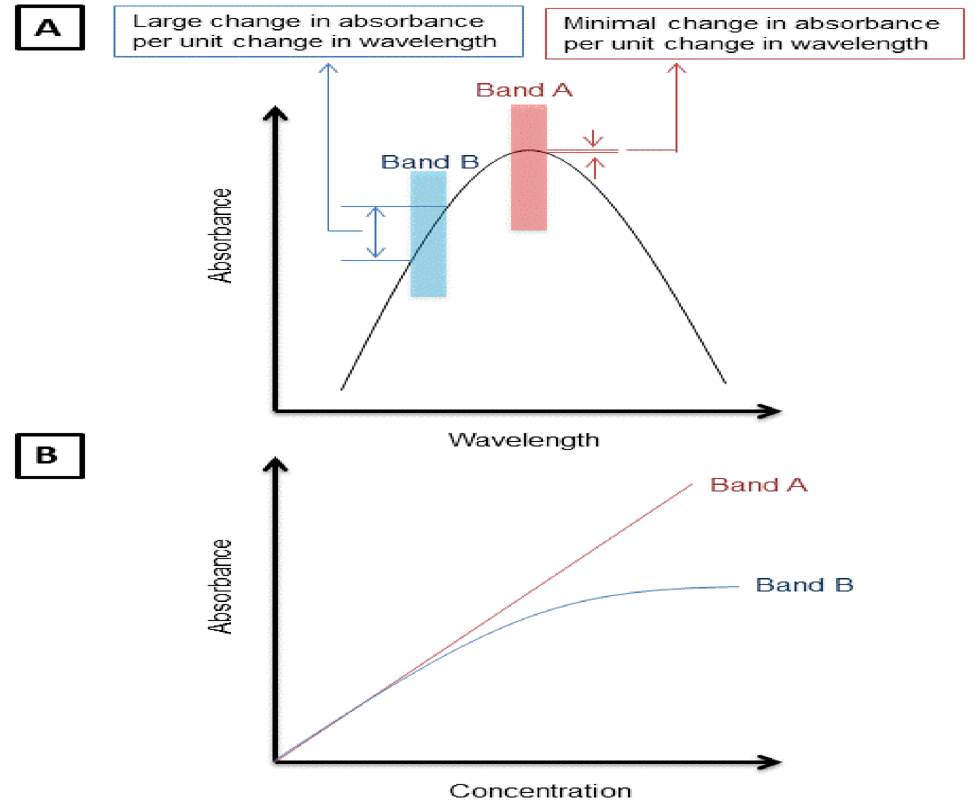


- For the Beer-Lambert deviations for Real and Chemical, magnetization can help resolve some of it if not all.
- The Real deviations of only allowing low concentrations, as shown with the experiments results and what was discussed, can easily resolve this issue.
- Reason is that applying a strong magnetic field can dilute and decluster the high concentrations of analytes of interest.
- Experimental evidence has shown with organic compound that it can be done.
- So, why not use a magnetic field to overcome this problem.
- Do an experiment to see if it works!
-

- For chemical deviations, the application of a magnetic field on a resonance structure should be able to have the effect of keeping only one species of the resonance.
- It should work on compound shown.



- For instrument deviations with using polychromatic light instead of monochromatic, which leads to only taking the maximum peak. As shown below.
- The use of a antimagnetic field could help to resolve this issue, but this is just a hypothesis that needs to be tested.



VISCOSITY

A measure of its resistance to deformation at a given rate.

For liquids, it corresponds to the informal concept of "thickness."

Example, syrup has a higher viscosity than water.

The box below shows the Reynolds number for measuring viscosity.

