Manonmaniam Sundaranar University,

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Tirunelveli - 627 012 Tamilnadu, India

OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

B.Sc. Mathematics

Course Material

Allied Physics - II

JEPH21

Prepared

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Tirunelveli - 12

ALLIED PHYSICS–II
JEPH21

UNIT	DETAILS
I	**OPTICS:** interference – Interference inthin films –Colorsof thin films – Air wedge – Determination of diameter of a thin wire by air wedge – Diffraction – Normal incidence – Experimental determination of wavelength using diffraction grating (no theory) – Polarization – Optical activity – Application in sugar industries
II	**ATOMICPHYSICS:** Atom models –Bohr atommodel–Mass number – Atomic number – Nucleons –Pauli's exclusion principle – electronic configuration – Periodic classification of elements –Zeeman effect (elementaryideasonly)–Photoelectriceffect–Einstein'sphotoelectricequation–Applicationsofphotoelectriceffect:
III	**NUCLEAR PHYSICS:**Nuclear models – Liquid drop model – Magic numbers –Nuclear energy – Mass defect – Binding energy –Radioactivity–Uses–Chainreaction-Controlledanduncontrolledchain reaction – Nuclear fission – Energy released in fission —Nuclear fusion – Differences between fissionand fusion.
IV	**INTRODUCTIONTORELATIVITYANDGRAVITATIONALWAVES**:Frame of reference – Postulates of special theory of relativity - Lorentz transformation equations – Derivation – Length contraction – Time dilation – Mass-energy equivalence.
V	**SEMICONDUCTOR PHYSICS:** p-n junction diode – Forward and reverse biasing – Characteristic of diode – Zener diode – characteristic of zener diode – Voltage regulator construction and working – Advantages (nomathematicaltreatment)–USBcellphonecharger–Introductiontoe-vehiclesandEVchargingstations.
Recommended Text	
1	R.Murugesan(2005),Allied Physics, S.Chand andCo, NewDelhi.
2	K.ThangarajandD.Jayaraman(2004),AlliedPhysics,Popular Book Depot, Chennai.
3	BrijlalandN.Subramanyam(2002),TextbookofOptics, S.Chand and Co, NewDelhi.
4	R.Murugesan(2005),ModernPhysics,S.ChandandCo,New Delhi.
5	A.Subramaniyam Applied Electronics, 2ndEdn., National Publishing Co.,Chennai.

UNIT –I
OPTICS

Interference

Interference is the phenomenon in which two monochromatic waves superpose to form the resultant wave. The amplitude of the resultant wave may be lower, higher or same as that of the incident wave.

There are two major types

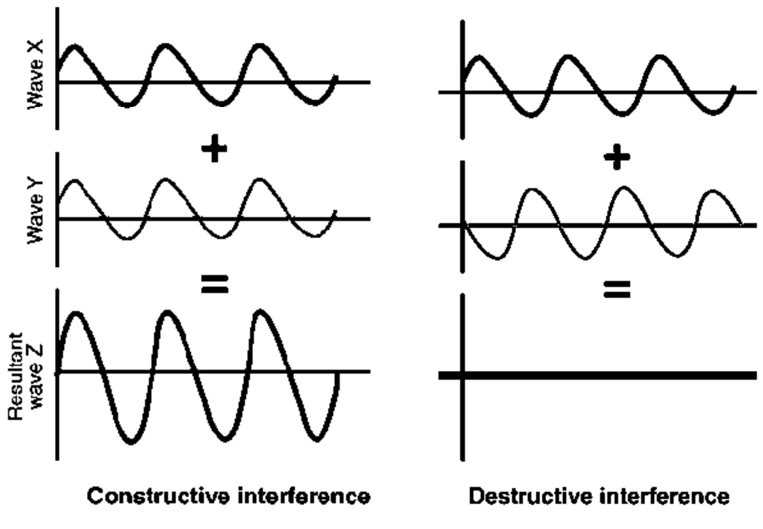
- Constructive interference
- Destructive interference

Constructive interference

Constructive interference occurs when two or more waves meet and their amplitudes align in a way that they reinforce each other, resulting in a wave with a larger amplitude than any of the individual waves. This alignment happens when the peaks of one wave coincide with the peaks of another wave, or when the peaks of one wave coincide with the troughs of another wave.

Destructive interference

Destructive interference occurs when two or more waves meet and their amplitudes align in a way that they partially or completely cancel each other out, resulting in a wave with a smaller amplitude than any of the individual waves. This cancellation happens when the peak of one wave coincides with the trough of another wave, or when the peak of one wave coincides with the midpoint (zero displacement) of another wave.



Interference in thin films

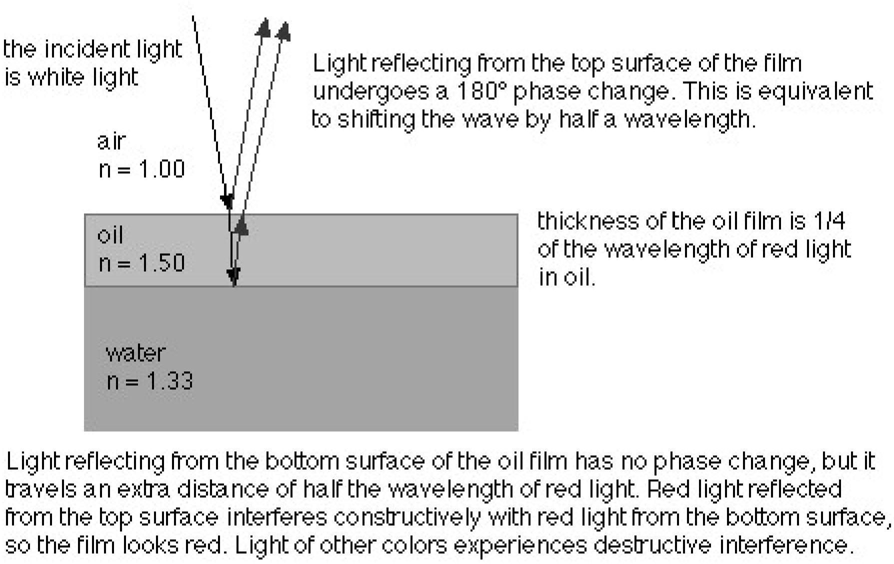
Constructive and destructive interference of light waves is also the reason why thin films, such as soap bubbles, show colorful patterns. This is known as thin-film interference, because it is the interference of light waves reflecting off the top surface of a film with the waves reflecting from the bottom surface. To obtain a nice colored pattern, the thickness of the film has to be on the order of the wavelength of light.

Consider the case of a thin film of oil floating on water. Thin-film interference can take place if these two light waves interfere constructively:

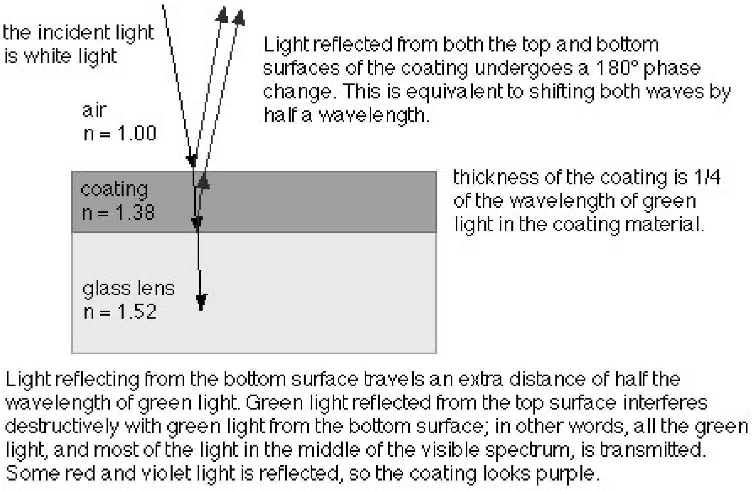
- the light from the air reflecting off the top surface
- the light traveling from the air, through the oil, reflecting off the bottom surface, traveling back through the oil and out into the air again.

An important consideration in determining whether these waves interfere constructively or destructively is the fact that whenever light reflects off a surface of higher index of refraction, a 180° phase shift in the wave is introduced.

To get constructive interference, the two reflected waves have to be shifted by an integer multiple of wavelengths. This must account for any phase shift introduced by a reflection off a higher-n material, as well as for the extra distance traveled by the wave traveling down and back through the film. With the oil film example, constructive interference will occur if the film thickness is 1/4 wavelength, 3/4 wavelength, 5/4, etc. Destructive interference occurs when the thickness of the oil film is 1/2 wavelength, 1 wavelength, 3/2 wavelength, etc.

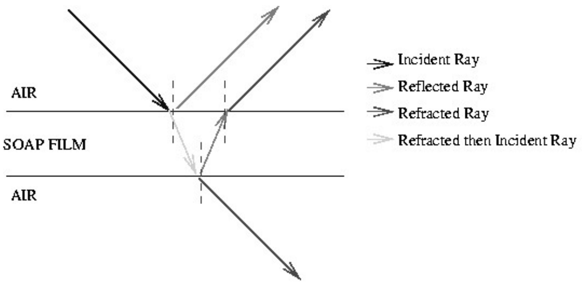


The cancellation (destructive interference) of reflected light waves is utilized to make non-reflective coatings. Such coatings are commonly found on some camera lenses or binocular lenses, and often have a bluish tint. The coating is put over glass, and the coating material generally has an index of refraction less than that of glass. In that case, then, both reflected waves have a 180° phase shift, and a film thickness of 1/4 wavelength (in the film) would produce a net shift of 1/2 wavelength, resulting in cancellation.



