Applied Physics-II Suggestion (2023-2024)

2nd Semester Polytechnic

Top 250 Question with Answer from All Chapter

According to New Syllabus

Prepared by
NatiTute YouTube Channel

Contents

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1. Define periodic motion with example.

Answer:

Periodic Motion: The motion of a body is said to be periodic if it passes through same path over and over again after equal interval of time.

Example: Motion of hands of a clock, rotation of earth around the sun, oscillation of simple pendulum.

2. What is a simple harmonic motion?

Answer:

Simple harmonic motion (SHM) is a periodic motion in which the particle acceleration is directly proportional to its displacement and is directed towards the mean position.

Example: Motion of a simple pendulum, Oscillation of floating body, Vibration of elastic spring.

3. Write down the characteristics of SHM.

Answer:

Characteristics of Simple Harmonic Motion:

i) The particle's acceleration in simple harmonic motion is directly proportional to its displacement and directed towards its mean location.

ii) The particle's total energy is preserved as it moves in a simple harmonic motion.

iii) SHM is a type of oscillatory and periodic motion.

iv) A single harmonic function of sine or cosine can represent SHM.

4. What is the formula for restoring force in SHM?

Answer:

The restoring force is given by the formula

$$F = -kx$$

The negative sign shows that the force is in the opposite direction.

k is the force constant.

x is the displacement of the string from the equilibrium position.

5. If A and ω are the amplitude and the angular frequency respectively of a particle in SHM, then write the formula for maximum acceleration of the particle.

Answer: Formula for maximum acceleration of the particle is $\omega^2 A$.

6. What is damped vibration? Give example.

Answer:

Damped vibrations: Damped vibrations are periodic vibrations with a continuously diminishing amplitude in the presence of a resistive force. The frictional forces (or resistive forces) act in the direction opposite to vibration. The vibrations gradationally drop in frequency or stop, and the system returns to its original state of balance.

Example: Vibrations of a simple pendulum in air.

7. What are forced vibrations? Give example.

Answer:

Forced Vibrations: When a body executes vibrations under the action of an external periodic force, then the vibrations are called forced vibrations.

Example: When guitar is played, the artist forces the strings of the guitar to execute forced vibrations.

8. What are free vibration?

Answer:

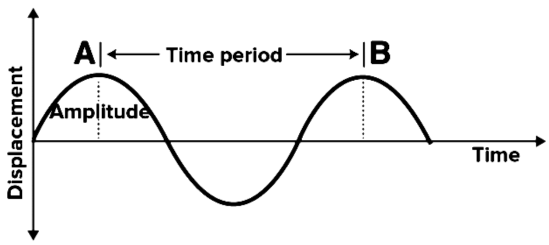
Free Vibrations: Free vibration of the body is the kind of vibration when a force is exerted on the body only at once and the body starts to vibrate at its natural frequency.

Example: The most common examples of free vibration are a pendulum or a spring-mass system displaced from their mean position.

9. What is meant by the amplitude of simple harmonic motion?

Answer:

The maximum displacement of the particle is called the amplitude of motion.



10. The equation of a particle executing S.H.M. is $y = 5\sin\frac{2\pi}{5}(10t + x)$. The frequency and amplitude of vibration is-
(a) 10, 5
(b) 5, 2
(c) 2, 5
(d) $\frac{5}{\pi}$, 5

Explanation:
Given Equation $y = 5\sin\frac{2\pi}{5}(10t + x)$
$$\Rightarrow y = 5\sin\left(4\pi t + \frac{2\pi x}{5}\right)$$
Comparing it with the general equation of SHM
$$y = A\sin(\omega t + \phi)$$
Angular frequency $\omega = 4\pi$ rad/s
$\therefore$ Frequency $= \frac{\omega}{2\pi} = \frac{4\pi}{2\pi} = 2$
Amplitude, $A = 5$
$\therefore$ Frequency, Amplitude = 2, 5
Answer: (c)

11. A simple harmonic motion is represented by y=5sin(10t+0.25). Determine its-
(i) amplitude, (ii) Angular frequency
(iii) Frequency, (iv) Time period
(v) Initial phase (Displacement is measured in metre and time in seconds)
Solution: Given, y=5sin(10t+0.25)
Comparing the above equation with standard equation for S.H.M. y=Asin(ωt+ϕ)
we get,
(i) Amplitude, A = 5 m
(ii) Angular frequency , ω=10rad/s
(iii) Frequency ,v=$\frac{\omega}{2\pi} = \frac{10}{2\pi}$=1.59Hz
(iv) Time period, T=$\frac{2\pi}{\omega} = \frac{2\pi}{10}$=0.629s
(v) Initial phase, φ=0.25 rad

12. Equation of a particle executing SHM is given by $y = A\sin(\omega t + \phi)$. What will be its total phase at any time t.
(a) $\omega t + \phi$
(b) ωt
(c) ϕ
(d) ω
Explanation:
The equation of displacement $y = A\sin(\omega t + \phi)$
The phase of this equation is $(\omega t + \phi)$
ϕ is the only initial phase.
Answer: (a)

13. A particle executing SHM has a maximum displacement of $4\ cm$ and its acceleration at a distance of $1.0\ cm$ from its mean position is $3\ cm/s^2$. What will be its velocity when it is at a distance of $2\ cm$ from its mean position?
Solution:
Maximum displacement = amplitude $A = 4\ cm$
Acceleration at a distance of $y = 1\ cm$ is $3\ cm/s^2$
$\therefore a = \omega^2 y$
$\Rightarrow 3 = \omega^2 \times 1, \Rightarrow \omega = \sqrt{3}$ rad/s
$\therefore$ Velocity at $y = 2\ cm$,
$v = \omega\sqrt{A^2 - y^2}$
$= \sqrt{3} \times \sqrt{4^2 - 2^2} = \sqrt{3 \times 12} = 6\ cm/s$ (Ans)

14. Mention types of mechanical waves.
Answer:
Types of Mechanical Waves: There are primarily two types of mechanical waves, namely:
i) Transverse Waves
ii) Longitudinal Waves

15. What are transverse waves? Give example.
Answer:
Transverse Wave: In transverse waves, the displacement of the particle is perpendicular to the direction of propagation of the wave. The particles do not move along with the wave. They move up and down about their equilibrium positions.
Example: Some examples of transverse waves are:
i) The ripples on the surface of the water
ii) The secondary waves of an earthquake
iii) Electromagnetic waves
iv) The ocean waves

16. What are longitudinal waves? Give example.
Answer:
Longitudinal Wave: In a longitudinal wave, the displacement of the particle is parallel to the direction of the wave propagation. The particles in the wave do not move along with the wave; they simply oscillate back and forth about their own equilibrium.
Example: Some examples of longitudinal waves are:
i) Sound waves in air
ii) The primary waves of an earthquake
iii) Ultrasound
iv) The vibration of a spring

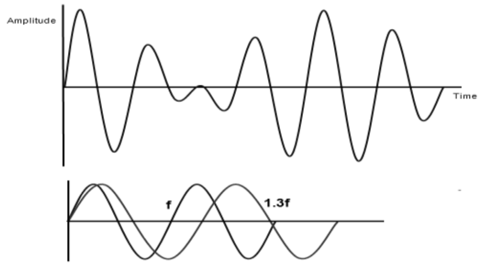
17. In which medium transverse wave cannot propagate?

