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FACULTY OF ENGNEERING & TECHNOLOGY

Electronic Spin Resonance or Electron Paramagnetic Resonance

Content Outline

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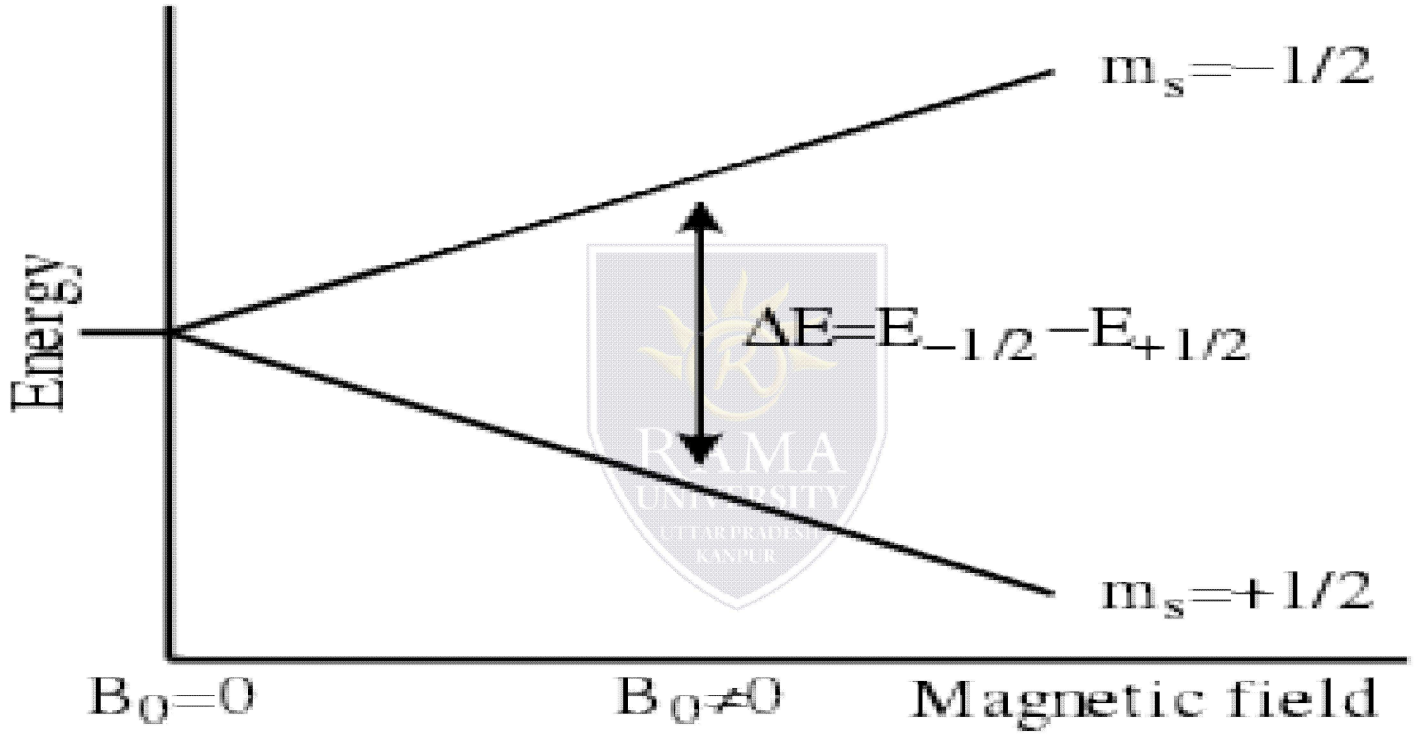
TOPIC

Electron spin resonance (ESR) is a spectroscopic technique that uses the spin magnetic moment of the electron as a probe of its local environment. ESR is used to observe and measure the absorption of microwave energy by unpaired electrons in a magnetic field.

Principle

Electron spin resonance (ESR) is a technique that can directly detect and quantify unpaired or odd electrons in atomic or molecular systems. The materials that contain unpaired electrons are known as paramagnetic materials since they exhibit a net magnetic moment in an external magnetic field.