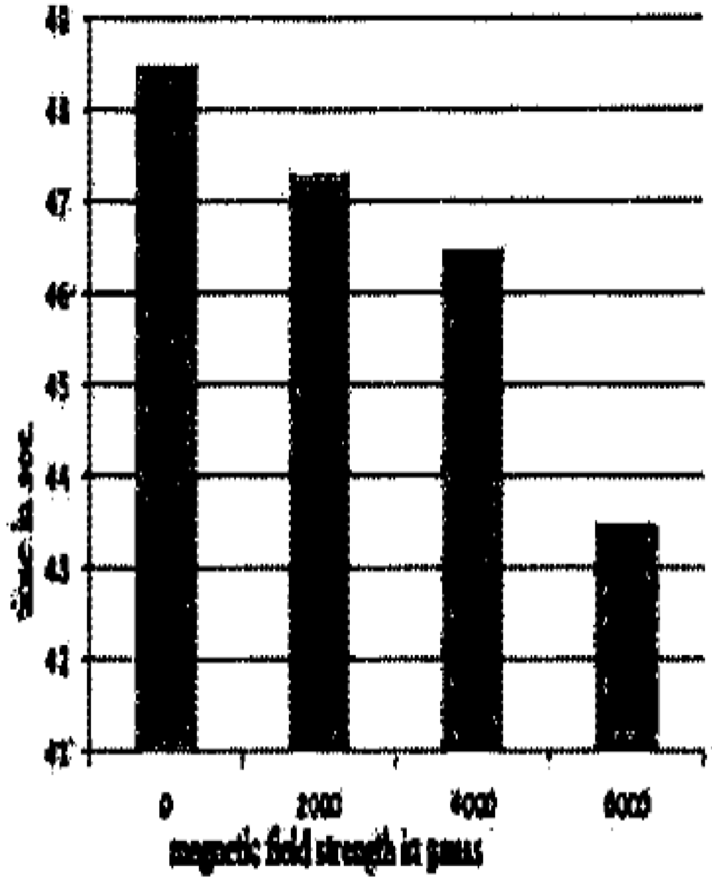
The Reynolds number is defined as[3]

$$\mathrm{Re} = \frac{\rho u L}{\mu} = \frac{u L}{\nu}$$

where:

- ρ is the density of the fluid (SI units: kg/m^3)
- u is the velocity of the fluid with respect to the object (m/s)
- L is a characteristic linear dimension (m)
- μ is the dynamic viscosity of the fluid (Pa·s or N·s/m^2 or kg/m·s)
- ν is the kinematic viscosity of the fluid (m^2/s).

- As previously mentioned in viscosity can be lessen by the application of a magnetic field.
- From the experimental findings for petrol, it showed that with the increased magnetic field strength the fuel flow quicker.
- Thus, the stronger the field the faster the flow. As shown below.



Graph 1. Magnetic field strength vs. fuel flow time

SR.NO	magnetic field strength (in gauss)	time in sec. to collect 20 ml of petrol in flask			average time
1	0	43.2	43.5	43.4	43.5
2	2000	47.5	47.3	47.4	47.3
3	4000	46.4	46.4	46.7	46.5
4	6000	43.6	43.5	43.5	43.5

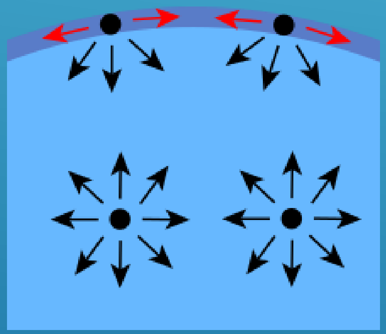
Table 1.Time required to collect 20 ml petrol in a flask for different magnetic fields.