Answer: For a transverse wave to propagate through a medium, the medium should be rigid. So, transverse waves can only be produced in solids and on the surface of liquids but they cannot be produced inside liquids or in gases.

18. What are beats?

Answer:

Beats: The rise and fall in the intensity of sound due to the superposition of two sound waves of slightly different frequencies traveling in the same direction is known as beats.



19. Prove that, the number of beats per second produced by two sources of sound is equal to the difference in the frequencies of the two sources.

Answer:

Let us consider two waves of frequencies n_1 and n_2 $(n_2 > n_1)$ have the same amplitude a. Then the equations of the waves are given by-

$y_1 = a\sin 2\pi n_1 t$ and $y_2 = a\sin 2\pi n_2 t$

Form superposition principle, the resultant wave is given by

$y = y_1 + y_2 = a\sin 2\pi n_1 t + a\sin 2\pi n_2 t$

$\Rightarrow y = 2a\sin 2\pi\left(\frac{n_1+n_2}{2}\right)t \,.\cos 2\pi\left(\frac{n_2-n_1}{2}\right)t$

$\Rightarrow y = A\sin 2\pi nt$

where $A = 2a\cos 2\pi\left(\frac{n_2-n_1}{2}\right)t$ and $n = \frac{n_1+n_2}{2}$

This represents a wave frequency n and amplitude A. The amplitude of this wave, therefore, varies with time in a periodic manner. It becomes maxima when, $t = \frac{1}{n_2-n_1}, \frac{2}{n_2-n_1}, \frac{3}{n_2-n_1}$ etc

$\therefore$ The successive maxima offer the time of $\frac{1}{n_2-n_1}$ second.

Hence the number of beats per second is $n_2 - n_1$.

(Proved)

20. If two progressive waves given by $\boldsymbol{y_1 = 6\sin 250\pi t}$ and $\boldsymbol{y_2 = 3\sin 256\pi t}$ superpose, the number beats forms per second is-

(a) 3

(b) 5

(c) 6

(d) 8

Explanation:

$y_1 = 6\sin 250\pi t \therefore$ Frequency $n_1 = \frac{250\pi}{2\pi} = 125$

$y_2 = 3\sin 256\pi t \therefore$ Frequency $n_2 = \frac{256\pi}{2\pi} = 128$

$\therefore$ No of beats per second $= n_2 - n_1$

$= 128 - 125$

$= 3$

Answer: (a)

21. What are the requirements of good acoustic in a auditorium?

Answer: The requirements of good acoustic in a auditorium are-

i) an appropriate reverberation time.

ii) uniform sound distribution

iii) an appropriate sound level

iv) an appropriately low background noise

v) no echo or flutter echo

vi) the sound should be evenly distributed throughout the hall.

vii) the size & the shape of the hall has also to be taken care.

22. The equation of a progressive wave is given by $\boldsymbol{y = 5\sin(100\pi t - 0.4\pi x)}$ where $\boldsymbol{y}$ and $\boldsymbol{x}$ are in $\boldsymbol{m}$ and $\boldsymbol{t}$ is in $\boldsymbol{s}$. Find out the amplitude, wavelength, frequency and velocity of the wave.

Solution:

Given wave equation $y = 5\sin(100\pi t - 0.4\pi x)$

So, amplitude of the given wave, $a = 5\,m$ (Ans)

Since we know $k = \frac{2\pi}{\lambda}$

According to the given wave equation, Angular wavenumber, $k = 0.4\pi$

$\Rightarrow \frac{2\pi}{\lambda} = 0.4\pi$

$\Rightarrow \lambda = \frac{2\pi}{0.4\pi} = 5\,m$ (Ans)

From the given waveequation, angular frequency, $\omega = 100\pi$

Since $\omega = 2\pi f$

So, frequency, $f = \frac{\omega}{2\pi} = \frac{100\pi}{2\pi} = 50\,Hz$ (Ans)

Given, wavelength of the wave, λ=5m

Wave velocity, $v = f\lambda$

$\Rightarrow v = 50 \times 5 = 250\,ms^{-1}$ (Ans)

23. What is resonance? Give example.

Answer:

Resonance: When the frequency of an externally applied periodic force an a body is equal to the natural frequency of the body, the body readily begins to vibrate or free to vibrate with an increased amplitude. This phenomenon is known as resonance.

Example: Pushing a person in a swing is a common example of resonance. The loaded swing, a pendulum, has a natural frequency of oscillation, its resonant frequency, and resists being pushed at a faster or slower rate.

24. State the principle of superposition of waves. Name the phenomenon produced due to the superposition of waves.

Answer:

Principle of Superposition of Waves: When two or more waves superpose, he resultant displacement of particle of the medium is equal to the vector sum of the displacements due to individual waves.

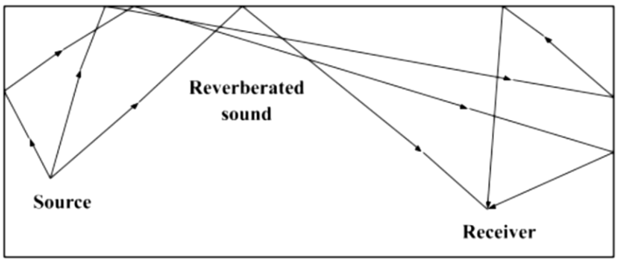
Mathematically $y = y_1 + y_2 + y_3 + \cdots$

Superposition of waves leads to the phenomenon of interference, diffraction, beats, and formation of stationary waves are due to the superposition of waves.

25. Explain the term reverberation. Suggest some steps to reduce the reverberation.

Answer:

Reverberation: Reverberation is the phenomenon of overlapping of sound caused by multiple reflections. It causes the overlapping of several reflected waves. If the time gap between the reflected waves is so short that these cannot be distinguished. So we hear multiple noisy sounds.



Reverberation can be reduced by covering the ceiling and walls of the enclosed space with some absorbing materials like fibre board, loose woolens etc.

26. Define ultrasonic wave.

Answer: The audible frequency range for human ear is from 20Hz to 20000Hz, above frequency 20000Hz, sound waves are called ultrasonic. So it is clear that sound waves having frequency higher than audio frequency range (20.000Hz), are ultrasonic waves .

27. Write down the properties of ultrasonic wave.

Answer:

Properties of Ultrasonic Waves:

1) Ultrasonic waves vibrate at a frequency greater than the audible range for humans (20 kilohertz).
2) They have smaller wavelengths. As a result, their penetrating power is high.
3) They cannot travel through vacuum.
4) Ultrasonic waves travel at the speed of sound in the medium. They have maximum velocity in a denser medium.
5) In a homogeneous medium, they travel at a constant velocity.
6) In low viscosity liquids, ultrasonic waves produce vibrations.
7) They undergo reflection, refraction and absorption.
8) They have high energy content. They can be transmitted over a large distance without much loss of energy.
9) They produce intense heat when they are passed through objects.