Colors of thin films

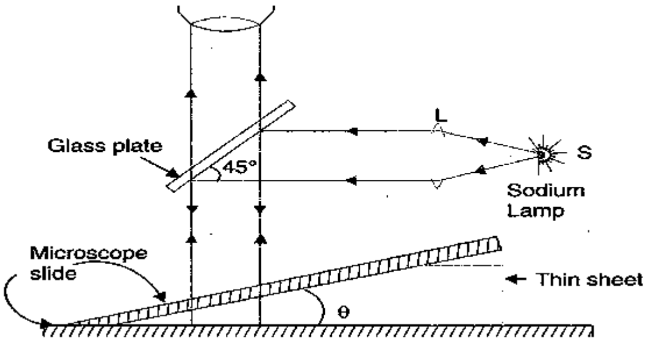
Everyone is familiar with the brilliant colours exhibited by a thin oil film spread on the surface of water and also by a soap bubble. These colours are due to interference between light waves reflected from the top and the bottom surfaces of thin films. When white light is incident on a thin film, the film appears coloured and the colour depends upon the thickness of the film and also the angle of incidence of the light.

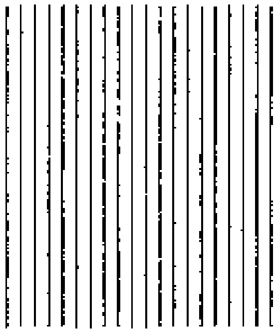


Air wedge

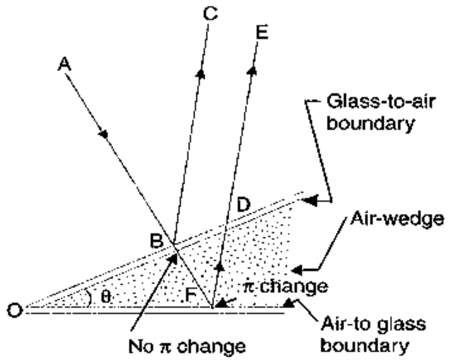
A thin film having zero thickness at one end and progressively increasing to a particular thickness at the other end is called a wedge.

A thin wedge of air film can be formed by two glasses slides on each other at one edge and separated by a thin spacer at the opposite edge.





The arrangement for observing interference of light in a wedge-shaped film. the wedge angle is usually very small and of the order of a degree. When a parallel beam of monochromatic light illuminates the wedge from above. The rays reflected from the two bounding surfaces of the film are not parallel they appear to diverge from a point near the film. these raysinterfere constructively or destructively producing alternate bright and dark fringes.



When the light is incident on the wedge from above, it gets partly reflected from the glassto-air boundary at the top of the air film. The other Part of the light is transmitted through the air film and gets reflected at the air-toglass boundary.

The two rays BC and DE reflected from the top and the bottom of the air film has a varying path difference along the length of the film due to variation of the film thickness. Because ray DE travels more distance than BC.

Also ray DE undergoes a phase change of half wave length occurs at the air to glass boundary due to reflection.

The optical phase difference between the two rays BC and DE is given by:

$$\Delta = 2nt + \frac{\lambda}{2}$$

Minima occurs when the phase difference is an odd multiple of $\frac{\lambda}{2}$, the two waves arriving are 180^0 out of phase and give rise to destructive interference. Therefore, the condition for dark fringes, or destructive interference is:

$$\Delta = \left(m + \frac{1}{2}\right)\lambda$$

$$2nt = m\lambda$$

Because the film produced from air n=1

$$2t = m\lambda$$

Determination of diameter of a thin wire by air wedge
Aim

To determine the thickness of a wire using air wedge.

Apparatus required

Travelling microscope, optically plane glass plates, A thin wire, Sodium vapour lamp, Reading lens, Scale.

Formula

Thickness of the given wire,

$$t = \frac{L\lambda}{2\beta}\ (m)$$

Where;

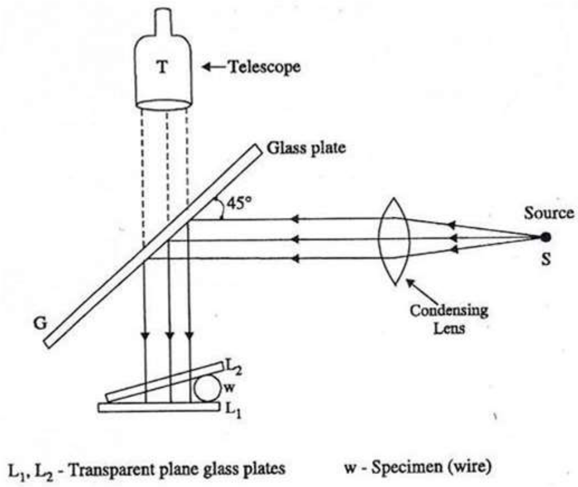
t - thickness of the given wire in m

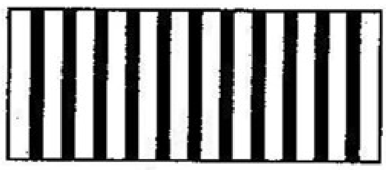
L - distance between the tied end and the thin wire in m

λ - wavelength of sodium vapor light in m

β - fringe width in m

Experimental setup





Observation

Length of the air wedge	L =		$\times 10^{-2}$m
Wavelength of the sodium light	λ =	5893	$\times 10^{-10}$ m
Band width	β =		$\times 10^{-2}$m

Table

To determine the fringe width (β)

LC = 0.001cm TR = MSR + (VSC × LC)

Order of fringes	Microscope reading			Width for 5 fringes (10^{-2} m)	Fringe width β (10^{-2} m)
	MSR (10^{-2} m)	VC (div)	TR (10^{-2} m)		

Procedure

1. Two optically plane glass plates are placed one over the other and tied at one end.
2. The given wire is introduced near the other end, so that an air wedge is formed.
3. The distance between the wire and the tied end (L) is measured using a scale.
4. Light from a sodium vapour lamp is incident on a plane glass plate inclined at 45^0C to
5. the horizontal.
6. The reflected light from the plane glass plate is incident normally on the optically
7. plane glass plates forming the air wedge and reflected back.
8. The reflected light from the air-wedge is viewed through the eye-piece of a
9. microscope. The microscope is moved up and down and adjusted for clear
10. interference fringes of alternate dark and bright.
11. The microscope is fixed so that the vertical cross-wire coincides with the dark band
12. (say nth band) and the reading is noted.
13. The microscope is moved across the fringes and readings are noted when the vertical
14. cross-wire coincides with the (n+5)th, (n+10)th….. dark bands.
15. The observed readings are tabulated and the band width ((β) is calculated.
16. The thickness of the given wire/thin-sheet is calculated using the formula.

Calculation

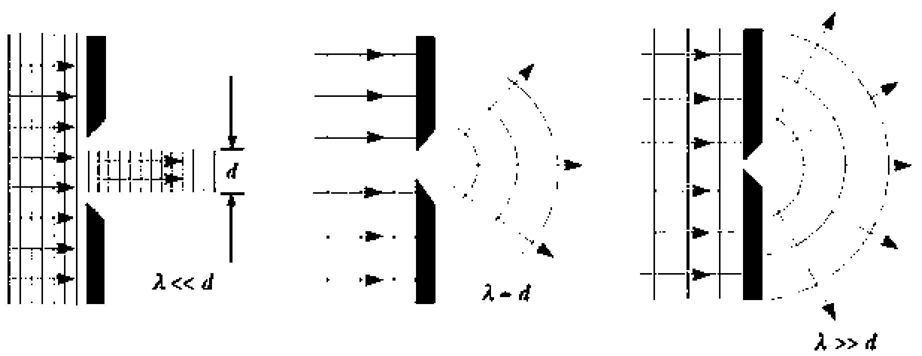
$$t = \frac{L\lambda}{2\beta}\ (m)$$

Result

The thickness of a thin wire using air wedge method **(t) =** **m**

Diffraction

The phenomenon of bending of light waves around edges of small obstacles and hence it's spreading into the geometrical shadow of the obstacle is called diffraction. The diffraction effects were first observed by Grimaldi in 1665. The effects can be observed only when the size of the obstacle is very small and comparable to the wavelength of light.



Types of diffraction

Fresnel diffraction: when the light source and the observation point are at finite distance from the obstacle, diffraction so produced, is called Fresnel diffraction. In this diffraction the incident and the diffracted wave front are spherical or cylindrical.

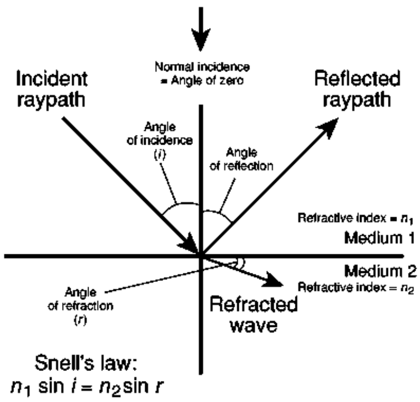
Fraunhoffer diffraction: In Fraunhofer diffraction, the light source and observation point are at infinite distance from the obstacle. that is, the incident and diffracted wavefronts are plane.

Difference between Fresnel diffraction and Fraunhoffer diffraction

Fraunhoffer diffraction	**Fresnel diffraction**
Source and screen are at infinite distances from slit.	Source and screen are at finite distances from slit.
Incident wavefront on the aperture is plane.	Incident wavefront on the aperture is either spherical or cylindrical.
The diffracted wavefront is plane.	The diffracted wavefront is either spherical or cylindrical.
Two biconvex lenses are needed to study diffraction in lab.	No lenses are needed to study diffraction in the lab.
Mathematical treatment is easy.	Mathematical treatment is complicated.
The center of the diffraction pattern isalways bright for all rays parallel to the axis of the lens.	The center of diffraction pattern may be bright or darkdepending upon the number of Fresnel's half period zoneexposed.
The maxima and minima are well defined.	The maxima and minima are not well defined.