SURFACE TENSION

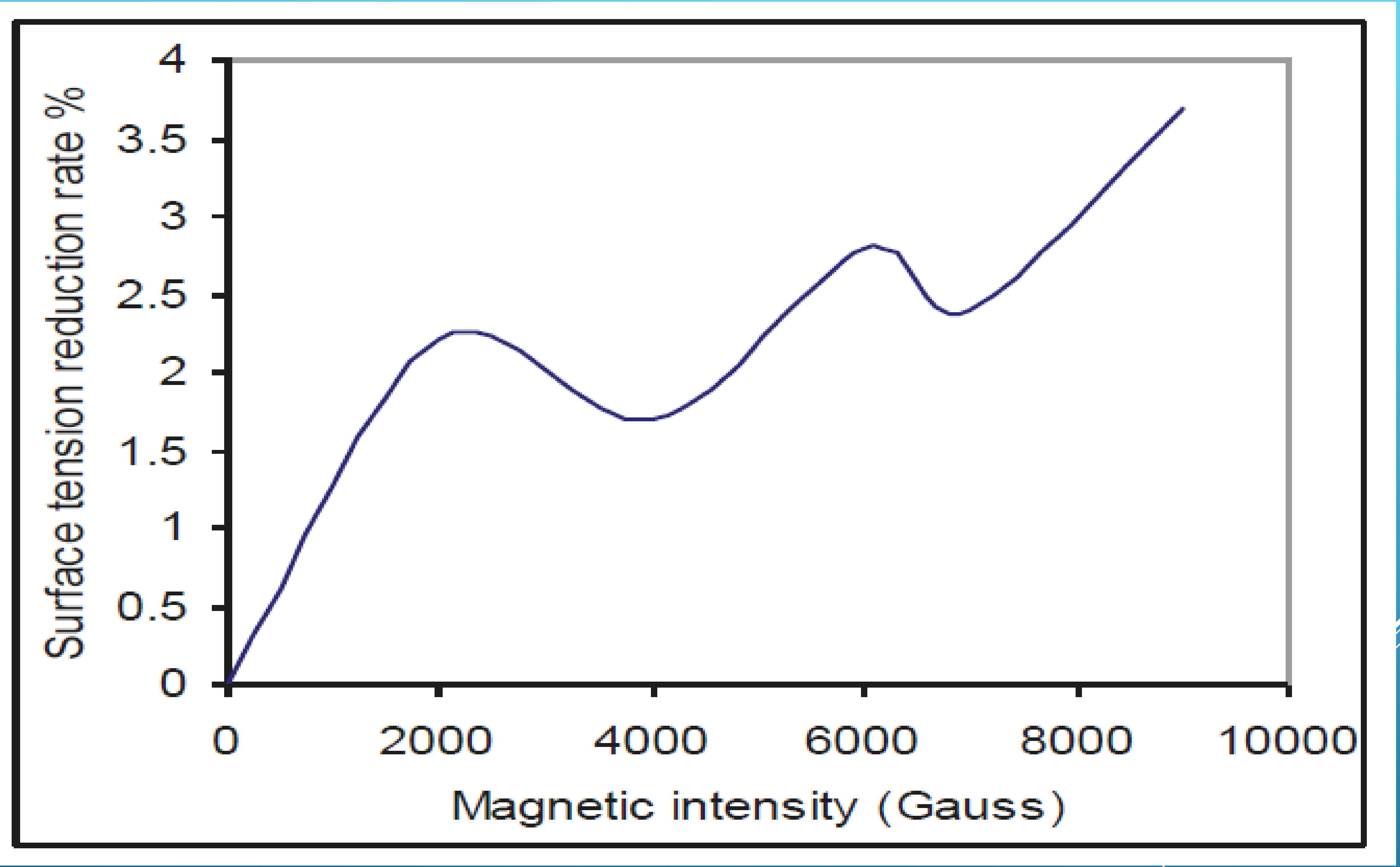
The tendency of liquid surfaces to shrink into the minimum surface area possible.

Using liquid–air interfaces as an example;

surface tension results from the greater attraction of liquid molecules to each other (due to cohesion) than to the molecules in the air (due to adhesion).



Next slide show the change in surface tension of the fuel with the intensity of the magnetic field from the petrol experiment.