28. Write down the applications of ultrasonic wave.

Answer: The important application of ultrasonic wave are-

1) Ultrasonic waves are used in echocardiography It is used to construct the image of the heart.
2) Ultrasonic waves are used in the detection of cracks in metal blocks.
3) Ultrasonic waves are used to kill bacteria in liquid.
4) Ultrasonic waves for determining the depth of the sea.
5) Ultrasonic waves is also used to see what is happening to the components inside a nuclear reactor.
6) Commonly practiced application of ultrasonic waves is in conducting ultrasonography. It is an imaging technique which is used by doctors to check on a developing baby.

1. **The power of two lenses is +5D and −2.5D. The focal length of two lenses in contact will be-**
   (a) +40cm
   (b) −40cm
   (c) +40m
   (d) none of these
   Explanation:
   Combined power $P = P_1 + P_2$
   $= +5 + (-2.5)$
   $= +2.5\text{D}$
   $\therefore$ Focal length $f = \frac{1}{P} = \frac{1}{+2.5} m = \frac{100}{+2.5}\ cm = +40\ cm$
   Answer: (a)

2. **The focal length of a convex lens is maximum for the color of light-**
   (a) blue
   (b) yellow
   (c) green
   (d) red
   Explanation: The smaller the refractive index of the given colour, the higher will be the focal length. As red colour has the lowest refractive index. Thus, the focal length of a convex lens will be maximum for red color.
   Answer: (d)

3. **The focal lengths of convex lens for blue and yellow light f_b and f_y respectively. The correct relation is-**
   (a) $f_b = f_y$
   (b) $f_b > f_y$
   (c) $f_b < f_y$
   (d) $f_b \ll f_y$
   Explanation: The focal length and refractive index are inversely proportional to each other. The larger the refractive index of the given colour, the lower will be the focal length. The variation of focal length will be given as
   $$f_R > f_O > f_Y > f_G > f_B > f_I > f_V$$
   Answer: (c)

4. **The maximum magnifying power of a convex lens of focal length 5 cm can be-**
   (a) 6
   (b) 10
   (c) 25
   (d) 1
   Explanation: The least distance vision is $d = 25cm$
   For a convex lens maximum magnification
   $m_{max} = 1 + \frac{d}{f} = 1 + \frac{25}{5} = 6$
   Answer: (a)

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5. **If a lens is surrounded by a medium denser than air, the focal length of the lens-**
   (a) decreases
   (b) increases
   (c) remains same
   (d) cannot be determined
   Explanation: As lens is surrounded by a medium denser than air, refractive index decreases. The smaller the refractive index the focal length increases.
   Answer: (b)

6. **In a interference fringe, if width of dark band is β_1 and that of the bright band is β_2 then-**
   (a) $2\beta_1 = \beta_2$
   (b) $2\beta_2 = \beta_1$
   (c) $\beta_1 = \beta_2$
   (d) $\beta_1 + 3\beta_2 = 1$
   Explanation:
   We know, fringe width $\beta = \frac{\lambda D}{d}$. It is found that dark and bright fringe d are equally spaced fringe width will be the distance between two consecutive bright or dark fringes. Therefore $\beta_1 = \beta_2$
   Answer: (c)

7. **The speed of light in air is $3 \times 10^8\ ms^{-1}$. Its speed in diamond of refractive index 2.4 is-**
   (a) $3 \times 10^8\ ms^{-1}$
   (b) $7.2 \times 10^8\ ms^{-1}$
   (c) $1.25 \times 10^8\ ms^{-1}$
   (d) none of these
   Explanation:
   Refractive index $= \frac{\text{Speed of light in vacuum or air}}{\text{Speed of light in a diamond}}$
   $\Rightarrow$ Speed of light in a diamond $= \frac{3\times10^8}{2.4}$
   $= 1.25 \times 10^8\ ms^{-1}$
   Answer: (c)

8. **If a lens is immersed in water what will happen to its focal length?**
   Answer: When the lens is immersed in water the refractive index of the lens reduces. The ray of light would be deviated to a lesser extent. Hence, the point where the refracted ray would meet the principal axis would be farther away from the lens. So, the focal length of the lens would be increased when immersed in water.

9. Write the definition of refractive index of a medium.

Answer:

Refractive Index: Refractive index of a medium is defined as ratio of speed of light in vacuum to that in the medium. The refractive index is the measure of bending of a light ray when passing from one medium to another. It is a dimensionless quantity.

Refractive Index $\mu = \frac{c}{v}$

Where, $c =$ Speed of light in vacuum or air

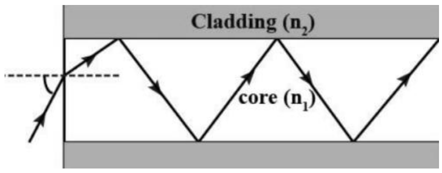
$v =$ Speed of light in a given medium

Refractive index of some materials:

Material	Refractive Index
Vacuum	1
Air	1.0003
Water	1.333
Glass	1.52
Diamond	2.417

10. Which one of the core and cladding in an optical fiber has higher refractive index?

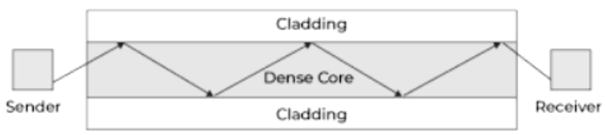
Answer:



Optical fiber communication works on the principle of the total internal reflection. The core should have higher refractive index than cladding for total internal reflection to take place.

11. Explain the mechanism of light propagation through optical fiber.

Answer:



Optical fiber works on the principle of total internal reflection. The core should have higher refractive index than cladding for total internal reflection to take place. When light ray strikes at the internal surface of optical fiber cable called such that incidence angle is greater than critical angle, then incident light ray reflects in the same medium and this phenomenon repeats. In this way light signal travels from one end of the cable to another end.

12. Write the important uses of optical fiber.

Answer: The application and uses of optical fibre can be seen in:

(i) Medical Industry: It is used as lasers during surgeries, endoscopy, microscopy and biomedical research.

(ii) Communication: It is used in various networking fields and even increases the speed and accuracy of the transmission data.

(iii) Defence: Fibre optics are used for data transmission in high-level data security fields of military and aerospace applications.

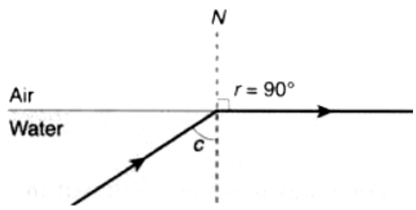
(iv) Industries: These fibres are used for imaging in hard-to-reach places such as they are used for safety measures and lighting purposes

(v) Mechanical Inspections: On-site inspection engineers use optical fibres to detect damages and faults which are at hard-to-reach places.

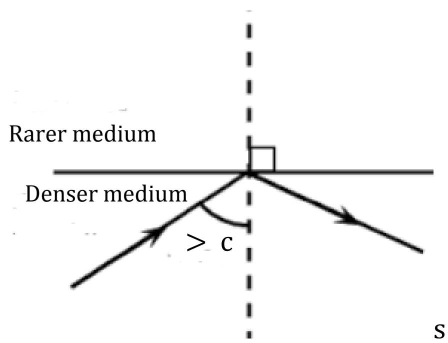
13. Explain critical angle and total internal reflection.