Normal incidence

The condition in which a wave-front is parallel to an interface, such that the ray path is perpendicular (normal) to the surface. The angle of incidence is zero.



First law of reflection:

From the laws of reflection, the angle of incidence is equal to the angle of reflection. So, the angle of reflection is also 0.

Experimental determination of wavelength using diffraction grating (no theory)

Aim

To determine the wave length of mercury lines using spectrometer and grating

Apparatus required

Spectrometer, plane transmission grating, sodium vapour lamp, mercury vapour lamp, reading lens

Formula

Wavelength of lines in mercury spectrum,

$$\lambda = \frac{\sin\theta}{Nn}\ (m)$$

Where;

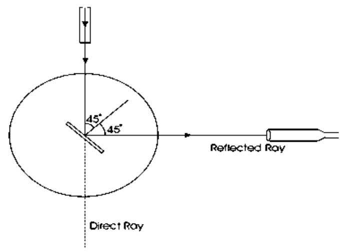
θ =angle of diffraction in degrees

N = order of diffraction (spectrum)

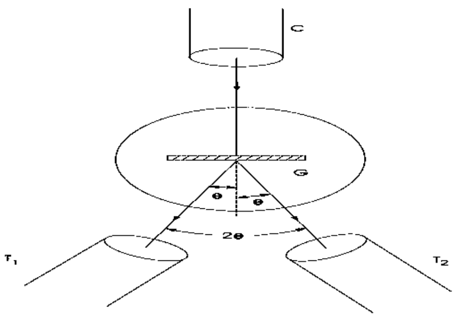
n = number of lines per meter in the grating

Experimental setup

Normal incidence



Spectral lines



Observation

Order of diffraction (n) =

Number of lines per meter in the grating (N) = lines/m

Angle of diffraction in degrees for violet line (θ) =

Table

Colour of Light	Diffracted Ray Reading (Degree)												Difference 2θ (Degree)			θ (Degree)
	Left						Right									
	Vernier A			Vernier B			Vernier A			Vernier B						
	MSR	VSC	TR	MSR	VSC	TR	MSR	VSC	TR	MSR	VSC	TR	VER A	VER B	Mean	
Blue																
Green																
Yellow																
Red																

Procedure

1. The telescope is turned towards a distant object and its focusing screw is adjusted till the image of the object is clearly seen. In this position, the telescope is capable of receiving parallel rays.
2. The slit is illuminated with sodium vapour lamp or Hg vapour lamp. The telescope is turned so that the telescope and the collimator are in a line. In this position one can see the image of the slit through the telescope. The clear image of the slit is obtained by adjusting the collimator screw. The slit must be adjusted to be narrow and vertical.
3. This is done with a spirit level. The spirit level is kept on the prism table and the three levelling screws of the prism table are adjusted till the air bubble comes to the centre.
4. After making the initial adjustments, the plane transmission grating is mounted on the grating table.
5. The telescope is released and placed in front of the collimator. The direct reading is taken after making the vertical cross-wire to coincide with the fixed edge of the image of the slit which is illuminated by a source of light.
6. The telescope is then rotated by an angle 90^0 (either left or right) and fixed.
7. The grating table is rotated until on seeing through the telescope the reflected image of the slit coincides with the vertical cross-wire. This is possible only when a light emerging out from the collimator is incident at an angle 45^0 to the normal to the grating.
8. The vernier table is now released and rotated by an angle 45^0 towards the collimator. Now light coming out from the collimator will be incident normally on the grating
9. The slit is now illuminated by white light from mercury vapour lamp.

10. The central direct image will be an undispersed image. The telescope is moved to either side of the direct image, the diffraction pattern of the spectrum of the first order and second order are seen.
11. The readings are taken by coinciding the prominent lines namely violet, green, yellow and red with the vertical cross wire. The readings are tabulated and from this, the angles of diffraction for different colours are determined. The wavelengths for different lines are calculated by using the given formula. The number of lines per metre in grating is assumed.

Calculation

Wavelength of violet $\lambda_v = \frac{\sin\theta}{Nn}\ (m)$

Result

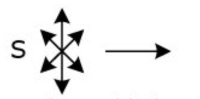
Wavelength of mercurylines using spectrometer and grating were tabulated

Spectral line colour	Wavelength $(10^{-10}m)$
Violet	
Blue	
Green	
Yellow 1	
Yellow 2	
Red	

Polarization

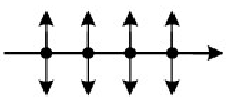
The phenomenon of restricting the vibration of a light wave to a particular direction in a plane perpendicular to the direction of propagation of light is called polarization of light.

According to Maxwell's electromagnetic theory, light waves are transverse in nature with the electric and magnetic field vectors vibrating at right angles to each other and both are perpendicular to the direction of propagation of light. Light is represented by the vibrations of electric field vector ($\vec{E}$). In an ordinary light (unpolarized light), vibrations of electric field vector are in every plane perpendicular to direction of propagation of light as shown in the diagram.

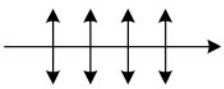


Unpolarised light source (right angles to plane of paper)

Unpolarized or ordinary light: The propagation of light is represented by electric field vectors vibrating in the vertical direction in the plane of the paper (arrows) and in the horizontal direction perpendicular to plane of paper (dots).


Unpolarised light

Plane Polarized light: The propagation of polarized light is represented by electric field vectors vibrating


Plane polarised light (vibrations parallel to plane of paper)


Plane polarised light (vibrations perpendicular to plane of paper)

in the vertical direction in the plane of the paper (arrows) or by electric field vectors vibrating in the horizontal direction perpendicular to plane of paper (dots). Here the vibrations are restricted to only one plane.

Optical activity

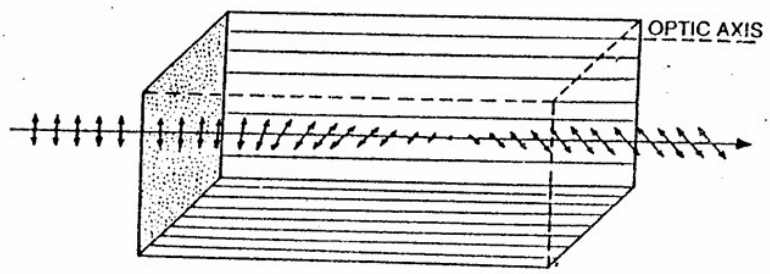
When a polarizer and an analyser are crossed, no light emerges out of the analyser. when a quartz plate cut with its faces parallel to the optic axis is introduced between N_1 and N_2 such that light falls normally upon the quartz plate, the light emerges out of N_2

The quartz plate turns the plane of vibration. The plane polarized light enters the quartz plate and its plane of vibration is gradually rotated as shown.

The amount of rotation through which the plane of vibration is turneddepends upon the thickness of the quartz plate and the wavelength of light.The action of turning the plane of vibration occurs inside the body of theplate and not on its surface. This phenomenon or the property of rotatingthe plane of vibration by certain crystals or substances is known as optical activity and the substance is known as an optically active substance

Application in sugar industries

It has been found that calcite does not produce any change in the plane of vibration of the plane polarised right. Therefore, it is not optically active.



substance like sugar crystals, sugar solution, turpentine, sodium chloride and cinnabar are optically active. Some of the substances rotate the plane of the vibration to the right and they are called dextro-rotatory or right-handed. Right-handed rotation means that when the observer is looking towards the lighttravelling towards him, the plane of vibration is rotated in a clockwise direction. The substances that rotate the plane of vibration to the left (anti-clockwise from the point of view of the observer) are known as laevo-rotatory or left-handed.

It has been found that some quartz crystals are dextro-rotatory while others are laevo-rotatory. one is the mirror image of the other in their orientation. The rotation of the plane of vibration in a solution depends upon the concentration of the optically active substance in the solution. This helps in finding the amount of cane sugar present in a sample of sugar solution

UNIT – II
ATOMICPHYSICS

Atom models

Thomson model of atom

J. J. Thomson, in 1898, proposed that an atom possesses a spherical shape (radius approximately 10–10 m) in which the positive charge is uniformly distributed. The electrons are embedded into it in such a manner as to give the most stable electrostatic arrangement (Fig. 2.4). Many different names are given to this model, for example, plum pudding, raisin pudding or watermelon. This modelcan be visualised as a pudding or watermelon of positive charge with plums or seeds (electrons) embedded into it. An important feature of this model is that the mass of the atom is assumed to be uniformly distributed over the atom. Although this model was able to explain the overall neutrality of the atom, but was not consistent with the results of later experiments.

Rutherford's nuclear model of atom

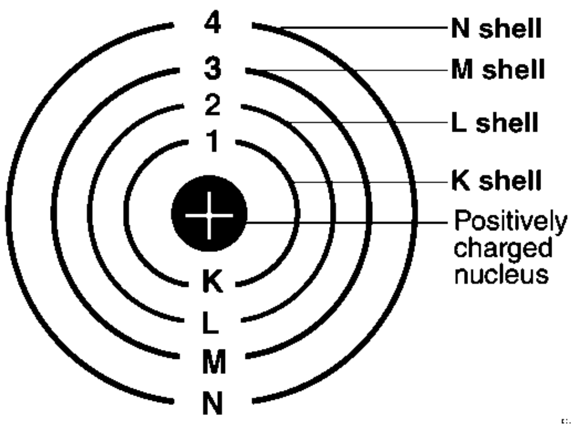
Rutherford and his students (Hans Geiger and Ernest Marsden) bombarded very thin gold foil with α–particles. Rutherford's famous –particle scattering experiment is represented in Fig. 2.5. A stream of high energy α–particles from a radioactive source were directed at a thin foil (thickness ~ 100 nm) of gold metal. The thin gold foil had a circular fluorescent zinc sulphide screen around it. Whenever α–particles struck the screen, a tiny flash of light was produced at that point

The observation concludes:

- The positive charge and most of the mass of the atom was densely concentrated in extremely small region. This very small portion of the atom was called nucleus by Rutherford.
- The nucleus is surrounded by electrons that move around the nucleus with a very high speed in circular paths called orbits. Thus, Rutherford's model of atom resembles the solar system in which the nucleus plays the role of sun and the electrons that of revolving planets.
- Electrons and the nucleus are held together by electrostatic forces of attraction.