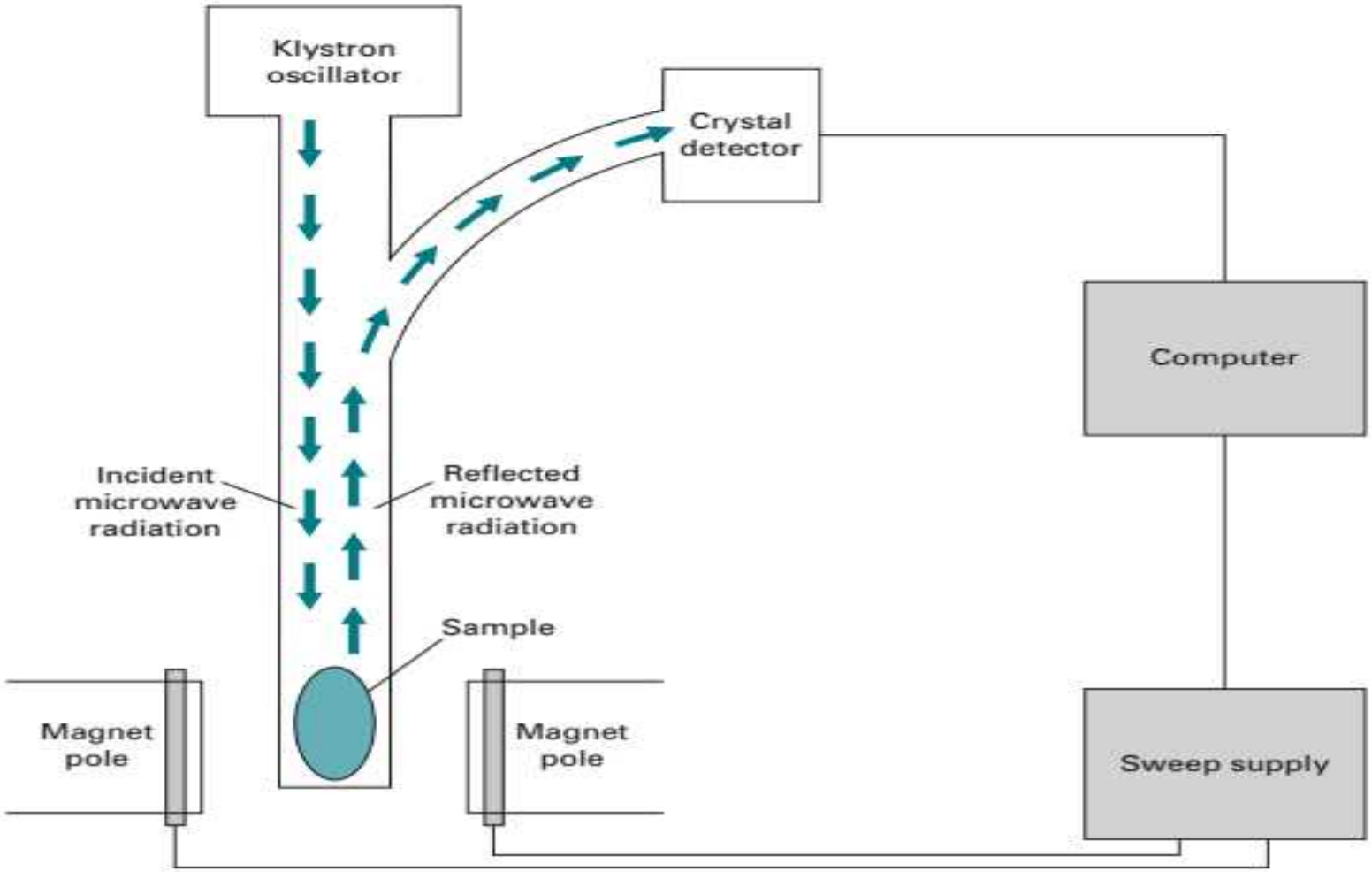

Energy
$m_s = -1/2$
$\Delta E = E_{-1/2} - E_{+1/2}$
$m_s = +1/2$
$B_0 = 0$
$B_0 \neq 0$
Magnetic field

Instrumentation

The magnetic fields generated by the electromagnets are of the order of 50 to 500 mT, and variations of less than 106 are required for highest accuracy. The monochromatic microwave radiation is produced in a klystron oscillator with wavelengths around 3 cm (9 GHz).

The samples are required to be in the solid state; hence biological samples are usually frozen in liquid nitrogen. The technique is also ideal for investigation of membranes and membrane proteins.

Instead of plotting the absorption A versus B, it is the first-order differential (dA/dB) that is usually plotted against B. Such a shape is called a ‘line’ in EPR spectroscopy. Generally, there are relatively few unpaired electrons in a molecule, resulting in fewer than 10 lines, which are not closely spaced.



Schematic of EPR

Applications

Metalloproteins

•EPR spectroscopy is one of the main methods to study metalloproteins, particularly those containing molybdenum (xanthine oxidase), copper (cytochrome oxidase, copper blue enzymes) and iron (cytochrome, ferredoxin). Both copper and non-haem iron posseses EPR absorption peaks in one of their oxidized states. The appearance and disappearance of their EPR signals are used to monitor the activity of these proteins in the multi-enzyme systems of intact mitochondria and chloroplasts, as well as in isolated enzymes.

Free_radicals

Molecules in their triplet states have unpaired electrons and thus are amenable to EPR spectroscopy. Carcinogenesis is an area where free radicals have been implicated. EPR has been used to study implanted tumours in mice, but also in evaluation of potential chemical carcinogens.

Test your understanding

Electron spin resonance spectroscopy uses

a. spin magnetic moment of the electron as a probe
b. spin magnetic moment of the nuclei as a probe
c. π electron delocalisation
d. None of the above

Electron spin resonance spectroscopy measures

a. the absorption of Infrared energy by unpaired electrons in a electric field
b. the absorption of UV energy by unpaired electrons in a electric field
c. the absorption of microwave energy by unpaired electrons in a magnetic field
d. the absorption of radiofrequency energy by unpaired electrons in a electric field

The materials that contain unpaired electrons are known as

a. Paramagnetic material
b. Diamagnetic material
c. Piezoelectric material
d. Hysteresis loop

Electron Spin Resonance is the best method to study

a. Metalloprotein
b. Antibody
c. Glucose concentration
d. Glucoamylase

References & Further reading

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3. Biochemical Methods of Analysis, Saroj Dua And Neera Garg : Narosa Publishing House, New Delhi.
4. Bioanalytical Techniques, M.L. Srivastava, Narosa Publishing House, New Delhi.