Answer:

Critical Angle: When a ray of light goes from denser medium to rarer medium, it bends away from the normal as angle of incidence in the denser medium increases, the angle of refraction in the rarer medium also increase to 90°. This is called critical Angle(c).



Total Internal Reflection: When the angle of the incident in the dense medium exceeds the critical angle, then get reflected back in the denser medium and this phenomenon is called total internal reflection.



14. Write down the conditions for total internal reflection of light.

Answer:

The following 2 conditions need to be followed for Total Internal reflection:

i) The light ray must travel from denser medium to rarer medium.

ii) The angle of incidence must be greater than the critical angle.

15. Will there be any change in critical angle if the colour of light is changed? Give reason.

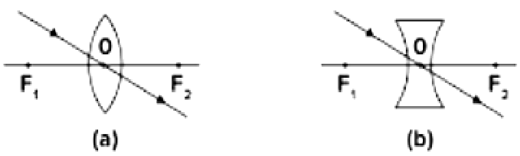
Answer: Yes, Colour depends on the wavelength of light, refractive index depends on wavelengths of light. So, far lights of different colours the refractive index changes this implies that critical angle also changes.

We know that refractive index is least for red coloured light and maximum for violet colour light. As a result critical angle for a given pair of media is least for violet colour and has a maximum value for red colour.

16. Define optical center of a lens with diagram.

Answer:

Optical Center of Lens: The optical centre of the lens is defined as the point which lies on the principal axis through which the rays of light pass without any deflection. In fig. below point O represents the optical centre in (a)convex and (b)concave lenses.



17. How does focal length of a lens change when red light incident on it is replaced by violet light? Give reason for your answer.

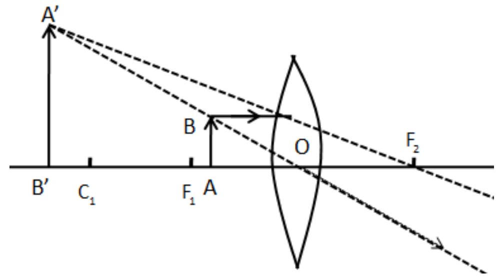
Answer: The refractive index of the material of a lens increases with the decrease in wavelength of the incident light. So, focal length will decrease with decrease in wavelength according to lens makers formula,

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Thus, when we replace red light with violet light, then due to decrease in wavelength the focal length of the lens will decrease.

18. Indicate in ray diagram the kind of lens needed, the position of the object and the position of the image to obtain a magnified virtual image.

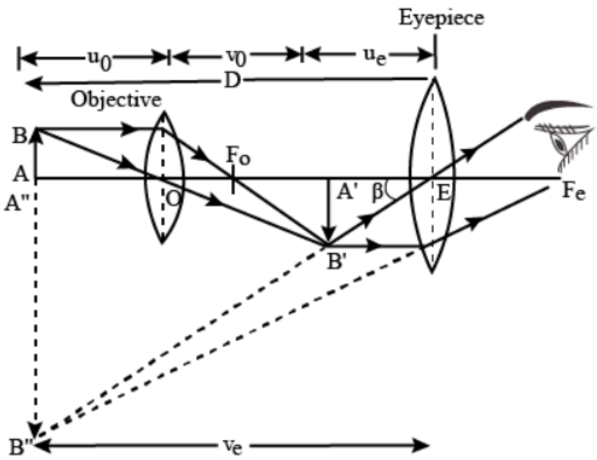
Answer: The convex lens produces magnified virtual images when the object is placed between the first principal focus and pole of the lens. The following figure shows image formation by the convex lens.



AB is the height of object and A'B' is the height of image, F_1 is the first principle focus, C_1 is the curvature of the lens and F_2 is the second principal focus.

19. Draw a ray diagram of a compound microscope. Write the expression for its magnifying power.

Answer:



Ray diagram of compound microscope

Expression for magnifying power

$$m = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$$

20. Define coherent source of light.

Answer:

Coherent Source of Light: Two sources are said to be coherent sources if they produce two waves having same frequency, same waveform and have constant phase different between them which does not change with time.

21. Give some example of coherent source.

Answer:

Example of Coherent Source:

i) Sound waves produced by speakers.

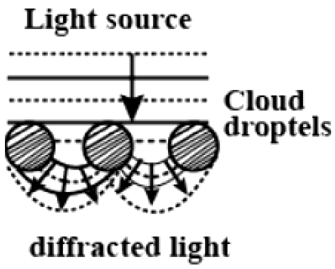
ii) A laser is also a type of coherent source.

iii) Small sources of light are partially coherent.

iv) While sunlight is incoherent while small portions on small areas are generally partially coherent.

22. What is meant by diffraction of light?

Answer: Diffraction is slight bending of light as it pass around the edge of an object. The amount of bending depends upon the wavelength of the light to the size of the opening. If the opening is much larger than light wavelength's, the bending will be almost unnoticeable.



23. How will the interference pattern in Young's double slit experiment get affected, when distance between the slits S_1 and S_2 reduced.

Answer:

Fringe width of interference pattern in Young's slit experiment is given by $\beta = \frac{\lambda D}{d}$ where, d is the distance between the two slits, D is the distance between the slit and the screen and λ is the wavelength of light used.

Therefore, $\beta \propto \frac{1}{d}$

Thus fringe width of the interference pattern increases as we decrease the distance between the two slits.

24. If Young's double-slit experiment is performed underwater, how would the observed interference pattern be affected?

Answer:

The formula for fringe width is $\beta = \frac{\lambda D}{d}$

where

λ is the wavelength,

D is the distance between source and screen

d is the distance between slits.

As in water the wavelength λ is decreased, fringe width decreases.

25. Describe lens maker's formula.

Answer:

Lens Maker's Formula: Lens maker formula is used to construct a lens with the specified focal length. A lens has two curved surfaces, but these are not exactly the same. If we know the refractive index and the radius of the curvature of both the surface, then we can determine the focal length of the lens by using the given lens maker's formula:

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Where,

f = The focal length of the lens

μ = Refractive index

R_1, R_2 = The radius of curvature of both surfaces

26. Determine the focal length of the lens of refractive index 1.7 when placed in air. The radii of curvature of the two spherical surfaces of the lens are 20cm and 35 cm.

Solution:

From lens maker's formula,

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

We have,

Refractive index, μ=1.7

$R_1 = 20\text{cm}$ and $R_2 = 35\text{cm}$

$\therefore \frac{1}{f} = (1.7 - 1)\left(\frac{1}{20} - \frac{1}{35}\right)$

$\Rightarrow \frac{1}{f} = 0.7 \times \frac{35-20}{20\times35}$

$\Rightarrow \frac{1}{f} = \frac{7}{10} \times \frac{15}{20\times35} = \frac{3}{200}$

$\Rightarrow f = \frac{200}{3} = 66.67$ cm

∴ The focal length of the lens is 66.67 cm (Ans)

27. An object placed at a certain distance from a convex lens of focal length 20cm. Find the distance of the object if the image obtained is magnified 4 times.