Bohr atom model

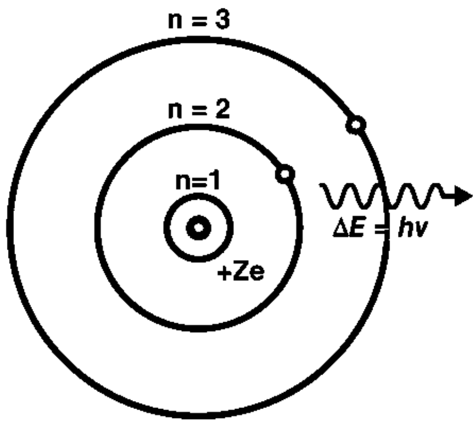
The Bohr model of the atom was proposed by Neil Bohr in 1915. It came into existence with the modification of Rutherford's model of an atom. Rutherford's model introduced the nuclear model of an atom, in which he explained that a nucleus (positively charged) is surrounded by negatively charged electrons.



Bohr theory modified the atomic structure model by explaining that electrons move in fixed orbitals (shells) and not anywhere in between and he also explained that each orbit (shell) has a fixed energy. Rutherford explained the nucleus of an atom and Bohr modified that model into electrons and their energy levels.

Bohr's model consists of a small nucleus (positively charged) surrounded by negative electrons moving around the nucleus in orbits. Bohr found that an electron located away from the nucleus has more energy, and the electron which is closer to nucleus has less energy

Postulates of Bohr's Model of an Atom



- In an atom, electrons (negatively charged) revolve around the positively charged nucleus in a definite circular path called orbits or shells.
- Each orbit or shell has a fixed energy and these circular orbits are known as orbital shells.
- The energy levels are represented by an integer (n=1, 2, 3…) known as the quantum number. This range of quantum number starts from nucleus side with n=1 having the lowest energy level. The orbits n=1, 2, 3, 4… are assigned as K, L, M, N…. shells and when an electron attains the lowest energy level, it is said to be in the ground state.
- The electrons in an atom move from a lower energy level to a higher energy level by gaining the required energy and an electron moves from a higher energy level to lower energy level by losing energy.

Mass number

The positive charge of the nucleus is due to protons, the mass of the nucleus, due to protons and neutrons. Protons and neutrons present in the nucleus are collectively known as nucleons.The total number of nucleons is termed as mass number (a) of the atom.

Mass number (a) = number of protons (Z) + number of neutrons (n)

Atomic number

The presence of positive charge on the nucleus is due to the protons in the nucleus. As established earlier, the charge on the proton is equal but opposite to that of electron. The number of protons present in the nucleus is equal to atomic number (Z).

Atomic number (Z) = number of protons in the nucleus of an atom

(or)

Atomic number (Z) =number of electrons in a nuetral atom

For example: The number of protons in the hydrogen nucleus is 1, in sodium atom it is 11, therefore their atomic numbers are 1 and 11 respectively. In order to keep the electrical neutrality, the number of electrons in an atom is equal to the number of protons (atomic number, Z). For example, number of electrons in hydrogen atom and sodium atom are 1 and

11 respectively.

Nucleons

The positive charge of the nucleus is due to protons, the mass of the nucleus, due to protons and neutrons. Protons and neutrons present in the nucleus are collectively known as nucleons.

Pauli's exclusion principle

The number of electrons to be filled in various orbitals is restricted by the exclusion principle, given by the Austrian scientist Wolfgang Pauli (1926). According to this principle:

"No two electrons in an atom can have the same set of four quantum numbers. only two electrons may exist in the same orbital and these electrons must have opposite spin."

This means that the two electrons can have the same value of three quantum numbers n, l and m_l, but must have the opposite spin quantum number. The restriction imposed by Pauli's exclusion principle on the number of electrons in an orbital helps in calculating the capacity of electrons to be present in any subshell.

For example, subshell 1s comprises one orbital and thus the maximum number of electrons present in 1s subshell can be two, in p and d subshells, the maximum number of electrons can be 6 and 10 and so on. This can be summed up as: the maximum number of electrons in the shell with principal quantum number n is equal to $2n^2$.

Electronic configuration

The distribution of electrons into orbitals of an atom is called its electronic configuration. If one keeps in mind the basic rules which govern the filling of different atomic orbitals, the electronic configurations of different atoms can be written very easily.

The electronic configuration of different atoms can be represented in two ways. For example:

- s^a,p^b,d^c notation
- Orbital diagram

In the first notation, the subshell is represented by the respective letter symbol and the number of electrons present in the subshell is depicted, as the super script, like a, b, c, ... etc. The similar subshell represented for different shells is differentiated by writing the principal quantum number before the respective subshell. In the second notation each orbital of the subshell is represented by a box and the electron is represented by an arrow (↑) a positive spin or an arrow (↓) a negative spin. The advantage of second notation over the first is that it represents all the four quantum numbers.

The hydrogen atom has only one electron which goes in the orbital with the lowest energy, namely 1s. The electronic configuration of the hydrogen atom is 1s1 meaning that it has one electron in the 1s orbital. The second electron in helium (He) can also occupy the1s orbital. Its configuration is, therefore, 1s2. As mentioned above, the two electrons differ from each other with opposite spin, as can be seen from the orbital diagram

Periodic classification of elements

Dobereiner's Triads

- 30 elements had been discovered by 1829.
- Dobereiner, a German scientist, divided some of these elements into a group of 3 and named them as Triads. • Elements in his triads have similar chemical properties.
- The atomic mass of the middle element of the triad was roughly the average of the atomic masses of the other two elements.

Newland's Law of Octaves

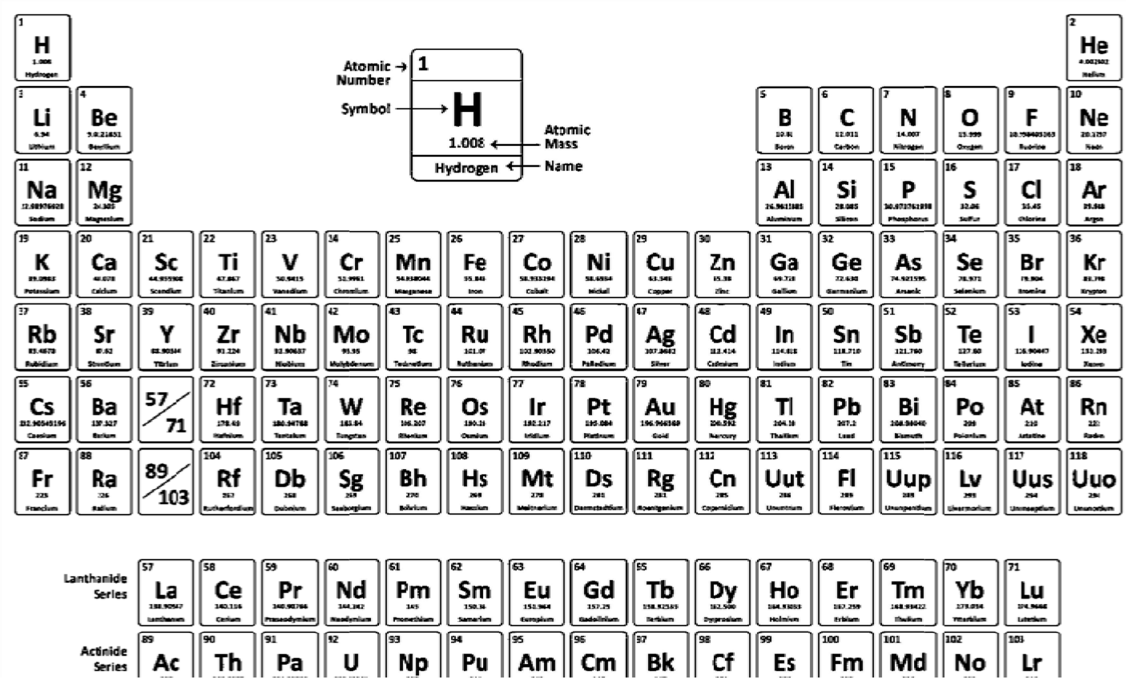
- By 1866, 56 elements had been discovered.
- Newland, an English scientist, arranged the then known elements in the order of increasing atomic masses and found that the property of every 8th element repeats. (i.e. property of 8th element = property of 1st element; property of 9th element = property of 2nd element and so on)
- He compared this to the octaves found in music (sa, re, ga, ma….) and called it the 'Law of Octaves'. For example, the properties of lithium (Li) and sodium (Na) were found to be the same.

Mendeleev's Periodic Table

- Dmitry Mendeleev, a Russian chemist, in 1869 gave Mendeleev's Periodic Table.
- 63 elements were discovered by then.
- Mendeleev arranged elements in the increasing order of their atomic mass and found that element with similar properties occur at regular intervals.
- He tried to put elements with similar properties in a group. Due to this, certain empty boxes are found in his periodic table.
- According to Mendeleev "the properties of the elements are a periodic function of their atomic masses."The horizontal rows present in the periodic table are called periods.
- The vertical columns present in it are called groups. There were total eight groups in Mendeleev's periodic table, I to VIII.
- Properties of elements in a particular period show regular gradation (i.e. increase or decrease) from left to right.
- Groups I to VII are subdivided into A and B subgroups. Groups VIII don't have any subgroups.
- All the elements in a particular group have similar properties. They show regular gradation in their physical properties and chemical reactivities.