Surface tension reduction rate %
4
3.5
3
2.5
2
1.5
1
0.5
0
0
2000
4000
6000
8000
10000
Magnetic intensity (Gauss)

- From examining the graph on the previous slide, it shows that the surface tension goes though an increasing up and down from 2000 to 7000 gauss.
- It is thought to be due to viscous heating from the fuel.
- Viscous heating is an irreversible process which the work done by a fluid on adjacent layers due to shear force action produces heat.
- So, surface tension value is molecular orientation state on the liquid surface besides the intermolecular forces.
- Meaning that the way the molecules are positioned determines cohesiveness in the magnetic field.

HOW THIS CAN BE APPLIED TO ICP, GC, AND HPLC SYSTEMS.

The ionization of organic compound by magnetization can;

Make atomizing/nebulizing compounds more thoroughly for analysis.

Less waste of target compounds due incomplete nebulization.

Can be used for ICP, GC, and HPLC systems.

- For ICP systems, putting a strong magnet on the line to nebulizer can effectively polarize the compounds for easier nebulization.
- Spectra enhancement for the Optical Emission Spectra (OES).
- This should be similar as with Infrared and UV-Vis spectra.
- This could be done by having a magnet or magnetic coil around the plasma.
- The possible issues is having magnetic inferences with the RF coil and a coil or magnetic that can resist the intense heat.
- A possible solution is to develop a RF/ Magnetic coil which can be used to ignite the plasma and then create the magnetic field.

- For GC applications, a strong magnet would be on the injection port.
- An obvious benefit for headspace injection.
- Thus, producing better volatility of the compounds.
- The only issue would be with the high boilers and/or compounds with polar groups which need derivation.
- May be even better if magnets could be on the line from the injection port to maintain the effect so that the compounds would not lose the polarization so soon.

Other issues would be with the high boilers and/or compounds with polar groups which need derivation.

Concerns with the injector, line, and/or column being clogged.

For some compounds, this will not be an issue because the magnetic field would be adjustable so they can go through without condensing in the column with a proper temperature and flow rate.

For others a combination of derivatives, column conditions, and properly adjusted magnetic field would be needed.

It could possibly be used for compounds that normally would not be suited for GC analysis.

For HPLC applications;

The benefit is the reduction of viscosity and surface tension of the compounds and mobile phase.

Improvement in flow rates without the concern for pressure build up.

Or increased temperature risking compound decomposition.

It can possibly help increase column life by altering impurities that normally be trapped in the column especially with highly retained compounds.

As shown from the results of the petrol and diesel fuel tests, a strong applied field can break up clusters and increase flow rate.

It can possibly help in removing/reducing any impurities that would be retained or trapped in the column.

Make it easier to wash out the column reducing need for buffer solvents.

- It would a benefit having a magnetic coil on the column itself.
- Because a magnetic field being where the separations occur can further help with retentions times, column flow, selectivity, Etc.
- A specialized column using a magnetic field instead with an inert gel stationary phase might be useful.
- For two reasons, one is the magnetic field can be adjust in strength and possibly direction to ensure separations.
- The other is the coil that produces the magnetic field can also act as a heating element which can be adjusted in compound separating.
- Another option is to have a specialized stationary phase column that is tunable with a magnetic field eliminating/reducing the need for chemical solvents.

- Producing the required magnetic field for these applications would be a strong ferrite or neodymium magnet.
- Increasing the field strength more magnets would be just added on.
- An alternative would be an electromagnet that is adjustable to vary the field strength.
- A better idea would an NMR magnet which provides the best in high field strength
- Could be used in tandem with any other detector used if it be for GC, HPLC, ICP, Etc

CONCLUSION

In conclusion, Magnetic chemistry has a great potential in using the magnetic field to altering properties and conditions of compounds. Thus, making better to react with compounds by inducing reaction similar to using an electric current used in electrochemistry. By going over the principles of Faradays induction law, paramagnetism/diamagnetism, intermolecular forces, quantum mechanics with spin orbit coupling, and the Zeeman effect to explain how this can be done shows how this can be useful in practical applications. As shown from the results of petrol and diesel fuel experiments as an example of how this can be done has shown practical applications in the areas of spectroscopy. As was