Solution:

Given data, Focal length $l = 20\ cm$

Magnification $m = 4$

Now $m = \frac{v}{u}$ [with usual notation]

$\Rightarrow 4 = \frac{v}{u}, \Rightarrow v = 4u$

We know lens formula,

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\Rightarrow \frac{1}{20} = \frac{1}{4u} - \frac{1}{u}$ [As $v = 4u$]

$\Rightarrow \frac{1}{20} = \frac{1-4}{4u}$

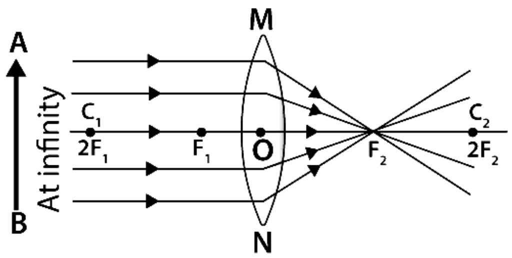
$\Rightarrow \frac{1}{20} = \frac{-3}{4u}, \Rightarrow u = -\frac{3\times20}{4} = -15\text{cm}$

∴ The distance of object is −15 cm. (Ans)

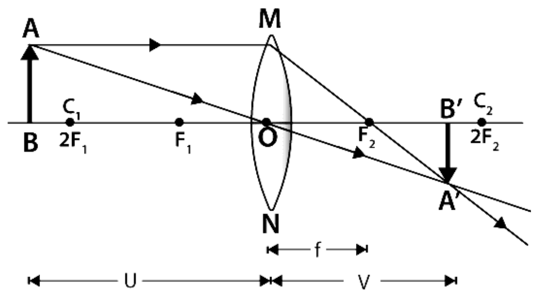
28. Describe image formation by convex lenses.

Answer:

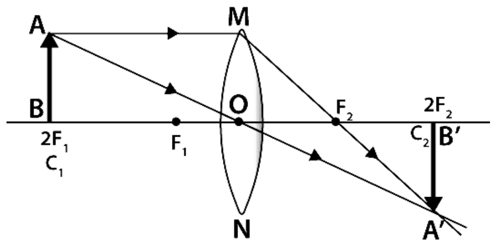
(i) When an object is placed at infinity, the real image is formed at the focus. The size of the image is highly diminished and point size.



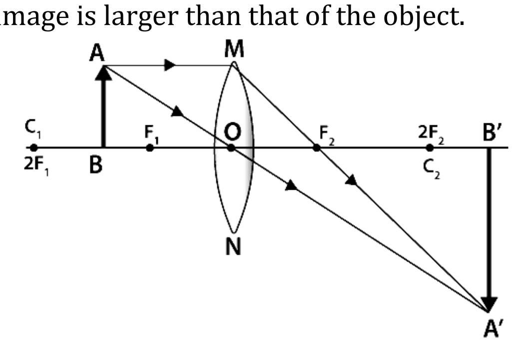
(ii) When an object is placed beyond the centre of curvature, the real image is formed between the centre of curvature and focus. The image size will not be the same as the object. It will be diminished in size.



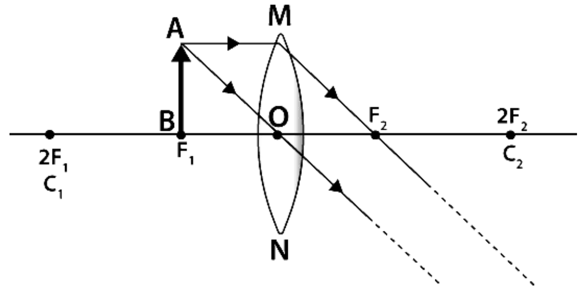
(iii) When an object is at the centre of curvature, the real image is formed at the other centre of curvature. The size of the image is the same as compared to that of the object.



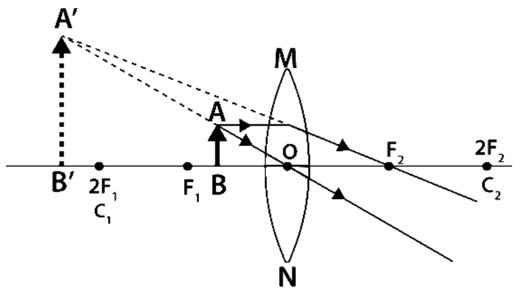
(iv) When an object is placed in between the centre of curvature and focus, the real image is formed behind the centre of curvature. The size of the image is larger than that of the object.



(v) When an object is placed at the focus, a real image is formed at infinity. The size of the image is much larger than that of the object.



(vi) When an object is placed in between focus and optical centre, a virtual image is formed. The size of the image is larger than that of the object.



29. Define power of lens.

Answer:

Power of Lens: The degree of convergence or divergence of light rays achieved by a lens is expressed in terms of its power. The power of a lens is defined as the reciprocal of its focal length. The power P of a lens of focal length f (in m) is given by

$$P = \frac{1}{f}$$

The SI unit of power of a lens is 'dioptre'. It is denoted by the letter D. The power of a convex lens is positive and that of a concave lens is negative.

30. What is meant by magnification of a lens? Write its expression.

Answer:

Magnification of a lens: The ratio of length of image (I) perpendicular to the principle axis, to the length of object (O) is called the magnification. Also, magnification is equal to the ratio of image distance (v) to that of object distance(u). This is denoted by m.

$$\text{Magnification} = \frac{\text{Length of image}}{\text{Length of object}}$$

or, $m = \frac{I}{O}$ or, $m = \frac{v}{u}$

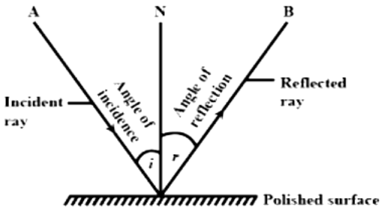
31. What are the laws of optics?

Answer:

Laws of Reflection-

(i) The principle when the light rays fall on a smooth surface, the angle of reflection is equal to the angle of incidence.

(ii) The incident ray, the reflected ray, and the normal to the surface all lie in the same plane.

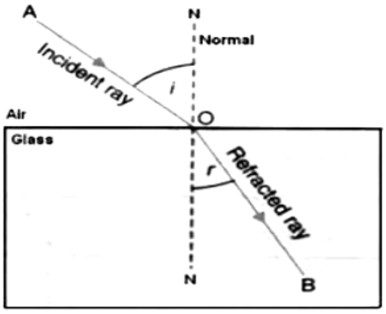


Laws of Refraction-

(i) The incident ray, refracted ray, and the normal to the interface of two media at the point of incidence all lie on the same plane.

(ii) The ratio of the sine of the angle of incidence (i) to the sine of the angle of refraction (r) is constant. This is also known as Snell's law of refraction.