Modern Periodic Table

In 1913, Moseley showed or proved that atomic number is a very important property of an element. After that, Neil Bohr made the Modern Periodic Table using atomic number.



Characteristics of Modern Periodic Table:

- In periodic table, elements have been arranged by increasing atomic number.
- Horizontal rows on the periodic chart are called periods.
- There are seven rows in the periodic table. Each row is called a period. The periods have been numbered from 1 to 7.
- The 1st period is the shortest period of all and contains only 2 elements, H and He.
- The 2nd and 3rd periods are called short periods and contain 8 elements each.
- 4th and 5th periods are long periods and contain 18 elements each.
- 6th period is very long period containing 32 elements.
- Vertical columns are called groups. There are 18 groups in the periodic table.
- Group 1 on extreme left position contains alkali metals (Li, Na, K, Rb, Cs and Fr).
- Group 18 on extreme right-side position contains noble gases (He, Ne, Ar, Kr, Xe and Rn).
- In the middle of periodic table, we have semi-metals or metalloid because they exhibit some properties of metals and non-metals.

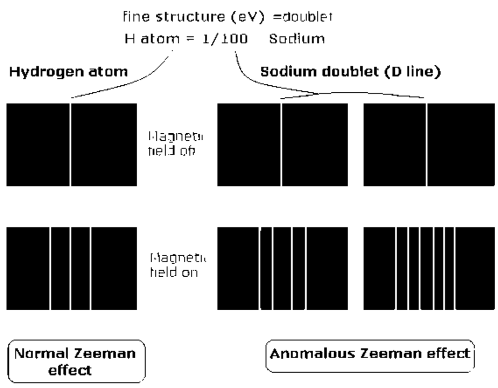
Zeeman effect (elementary ideas only)

Zeeman effect is a magneto-optical phenomenon discovered by Zeeman in 1896. If a source of light producing line spectrum is placed in a magnetic field, the spectral lines are split into components. This phenomenon is called Zeeman effect. They are of two kinds,

- Normal Zeeman effect and
- Anomalous Zeeman effect.

Normal Zeeman effect:

The splitting of a spectral line into two or three components in a magnetic field is called the



Normal Zeeman effect.

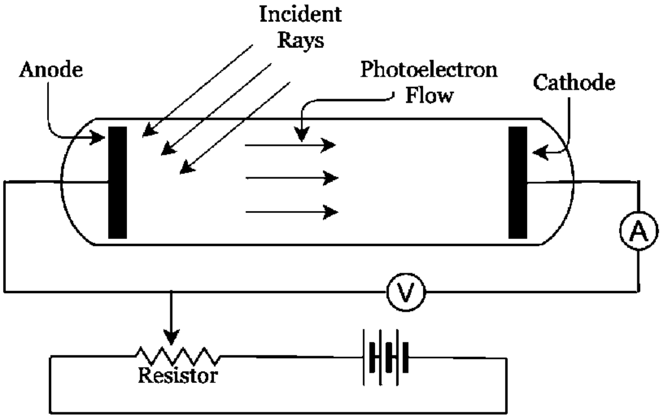
Anomalous Zeeman effect:

The splitting of a spectral line into more than three components in ordinary weak magnetic field is called Anomalous Zeeman effect.

Photo electric effect

The phenomenon of ejection of electron from a metal surface while, light rays hitting the metal surface is called photoelectric effect.

For example: Electrons (or electric current) were ejected when certain metals (for example potassium, rubidium, caesium etc.) were exposed to a beam of light as shown. The phenomenon is called Photoelectric effect



Einstein's photo electric equation

Einstein (1905) was able to explain the photoelectric effect using Planck's quantum theory of electromagnetic radiation as a starting point.

Shining a beam of light on to a metal surface can, therefore, be viewed as shooting a beam of particles, the photons. When a photon of sufficient energy strikes an electron in the atom of the metal, it transfers its energy instantaneously to the electron during the collision and the electron is ejected without any time lag or delay. Greater the energy possessed by the photon, greater will be transfer of energy to the electron and greater the kinetic energy of the ejected electron. In other words, kinetic energy of the ejected electron is proportional to the frequency of the electromagnetic radiation. Since the striking photon has energy equal to hν andthe minimum energy required to eject the electron is $h\nu_0$ (also called work function, W_0), then the difference in energy ($h\nu - h\nu_0$) is transferred as the kinetic energy of the photoelectron. Following the conservation of energy principle, the kinetic energy of the ejected electron is given by the equation.

$$h\nu = h\nu_0 + \frac{1}{2} m_e V^2$$

Where;

m_e = Mass of the electron

V = Velocity associated with the ejected electron

$h\nu$ = Photon

Applications of photo electric effect:

1. Used to generate electricity in Solar Panels. These panels contain metal combinations that allow electricity generation from a wide range of wavelengths.
2. Motion and Position Sensors: In this case, a photoelectric material is placed in front of a UV or IR LED. When an object is placed in between the Light-emitting diode (LED) and sensor, light is cut off and the electronic circuit registers a change in potential difference
3. Lighting sensors such as the ones used in smartphones enable automatic adjustment of screen brightness according to the lighting. This is because the amount of current generated via the photoelectric effect is dependent on the intensity of light hitting the sensor.
4. Digital cameras can detect and record light because they have photoelectric sensors that respond to different colours of light.
5. X-Ray Photoelectron Spectroscopy (XPS): This technique uses xrays to irradiate a surface andmeasure the kinetic energies of the emitted electrons. Important aspects of the chemistry of a surface can be obtained such as elemental composition, chemical composition,
6. the empirical formula of compounds and chemical state.
7. Photoelectric cells are used in burglar alarms.
8. Used in photomultipliers to detect low levels of light.
9. Used in video camera tubes in the early days of television.
10. Night vision devices are based on this effect.
11. The photoelectric effect also contributes to the study of certain nuclear processes. It takes part in the chemical analysis of materials since emitted electrons tend to carry specific energy that is characteristic of the atomic source.

UNIT –III

NUCLEAR PHYSICS

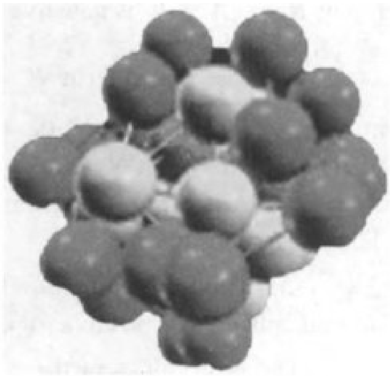
Nuclear models

The precise nature of the forces acting in the nucleus is unknown. Hence, nuclear models are

resorted to for investigation and theoretical prediction of its properties. Such models may be based on

- The extrinsic analogy between the properties of atomic nuclei and those of a liquid drop
- Theelectron shell of an atom etc.

Liquid drop model



In the liquid-drop model, the forces acting in the nucleus areassumed to be analogical to the molecular forces in a droplet ofsome liquid. This model was proposed by Neils Bohr who observedthat there are certain marked similarities between an atomic nucleusand a liquid drop. The similarities between the nucleus and a liquiddrop are the following:

- The nucleus is supposed to be spherical in shape in thestable state, just as a liquid drop is spherical due to the symmetricalsurface tension forces.
- The force of surface tension acts on the surface of the liquid drop. Similarly, there is a potential barrier at the surface of the nucleus.
- The density of a liquid-drop is independent of its volume. Similarly, the density of the
- nucleus is independent of its volume.
- The intermolecular forces in a liquid are short range forces. The molecules in a liquid
- drop interact only with their immediate neighbors. Similarly, the nuclear forces are short rangeforces. Nucleons in the nucleus also interact only with their immediate neighbours. This leads to thesaturation in the nuclear forces and a constant binding energy per nucleon.
- The molecules evaporate from a liquid drop on raising the temperature of the liquid due to
- their increased energy of thermal agitation. Similarly, when energy is given to a nucleus by bombarding it with nuclear projectiles, a compound nucleus is formed which emits nuclear radiations almostimmediately.
- When a small drop of liquid is allowed to oscillate, it breaks up into two smaller drops of
- equal size. The process of nuclear fission is similar and the nucleus breaks up into two smaller nuclei.Semi-empirical mass formula. The liquid-drop model can be used to obtain an expression for the binding energy of the nucleus. Weizacker proposed the semi-empirical nuclear binding energyformula for a nucleus of mass number A, containing Z protons and N neutrons.

Magic numbers

It is known that a nucleus is stable if it has a certain definite number of either protons or neutrons. These numbers are known as magic numbers. Magic numbers are 2, 8, 20, 50, 82 and 126. Thus, nuclei containing 2, 8, 20, 50, 82 and 126 nuclei of the same kind form some sort of closed nuclear shell structures.

Nuclear energy

Nuclear energy is a powerful source of electricity generated through either nuclear fission or fusion reactions. In nuclear fission, atoms split, releasing significant amounts of energy, while fusion involves combining atomic nuclei. It's a low-carbon energy source, but concerns about safety, radioactive waste, and nuclear proliferation persist. Despite challenges, nuclear power remains a crucial component of the global energy mix, offering reliable electricity generation with relatively low environmental impact.

Mass defect

"Mass defect" ofa given isotope is defined as the difference between the experimentally measured mass of the isotope (M) and its mass number (A).

$$\boldsymbol{Mass\ defect\ \Delta = M - A}$$

Binding energy

When Z protons and N neutrons combine to make a nucleus, some of the mass(Δm) disappears because it is converted into an amount of energy ΔE = (Δm) c^2. This is called thebinding energy (B.E.) of the nucleus.

$$\mathbf{B.E} = (\boldsymbol{Zm_p} + \boldsymbol{Nm_n})\boldsymbol{c^2} - \boldsymbol{M_n c^2}$$

Where;

m_p = mass of the proton

m_n = mass of neutron

M_n = nuclear masss

Radioactivity

Introduction

Radioactivity was discovered by Henri Becquerel in 1896. He found that auranium saltwrapped up in paper emitted certain penetrating radiations whichaffected aphotographic plate. He found that these radiations were given off spontaneously without any need to any initial excitation of the uranium salt. He showedthat theradiation is not influenced by any external agency. Further investigationsby Madame Curie, Piere Curie, Rutherford etc., showed that the phenomenon wasexhibited by heavy elements like uranium, polonium, radium, thorium etc. Radioactivity involves thespontaneous transmutation of one element into another.

Definition

The phenomenon of spontaneous emission of highly penetrating radiations from heavy elements of atomic weights greater than about 206, occurring in nature, is called natural radioactivity. The elements which exhibit this property are called radioactive elements. The atoms of radioactiveelements emit radiations composed of three distinct kinds of rays (α,$\beta and\, \gamma$). In the process, theelements break up, leading to an irreversible self-disintegration. The activity is spontaneous. Radioactivity is unaffected by any external agent like high temperature, high pressure, large electric andmagnetic fields etc.

Uses

Medical use

X-rays and other forms of radiation also have a variety of therapeutic uses.

X-ray machines have also been connected to computers in machines called computerized axial tomography (CAT) or computed tomography (CT) scanners. These instruments provide doctors with color images that show the shapes and details of internal organs. This helps physicians locate and identify tumors, size anomalies, or other physiological or functional organ problems.

Scientific uses

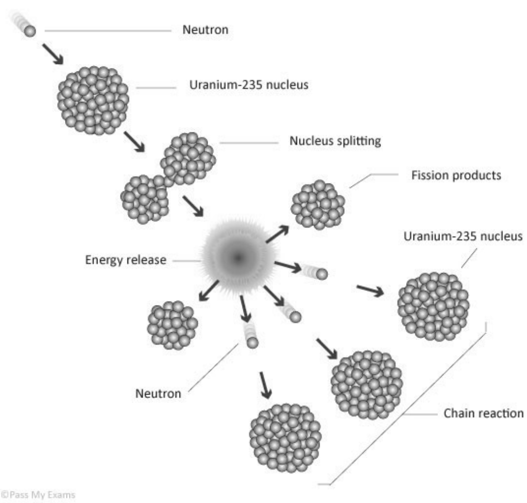
Archaeologists also use radioactive substances to determine the ages of fossils and other objects through a process called carbon dating.

Energy generation

Electricity produced by nuclear fission — splitting the atom — is one of the greatest uses of radiation. As our country becomes a nation of electricity users, we need a reliable, abundant, clean, and affordable source of electricity. We depend on it to give us light, to help us groom and feed ourselves, to keep our homes and businesses running, and to power the many machines we use. As a result, we use about one-third of our energy resources to produce electricity.

Chain reaction

A chain reaction is a self-propagating process in which number of neutrons goes on multiplying rapidly almost in geometrical progression during fission till whole of fissile material is disintegrated.



Controlled and uncontrolled chain reaction

Nuclear fission

The process of breaking up of thenucleus of a heavy atom into two, moreor less equal fragments with the releaseofa large amount of energy is known asfission.

When uranium is bombarded with neutrons, a uranium nucleus capturesa slow neutron, forming anunstable compound nucleus. The compound nucleussplits into two nearly equal parts. Some neutrons are also released in this process.

The schematic equation for the fission process is

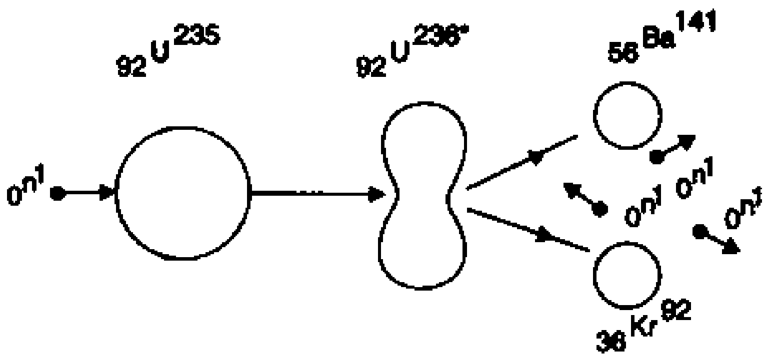
$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236*} \rightarrow X + Y + neutrons$$

$_{92}U^{236*}$ is a highly unstable isotope, and X and Y are the fission fragments. The fragment arenot uniquely determined, because there are various combinations of fragments possible and a numberof neutrons are given off. Typical fission reactions are

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236*} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q$$

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236*} \rightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_0n^1 + Q$$

According to above Eqn, when 92U235 is bombarded by a slow-moving neutron, the nucleusbecomes unstable ($_{92}U^{236*}$) and splits into $_{56}Ba^{141}$ and $_{36}Kr^{92}$releasing 3 neutrons and energy Q



Energy released in fission

We know that in the process of nuclear fission a large amount of energy is released. Thisenergy is produced because the original mass of the nucleus is greater than the sum of the masses of

the products produced after fission. The difference between these masses before and after fission isconverted into energy according to Einstein' s equation $E = mc^2$.

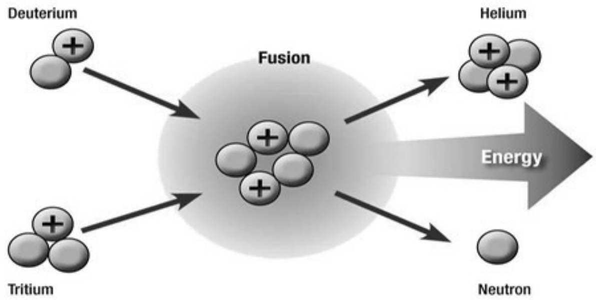
The energy released by fission of 1kg of U^{235} is 2.26 x 107 kWh. Due to this reason,nuclear energy is being used for the generation of electricity. The most striking aspect of nuclearfission is the magnitude of the energy involved. Ordinary chemical reactions, such as those that participate in the combustion of coal and oil, liberate only a few electron volts per individual reaction.Most of the energy that is released during fission goes into the K.E. of the fission fragments. The emitted neutrons, and Y -rays and neutrinos carry off perhaps 20%

of the total energy.

Nuclear fusion

Very light nuclei can combine to form heavier atoms in a process known as fusion.

When fusion happens, the products have a larger binding energy than the reactants. The mass defect results in the release of huge amounts of energy.Actually produces more energy per gram of products than fission and produces no by-products



$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n $$

Differences between fission and fusion.

Nuclear Fission	Nuclear Fusion
Fission is the splitting of a large atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one.	Fission is the splitting of a large atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one.
Fission reaction does not normally occur in nature.	Fusion occurs in stars, such as the sun.
Fission produces many highly radioactive particles.	Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that.
Critical mass of the substance and high-speed neutrons are required.	High density, high temperature environment is required.
Takes little energy to split two atoms in a fission reaction.	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.
The energy released by fission is a million	The energy released by fusion is three to

times greater than that released in chemical reactions; but lower than the energy released by nuclear fusion.	four times greater than the energy released by fission.

UNIT –IV
INTRODUCTIONTORELATIVITYANDGRAVITATIONALWAVES

Frame of reference

A system of co-ordinate axis which defines the position of aparticle in two- or three-dimensional space is called a frame of reference. The simplestframe of reference is the Cartesian system of co-ordinates, in which the position of theparticle is specified by its three co-ordinates x,y,z along the three perpendicular axes. Ingeneral, it is a framework that is used for the observation and mathematical descriptionof physical phenomena and the formulation of physical laws, usually consisting of anobserver, a coordinate system, and a clock or clocks assigning times at positions withrespect to the coordinate system

Inertial and non-inertial frames of reference

Inertia frames of reference are those reference frames in which Newton’s laws are valid. They are non-accelerating frames or constant velocity frames. Such a constant velocityframe of reference is called an inertial frame because the law of inertia holds in it. In aninertial frame of reference, no fictitious forces arise.

Example:A space shuttle moving with constant velocity relative to the earth, a rocketmoving with constant velocity relative to the earth, any reference frame that is notaccelerating, a frame attached to a particle on which there are no forces, any referenceframe that is at rest, a reference frame attached to the center of the universe, a referenceframe attached to Earth.

Non-inertial frame of reference are those reference frames in which Newton’s laws are not valid. They are accelerating frames. Such an accelerating frame of reference is called a non-inertial frame because the law of inertia does not hold in it. That is, its velocity is not constant. So, it is either changing its speed by speeding up or slowing down, or it is changing its direction by traveling in a curved path, or it is both changing its speed and changing its direction. In a non-inertial frame of reference fictitious forces arise.

Examples: Elevator, Rotating frames, any accelerating frames, etc.,…..

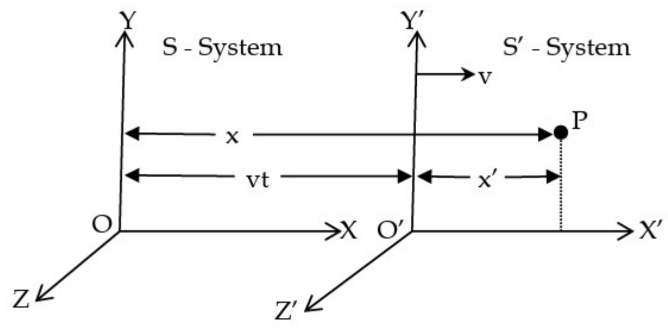
Postulates of special theory of relativity

The theory of special relativity was derived from two postulates proposed by Einstein in his 1905 paper:

Postulate 1. The laws of physics are the same in all inertial reference frames. There is no preferred or absolute inertial frame of referencei.e. all inertial frames are equivalent for the description of all physical laws such asNewton's laws as well as Maxwell's electromagnetic equations.