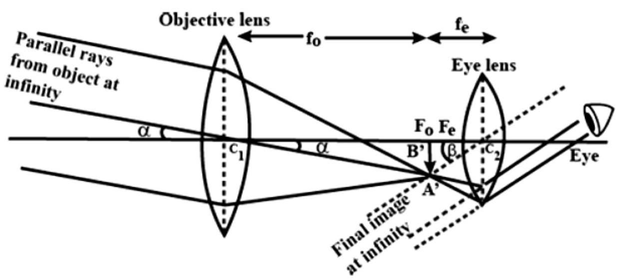
$$\frac{\sin i}{\sin r} = \text{Constant}$$



32. Draw a ray diagram of a astronomical telescope Write the expression for its magnifying power.

Answer: Ray diagram of the image formed at infinity by refracting telescope is shown here which indicates that focal length of objective lens and that of eye piece is f_o and f_e respectively. Magnifying power of telescope is defined as the ratio of angle subtended by image on eye (β) to angle subtended by object on eye (α).

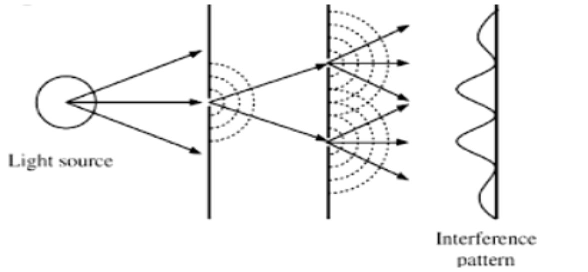
Magnifying power of telescope $m = -\frac{f_o}{f_e}$



33. What do you mean by interference of light? Discuss necessary conditions for interference.

Answer:

Interference of Light: Interference is the phenomenon of superimposition of two or more waves having same frequency emitted by coherent sources such that amplitude of resultant wave is equal to the sum of the amplitude of the individual waves.



Conditions for Interference: For interference to take place, the light emitting sources must be coherent i.e. the phase difference between the two sources must remain constant with time and the frequencies of emitted light must also be equal.

34. Discuss the limitations of lens maker's formula.

Answer: Limitations of the lens maker's formula-

(1) The lens should be thin so that the separation between the two refracting surface should be small.

(2) The medium on either side of the lens should be same.

35. Write down the expression for lens formula.

Answer: The lens formula is given as

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Where f = focal length, u = object distance from the lens and v = image distance from the lens.

The lens formula is implemented with proper sign convention using cartesian method.

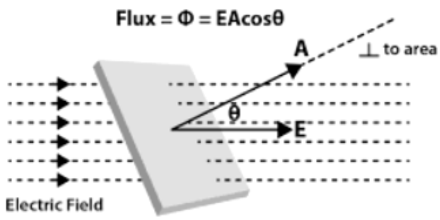
36. Give sign convention for lens.

Answer: Convention table for lens sign.

Quantity	Condition	Sign
Focal Length, f	Convex Lens Concave Lens	Positive (+) Negative (-)
Object Distance	Always	Negative (-)
Image Distance	Image Real Image Virtual	Positive (+) Negative (-)
Magnification	Image Upright Image Upturn	Positive (+) Negative (-)

1. **The electric field inside a hollow conducting sphere-**
   (a) Increases towards the centre
   (b) Decreases towards the centre
   (c) Is finite and constant throughout
   (d) Is zero
   Explanation: As there are no charges inside the hollow conducting sphere, as all charges reside on it surface. So, electric field inside the hollow conducting sphere is zero.
   Answer: (d)

2. **What is an electric flux?**
   Answer:
   Electric Flux: The total number of electric field lines passing a given area in a unit time is defined as the electric flux.
   Electric flux ϕ=EAcosθ
   SI unit of electric flux is Nm^2/C or Vm



3. **What is permittivity?**
   Answer: Permittivity can be explained as the ratio of electric displacement to the electric field intensity. It is the property of a material to measure the opposition generated by the material during the electric current development.
   The permittivity of a material is represented by the symbol ∈. The SI unit of permittivity is Farad per metre. The approximate value for permittivity is 8.85×10^{-12} Faraday/metre, which is found in a vacuum medium.

4. **State Gauss' law in electrostatics.**
   Answer:
   Gauss' Law in Electrostatics: According to Gauss law, the total electric flux linked with a closed surface is $\frac{1}{\epsilon_0}$ times the charge (q) enclosed by the closed surface.
   Total flux $\phi = \oint \vec{E}.\vec{ds} = \frac{1}{\epsilon_0} q$
   Where ϵ_0 is the permittivity of free space
   ($\epsilon_0 = 8.85 \times 10^{-12}$Farad/m)

5. **Using Gauss's law derive an expression for the electric field intensity due to a uniform charged thin spherical shell at a point.**
   (i) Outside the shell
   (ii) Inside the shell
   Answer:
   Let, R be the radius of the shell and Q be the charge uniformly distributed on the surface.
   (i) For a point outside the shell:
   By Gauss' law $E.4\pi r^2 = \frac{Q}{\epsilon_0}$
   Here r be the distance from center of shell ($r > R$) and charge enclosed by surface is Q.
   So, at a point outside the shell $E = \frac{Q}{4\pi\epsilon_0 r^2}$
   (ii) For a point inside the shell:
   By Gauss' law $E.4\pi r^2 = \frac{Q}{\epsilon_0}$
   Here r be the distance from center of shell ($r < R$) and charge inside the shell $Q = 0$.
   So, at a point inside the shell $E = \frac{0}{4\pi\epsilon_0 r^2} = 0$

6. **Why electrostatic potential is constant throughout the volume of the conductor and has the same value as on its surface?**
   Answer: Since electric field inside the conductor is zero and has no tangential component on its surface, therefore, no work is done in moving a test charge within the conductor or on its surface. It means potential difference between any two points inside or on the surface is zero. Hence, electrostatic potential is constant throughout the volume of charged conductor and has same value on its surface as inside it.

7. **If the capacitance of a capacitor is increased, what happens?**
   Answer: Keeping the charge same, if the capacitance of a capacitor is increased, the potential across is will decrease.

8. **What happens to the capacitance of a capacitor when a dielectric slab is placed between its plates. Explain with relevant formula.**
   Answer: The capacitance of a capacitor increases when a dielectric is introduced between its plates because the capacitance is related to the dielectric constant k by the equation: $C = \frac{\epsilon_0 kA}{d}$

9. Prove that the energy stored in parallel plate capacitor is $\frac{1}{2}CV^2$.

Answer: The capacitor is a charge storage device work has to be done to store the charges in a capacitor. This work done is stored as electrostatic potential energy in the capacitor.

Let q be the charge and V be the potential difference between the plates of the capacitor. If dq is the additional charge given to the plate, then work done is, $dw = Vdq$.

$\Rightarrow dw = \frac{q}{C}dq \quad \left[\because V = \frac{q}{C}\right]$

Total work done to charge a capacitor is

$$w = \int dw = \int_0^q \frac{q}{C}dq = \frac{q^2}{2C}$$

This work done is stored as electrostatic potential energy (U) in the capacitor.

$U = \frac{q^2}{2C} = \frac{C^2V^2}{2C} \quad [\because q = CV]$

$= \frac{1}{2}CV^2 \quad$ (Proved)

10. Find out the equivalent capacitance for two capacitors of capacitance $30\,\mu F$ and $50\,\mu F$ connected in series.