Postulate 2. The speed of light in a vacuum is equal to the value c, independent of the motion of the source. The speed of light is the same for all observers in uniformtranslational relative motion and is independent of the motion of the observer andthe source. Speed of light is invariant.

Lorentz transformation equations



Lorentz discovered new transformation equations which are consistent with the new concept of invariance of velocity of light in free space. Let S and S' be two inertial frames of reference. Let S be at rest and S' be moving with a uniform velocity v with respect to S along the positive X - direction. A light pulse produced at t = 0 will spread as a growing sphere. The radius of this sphere increases with speed c. After a time t, the observer will note that the light has reached a point $P(x, y, z)$ and for the observer it will reach the point $P(x', y', z')$ as shown. The transformation equation relating x and x' can be written as

Derivation

$x' = k(x - vt)$.

$t' = k(t - bx)$,

$y' = y$ and

$z' = z$ where k and b are constants.

They are given by k $= \frac{1}{\sqrt{1-\frac{v2}{C^2}}}$ and b $= \frac{v}{c^2}$

Substituting the constants in the transformation equations, we get

$$x' = \frac{(x - vt)}{\sqrt{1 - \frac{v2}{C^2}}}$$

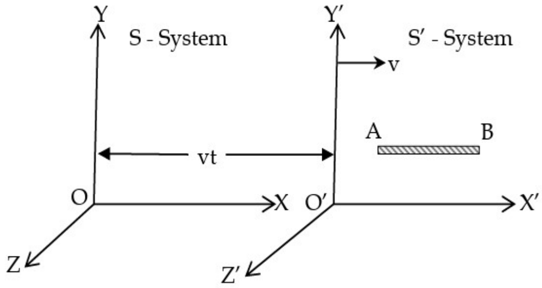
$$y' = y$$

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v2}{C^2}}}$$

These are called Lorentz transformation equations.

Length contraction

Let S and S' be two inertial frames of reference. Let S be at rest and S' be moving with a uniform velocity v with respect to S along the positive X - direction. Consider a rod AB of length L remaining at rest relative to the frame S'.



Let $x_1{}'$ and $x_2{}'$ be the coordinates (distance from the origin O') of the ends of the rod in the frame S'. As the rod is at rest relative to S', its length is called the proper length given by

$$\boldsymbol{L_0 = x_2{}' - x_1{}'}$$

Similarly the coordinates of the ends of the rod in the S frame x_1 and x_2 . Then the length of the rod as measured relative to S frame is $L = x_2 - x_1$. From the Lorentz transformation equation,

$$x_1' = \frac{(x_1 - vt)}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$x_2' = \frac{(x_2 - vt)}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$x_2' - x_1' = \frac{(x_2 - vt)}{\sqrt{1 - \frac{v2}{C^2}}} - \frac{(x_1 - vt)}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$= \frac{(x_2 - x_1)}{1 - \frac{v2}{C^2}}$$

$$L_0 = \frac{L}{1 - \frac{v2}{C^2}}$$

$$\boldsymbol{L = L_0\sqrt{1 - (v^2 / C^2)}}$$

$L < L_0$Thus, for an observer in S the length of the rod appears to be contracted or reduced by a factor of$\sqrt{1 - (v^2 / C^2)}$This shortening or contraction of length of an object along its direction of motion is known as Lorentz – Fitzgerald contraction. The contraction becomes appreciable when $v \approx$ c

Time dilation

Consider a gun placed at a point in a frame S' which is moving with uniform velocity v with respect to a frame S at rest. Let a clock in the moving frame S' measure $t1'$ and $t2'$ as the times at which two shots are fired from the gun in frame S'. As this clock is at rest with respect to the observer in frame S', the time interval between the two explosions is called the proper time interval $t0 = t2' - t1'$. Since the gun is fixed in S', it has a velocity $v$with respect to S in the positive X- direction. Let $t = t2 - t1$ represent the time interval between the two shots as measured by an observer in S. From the inverse Lorentz transformation equation, we have

$$t_1 = \frac{t_1' - \frac{vx'}{c^2}}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$t_2 = \frac{t_2' - \frac{vx'}{c^2}}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$t_2 - t_1 = \frac{t_2' - \frac{vx'}{c^2}}{\sqrt{1 - \frac{v2}{C^2}}} - \frac{t_1' - \frac{vx'}{c^2}}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$= \frac{t_2' - t_1'}{\sqrt{1 - \frac{v2}{C^2}}}$$

$$\boldsymbol{t = \frac{t_0}{\sqrt{1 - \frac{v2}{c^2}}}}$$

$t > t_0$Thus, the time interval between two events occurring at a given point in the moving frame S' appears to be longer for the observer in the stationary frame S. i.e. a stationary clock (frame S) measures a longer time interval between events occurring in a moving frame of reference than does the clock (frame S') in the moving frame. This effect is called time dilation.

Mass-energy equivalence.

Consider a body of mass m moving with velocity. Let F be the force acting on the body. From Newton's second law, force is equal to rate of change of momentum, given by

$$F = \frac{d}{dt}(mv)\ldots(1)$$

According to the special theory of relativity, both mass and velocity are variables. Therefore

$$F = m\frac{dv}{dt}v\frac{dm}{dt}\ldots(2)$$

Let the force F displace the body by a distance, dx. Then, the increase in the kinetic energy (dEk) of the body is equal to the amount of work done (Fdx) .

Hence,

$$dEk = Fdx\ldots.(3)$$

Substituting for F from (2) in (3), we get

$$\mathrm{dEk} = m\frac{dv}{dt}\mathrm{dx} + v\frac{dm}{dt}\mathrm{dx}$$

$$= m\frac{\mathrm{dx}}{dt}dv + v\frac{\mathrm{dx}}{dt}dm$$

$v = \frac{\mathrm{dx}}{dt}$the above equation becomes

$$dEk = mvdv + v^2\ \mathrm{dm}\ \ldots(4)$$

According to the law of variation of mass with velocity

$$m = \frac{m_0}{\sqrt{1-\frac{v2}{c^2}}}$$

Squaring this equation and rearranging the above eqn,

$$m^2 = \frac{m_0^2c^2}{c^2-v^2}$$

Or

$$m^2c^2 = m_0^2c^2 + m^2v^2$$

Differentiate the above equation,

$$c^2 2mdm = 0 + m^2 2vdv + v^2 2mdm$$

Dividing this equation by $2dm$, we get,

$$c^2dm = mvdv + v^2dm\ldots.(5)$$

Comparing (4) and (5), we get

$$dEk = c\ 2dm\ldots..(6)$$

Thus the change in kinetic energy is directly proportional to the change in mass, dm. When a body is at rest, its velocity is zero. Its KE is zero and the mass is m = $m0$. When the velocity of the body is v, its mass is m. Therefore integrating equation (6)

$$\int_0^{E_k} dE_k = c^2 \int_{m_0}^{m} dm$$

$$E_k = c^2(m - m_0)$$

$$E_k = (mc^2 - m_0c^2) \ldots\ldots (7)$$

This is the relativistic equation for kinetic energyof the particle.

When the body is at rest the internal energy stored in the body is $m0c$ 2 which is called the rest mass energy. Thus, the total energy (E) of the body is the sum of the K.E (Ek) and the rest mass energy (m_0c^2).

The total energy is

$$E \;= E_k + m_0c^2$$

sub eqn 7,

$$E \;= (mc^2 - m_0c^2) + m_0c^2$$

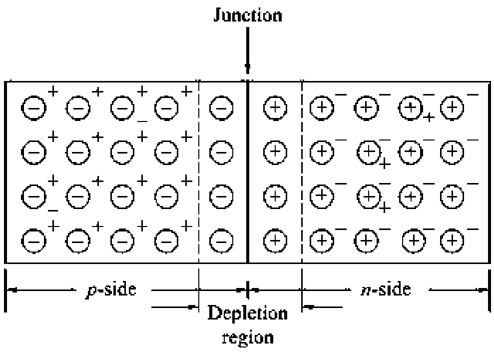
$$\boldsymbol{E \;=\; mc^2}$$

This is called the Einstein's mass energy relation. This relates the universal equivalence between mass and energy. i.e. mass and energy are interconvertible.

UNIT –V
SEMICONDUCTOR PHYSICS

p-n junction diode

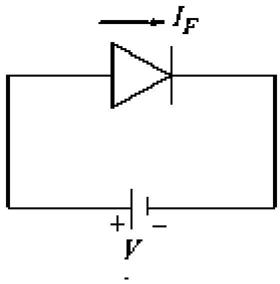
A p-n junction diode is formed by introducing n-type of impurity into one side and p-type impurity into the other side of a single crystal of a semiconductor, as shown. The concentration of charged particles on the two sides of the junction. Because of the concentration gradient across the junction, the holes from the p-side diffuse to the n-side, and the electrons from the n-side to the p-side. This process results in recombination of electrons and holes near the junction on both sides and the region near the junction becomes devoid of charge carriers. This region which is depleted of mobile charge carriers is referred to as the depletion, space charge, or transition region. At the junction, the space-charge density is zero, being negative on the p-side and positive on the n-side. This gives rise to an electric fi eld intensity and consequent electrostatic potential, which vary with the diffusion of charge carriers across the junction. This constitutes a potential energy barrier against the further diffusion of charge carriers across the junction and thermal equilibrium is established. Metallic contacts are made with the p-type and n-type semiconductors for applying a voltage across the junction



Forward and reverse biasing

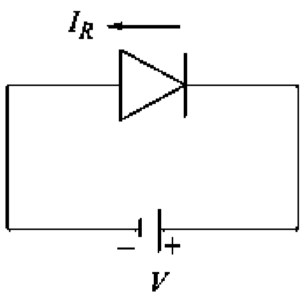
Forward bias

The positive terminal of the battery is connected to the p-side and the negative terminal to the n-side of the junction. This is referred to as the forward-biased junction. This causes both the holes in the p-side and the electrons in the n-side to move closer to the junction. Consequently, the width of the depletion region decreases, the height of the potential-energy barrier at the junction decreases and the equilibrium initially established is disturbed. Hence, the holes cross the junction from the p-side into the n-side, where they are referred to as injected minority carriers. Similarly, the electrons cross the junction in the reverse direction and are injected minority carriers in the p-side. The resulting current is I_F (p in the direction from p-side to n-side as indicated in the figure.