Solution:

Given, capacitances are $C_1 = 30\,\mu F$, $C_2 = 50\,\mu F$

Let, Equivalent capacitance for two capacitors is C

As the capacitors connected in series,

$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$\Rightarrow \frac{1}{C} = \frac{1}{30} + \frac{1}{50} = \frac{50+30}{50\times30} = \frac{80}{50\times30} = \frac{8}{150}$

$\Rightarrow C = \frac{150}{8} = \frac{75}{4} = 18.75\,\mu F \quad$ (Ans)

11. Net capacitance of three identical capacitors in series is $1\mu F$. What will be their net capacitance if connected in parallel? Find the ratio of energy stored in the two configurations, if they are both connected to the same source.

Solution:

Given, net capacitance in series $C_s = 1\mu F$

Let, capacitance of each capacitor is C.

In series combination,

$\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$

$\Rightarrow \frac{1}{1} = \frac{3}{C}, \Rightarrow C = 3\mu F$

When connected in parallel,

Net capacitance $C_p = C + C + C$

$\Rightarrow C_p = C + C + C = 3C = 3 \times 3 = 9\mu F \quad$ (Ans)

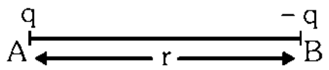
Ratio of energy stored,

$\frac{U_s}{U_p} = \frac{\frac{1}{2}C_sV^2}{\frac{1}{2}C_pV^2} = \frac{C_s}{C_p} = \frac{1}{9}$

$\Rightarrow U_s : U_p = 1 : 9 \quad$ (Ans)

12. Two point charges A and B, having charges +q and –q respectively, are placed at certain distance apart and force acting between is F. If 25% charge of A is transferred to B, then what will be the force between them.

Solution:



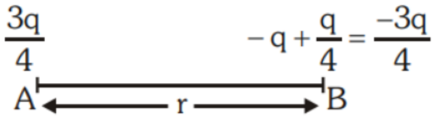
Force acting between charges $F = k \times \frac{q\times(-q)}{r^2}$

$\Rightarrow F = -\frac{kq^2}{r^2}$

25% charge of A $= q \times \frac{25}{100} = \frac{q}{4}$, transferred to B

then charge of B $= \left(-q + \frac{q}{4}\right) = -\frac{3q}{4}$ and

charge of A becomes $\left(q - \frac{q}{4}\right) = \frac{3q}{4}$



So, new force $F' = k\frac{\frac{3q}{4}\times\left(-\frac{3q}{4}\right)}{r^2}$

$= \frac{9}{16} \times \left(-\frac{kq^2}{r^2}\right)$

$= \frac{9F}{16} \quad$ (Ans)

13. State Coulomb's law in electrostatics.

Answer:

Coulomb's Law: The force of attraction or repulsion between two point charges is-

i) directly proportional to the product of the charges and

ii) Inversely proportional to the square of the distance between them.

$F = k\frac{q_1q_2}{r^2}$

where k is Coulomb's constant $(k = 9 \times 10^9 Nm^2C^{-2})$, q_1 and q_2 are the signed magnitudes of the charges, and the scalar r is the distance between the charges.

14. What Is an Electric Field?

Answer:

Electric Field: An electric field is defined mathematically as a vector field that can be associated with each point in space, the force per unit charge exerted on a positive test charge at rest at that point. The formula of the electric field is given as, $E = \frac{F}{Q}$

Where, E is the electric field.

F is the force.

Q is the charge.

15. What is the electric field line?

Answer:

Electric Field Lines: An electric field line is an imaginary line or curve drawn from a point of an electric field such that tangent to it (at any point) gives the direction of the electric field at that point.

16. What are the properties of electric field lines?

Answer:

Properties of Electric Field Line:

(i) The field lines never intersect each other.
(ii) The field lines are perpendicular to the surface of the charge.
(iii) The magnitude of charge and the number of field lines, both are proportional to each other.
(iv) The start point of the field lines is at the positive charge and ends at the negative charge.
(v) For the field lines to either start or end at infinity, a single charge must be used.

17. Define electric potential.

Answer:

Electric Potential: The electric potential at a point is equal to the work done by external force in bringing the unit positive charge from infinity to a point inside the electric field without changing the kinetic energy.

18. What are capacitors?

Answer: Capacitors are electronic devices that store electrical energy in an electric field. They are passive electronic components with two distinct terminals.

19. What is meant by capacitance?

Answer: Capacitance is the amount of electric charge that can be stored per unit change in electric potential.

20. What are the units of capacitance?

Answer: The SI unit of electrical capacitance is Farad (F). Capacitance is generally calculated in the sub-units of Farads such as pico-farads (pF) and micro-farads (�F).

21. What are parallel plate capacitors?

Answer: When two parallel plates separated by some distance are attached over a battery, the given plates are gradually charged, and an electric field is produced between them. These setups are called the parallel plate capacitors. The parallel plate capacitor formula is given by:

$$C = k\epsilon_0 \frac{A}{d}$$

Where,
ϵ_o is the permittivity of space ($8.854 \times 10^{-12}\ F/m$)
k is the relative permittivity of dielectric material
d is the separation between the plates
A is the area of plates

22. A parallel plate capacitor kept in the air has an area of $0.50m^2$ and is separated from each other by a distance of $0.04m$. Calculate the capacitance of the capacitor.

Solution: Given, Area $A = 0.50\ m^2$
Distance $d = 0.04\ m$
relative permittivity $k = 1$
$\epsilon_o = 8.854 \times 10^{-12}\ F/m$
The parallel plate capacitor formula is expressed by, $C = k\frac{\epsilon_0 A}{d}$

$$= \frac{8.854\times10^{-12} \times 0.50}{0.04}$$
$$= \frac{4.427\times10^{-12}}{0.04}$$
$$= 110.67 \times 10^{-12}\ F \quad \text{(Ans)}$$

23. Two equal and opposite charges are placed at a certain distance apart and force of attraction between them is F. If 75% charge of one is transferred to another, then find the force between the charges.

Solution:

Force acting between charges $F = k \times \frac{q\times(-q)}{r^2}$

$$\Rightarrow F = -\frac{kq^2}{r^2}$$

75% charge of A $= q \times \frac{75}{100} = \frac{3q}{4}$, transferred to B

then charge of B $= \left(-q + \frac{3q}{4}\right) = -\frac{q}{4}$ and

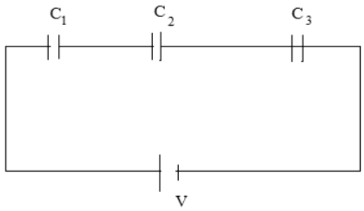
charge of A becomes $\left(q - \frac{3q}{4}\right) = \frac{q}{4}$

So, new force $F' = k\frac{\frac{q}{4}\times\left(-\frac{q}{4}\right)}{r^2}$

$$= \frac{1}{16} \times \left(-\frac{kq^2}{r^2}\right)$$
$$= \frac{F}{16} \quad \text{(Ans)}$$

24. Explain series combination of Capacitors. Derive the formula for equivalent capacitance.

Solution: When one terminal of a capacitor is connected to the terminal of another capacitors, called series combination of capacitors.