Reverse bias

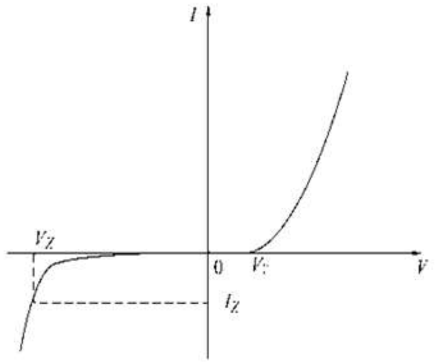
The polarity of the battery is opposite to that in Forward bias is referred to as the reverse-biased junction. This causes both, holes in the p-side and electrons in the n-side, to move away from the junction. Consequently, the depletion layer width increases which prevents the holes from the p-side to cross over to the n-side and electrons from n-side to p-side. However, the minority charge carriers, the



electrons from the p-side and the holes from the n-side, can easily cross the junction and constitute a reverse current I_R in the direction indicated in Figure. This current is very small, of the order of a few microamperes for germanium diodes and a few nanoamperes for silicon diodes, and is dependent on the temperature (approximately doubles for every 10 °C rise in temperature). The minority carriers near the junction cross over to the other side, recombine, and the concentration diminishes to zero at the junction. Far away from the junction, the minority carrier concentrations are equal to their thermal equilibrium values.

Characteristic of diode

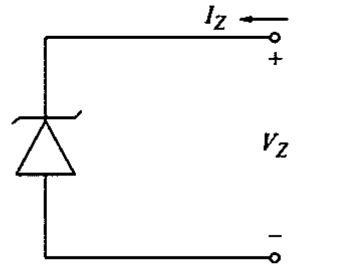
From the characteristic, we note that when the junction is forward biased, the current I_F is negligibly small up to the voltage V the cut-in, break-point or threshold voltage and beyond V_γ which is referred to as the current rises very rapidly. The value of V γ I is approximately 0.2 V and 0.6 V for germanium and silicon diodes, respectively. Thus, we see that the diode is a unidirectional device, i.e. it allows the current to fl ow in the forward direction (conducting) and does not allow the current to flow in the reverse direction (non-conducting) and hence acts as a switch.



V−I Characteristic of a Semiconductor Diode

Zener diode

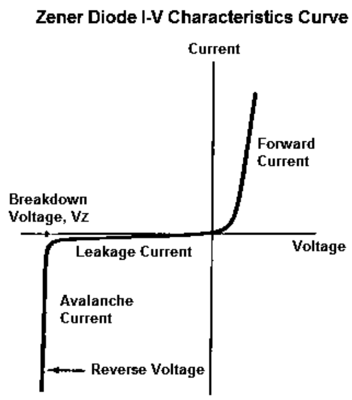
From the V−I characteristic, we observe that a large current flows in the reverse direction as the reverse voltage across a diode is increased beyond a voltage known as the Zener breakdownvoltage. When the diode is operating in the breakdown mode, the voltage across the diode is almost constant, V_Z, and the current in the diode is controlled by an external resistor. These diodes are used as voltage reference or constant-voltage sources.



Symbol for a Zener Diode

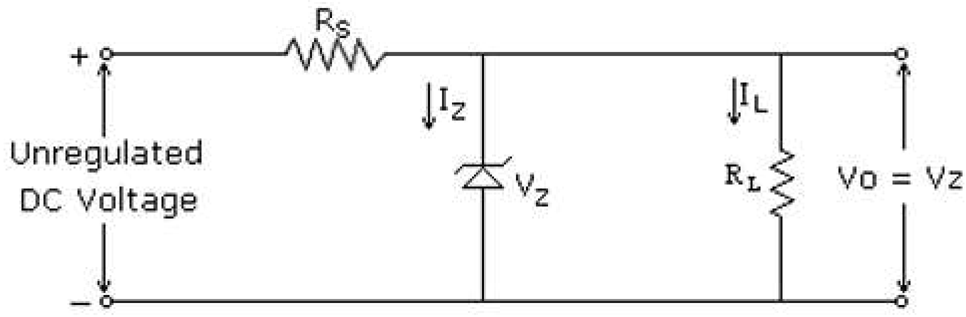
Characteristic of Zener diode

The VI characteristic graph of a Zener diode illustrates the relationship between voltage (V) and current (I) when the diode is operated in the reverse bias region. Typically, the graph shows a nearly vertical line until the Zener voltage (Vz) is reached, at which point the diode enters the breakdown region. In this region, the diode exhibits a highly predictable voltage drop (Vz) across its terminals, regardless of the current passing through it. This results in a nearly horizontal line on the graph, indicating that the voltage remains relatively constant despite changes in current. The sharp transition from the vertical to horizontal region reflects the Zener diode's ability to regulate voltage effectively, making it a vital component in voltage regulation circuits and other applications requiring stable voltage references.



Voltage regulator construction and working

Voltage regulator is nothing but an electronic circuit which keeps o/p voltage constant irrespective of changes in line voltage & load current.



Construction

An unregulated DC power supply is connected with a resistor at the positive terminal and the negative terminal is connected with a output voltage receiving end. The resistor is connected in series with the Zener diode, the load resistance and the voltage output. The series connection closes the circuit at the negative terminal of the unregulated power supply.

Working

The I/p voltage Vin is from the o/p of unregulated power supply. R_s is a series resistor used to control the current. The I/p voltage should be greater than V_z, then only zener diode will work in zener region. If Vin is higher than V_z the current through Zener diode increases & $I_L\downarrow$ we will get constant o/p voltage. If I_L changes, then I_z changes in such a way that at the o/p we get constant dc voltage.

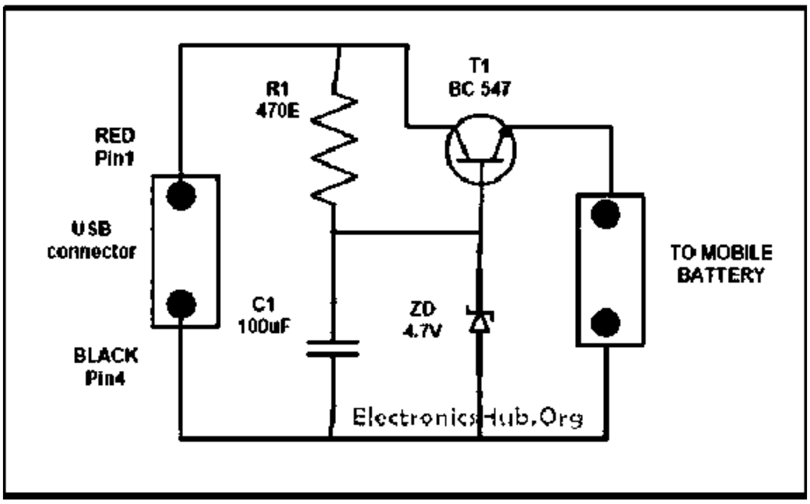
Advantages (no mathematical treatment)

The advantages of the Zener diode include the following.

- As compared to normal diodes, Zener is expensive
- Used in smaller circuits
- Capable for shifting voltage
- Overflow current control
- Simply compatible &accessible across systems
- The circuit voltage can be changed & stabilized
- It provides high performance
- It protects from over-voltage

USB cell phone charger

The USB port of the mobile is used for the charging, as the USB port is the very helpfulvoltage source that can charge themobile. Nowadays, there are two to four USB ports on the laptops that are available in the market. USB actually refers toUniversal Serial Bus. It is one of the newest incarnations of method which is used to get information in as well as out fromyour computer. We are concerned at the fact that ±5 volts of power is being provided by the USB port to the external devicesand can avail at the pin number 1 while on pin number 4, it is 0V. Till 100 mA of current can get from the USB port which ismore than sufficient that we required for this small application.



Components used in the circuit

- R 1-470E
- CI-100uF/25V
- Tl-BC547
- Zener
- Diode-I N4007

Introduction to e-vehicles and EV charging stations.

e-vehicles: An electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mix of fuel and gases. Therefore, such as vehicle is seen as a possible replacement for current-generation automobile.

EV charging stations: Electric vehicle (EV) charging stations are becoming increasingly important as the demand for electric vehicles continues to grow. These charging stations provide a convenient and efficient way for EV owners to recharge their vehicles, and they play a crucial role in supporting the widespread adoption of EVs.

There are several types of EV charging stations available on the market, each with their own unique features and capabilities. The most common types of charging stations include Level 1, Level 2, and Level 3.

Level 1: charging stations are the most basic type, and they typically use a standard 120-volt electrical outlet to charge an EV. These charging stations are often used in residential settings and can take up to 20 hours to fully charge an EV.

Level 2: charging stations are more powerful than Level 1 stations and can charge an EV in a shorter amount of time. They typically use a 240-volt outlet and can charge an EV in as little as 4 hours. These charging stations are often found in public locations such as parking garages and shopping centres.

Level 3: charging stations, also known as DC fast charging stations, are the most powerful type of EV charging stations available. They can charge an EV in as little as 30 minutes, making them ideal for long-distance travel. These charging stations are typically found along highways and at rest areas.