In series, each capacitor has same charge flow from battery. The three capacitors C_1, C_2 and C_3 are in series.

Now, charge on first capacitor is $Q_1 = C_1V_1$,
charge on second capacitor is $Q_2 = C_2V_2$
and charge on third capacitor is $Q_3 = C_3V_3$.
In series, $Q_1 = Q_2 = Q_3 = Q$ and $Q = C_sV$
Also, $V = V_1 + V_2 + V_3$

$$\Rightarrow \frac{Q}{C_s} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\Rightarrow \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

This is the formula for equivalent capacitance in series.

25. What are dielectrics?

Answer:

Dielectrics: Dielectrics are insulators. They do not have any free electrons and hence do not conduct electricity. However, they transmit an electric field.

26. Give some examples of dielectric materials.

Answer: Examples of dielectric materials are ceramic, mica, plastics, and glass.

27. How does the dielectric increase the capacitance of a capacitor?

Answer: The electric field between the plates of parallel plate capacitor is directly proportional to capacitance C of the capacitor. The strength of the electric field is reduced due to the presence of dielectric. If the total charge on the plates is kept constant, then the potential difference is reduced across the capacitor plates. In this way, dielectric increases the capacitance of the capacitor.

28. Define breakdown voltage.

Answer:

Breakdown Voltage: Breakdown voltage for a dielectric is the maximum voltage at which, applied electric field becomes so high that electrons break up from the molecules of dielectric and becomes free inside the dielectric due to this dielectric becomes conductive.

29. What is dielectric breakdown?

Solution:

Dielectric Breakdown: Electrical breakdown or dielectric breakdown is a long reduction in the resistance of an electrical insulator when the voltage applied across it exceeds the breakdown voltage. This results in the insulator becoming electrically conductive.

30. Three Capacitors 10, 20, 25 μF are Connected in Parallel with a 250V Supply. Calculate the Equivalent Capacitance.

Solution:

Given, $C_1 = 10\mu F, C_2 = 20\mu F, C_3 = 25\mu F$
Equivalent capacitance of a parallel combination is,
$C_p = C_1 + C_2 + C_3$
$C_p = 10 + 20 + 25 = 55\mu F$

31. Two Condensers of Capacities 10 μF and 25 μF are Charged to 12 V and 24 V respectively. What is the Common Potential When they are Connected in Parallel?

Solution:

$C_1 = 10\mu F, C_2 = 25\mu F$
$V_1 = 12V, V_2 = 24V$
Charge on 1st condenser,
$Q_1 = C_1V_1 = 10 \times 10^{-6} \times 12 = 120 \times 10^{-6}C$
Charge on 1st condenser,
$Q_2 = C_2V_2 = 25 \times 10^{-6} \times 24 = 600 \times 10^{-6}C$
Total charge $Q = Q_1 + Q_2$
$= 120 \times 10^{-6} + 600 \times 10^{-6}$
$= 720 \times 10^{-6}C$
Equivalent capacitance of a parallel combination is, $Cp = C_1 + C_2$
$= 10 + 25 = 35\,\mu F = 35 \times 10^{-6}F$
If V is common potential, Q = CV

$$\Rightarrow V = \frac{Q}{C} = \frac{720 \times 10^{-6}}{35 \times 10^{-6}} = 20.57V \text{ (Ans)}$$

1. **The SI unit of resistivity or specific resistance is-**
   (a) $\boldsymbol{Ohm.m^{-1}}$
   (b) $\boldsymbol{Vm^{-1}}$
   (c) $\boldsymbol{Vm}$
   (d) $\boldsymbol{Ohm.m}$
   Explanation:
   Specific resistance $\rho = \frac{RA}{L}$
   ∴ SI unit of specific resistance
   $= \frac{\Omega \times m^2}{m} = \Omega\, m$ or Ohm.m
   Answer: (d)

2. **If the current flowing through a circuit is 0.5A in 5 minutes, the amount of charge flowing through it is-**
   (a) 216C
   (b) 300C
   (c) 150C
   (d) 25C
   Explanation:
   Given, current $I = 0.5A$
   Time $t = 5 \text{ min} = 5 \times 60 = 300$ Sec.
   ∴ The amount of charge,
   $Q = It = 0.5 \times 300 = 150C$
   Answer: (c)

3. **A source of emf 2V sends 0.2A current to an external circuit for 5s. The energy used by the source is-**
   (a) 0.2 J
   (b) 0.4 J
   (c) 4.0 J
   (d) 2.0 J
   Explanation:
   We know, $H = I^2Rt$ [As usual notation]
   $\Rightarrow H = I^2 \times \frac{V}{I} \times t$ [$\because V = IR$]
   $\Rightarrow H = IVt$
   $= 0.2 \times 2 \times 5 = 2.0$ J
   Answer: (d)

4. **Specific resistance of the material of wire is $\boldsymbol{45 \times 10^{-8}}$ $\boldsymbol{\Omega m}$. The length of the wire (radius 0.25mm) required to make a resistance of 8Ω is-**
   (a) 5m
   (b) 4.5m
   (c) 3.5m
   (d) 2.5m
   Explanation:
   Given, specific resistance $\rho = 45 \times 10^{-8}\ \Omega m$
   Resistance $R = 8\Omega$
   Radius of wire $r = 0.25mm = 0.25 \times 10^{-3}m$
   ∴ Area $A = \pi r^2 = \pi \times (0.25 \times 10^{-3})^2$
   $= 0.196 \times 10^{-6}m^2$
   We, know $R = \rho \frac{l}{A}$
   $\Rightarrow 8 = 45 \times 10^{-8} \times \frac{l}{0.196 \times 10^{-6}}$
   $\Rightarrow l = \frac{8 \times 0.196 \times 100}{45} = 3.48 \approx 3.5m$
   Answer: (c)

5. **The resistance of a wire of length 170 cm and diameter 0.3 mm is 4Ω. The specific resistance of the material of the wire is-**
   (a) $\boldsymbol{1.66 \times 10^{-4}}$ **Ωm**
   (b) $\boldsymbol{1.66 \times 10^{-3}}$ **Ωm**
   (c) $\boldsymbol{1.66 \times 10^{-5}}$ **Ωm**
   (d) none of these
   Solution:
   We know, $R = \rho \frac{l}{A}$ [with usual notation]
   ∴ Specific resistance,
   $\rho = \frac{RA}{l} = \frac{4 \times \frac{\pi}{4} \times (0.3 \times 10^{-3})^2}{170 \times 10^{-2}}$
   $= \frac{\pi \times 0.09 \times 10^{-6}}{170 \times 10^{-2}} = 1.66 \times 10^{-4}\ \Omega$m
   Answer: (a)

6. **The length of a conducting wire be made half and the area of cross section be made double, the resistance becomes-**
   (a) four times
   (b) two times
   (c) halved
   (d) one-fourth
   Solution:
   We know resistance $R = \rho \frac{l}{A}$
   According to given condition the new resistance
   $R' = \rho \frac{\frac{l}{2}}{2A} = \frac{1}{4}\left(\rho \frac{l}{A}\right) = \frac{1}{4}R$
   Answer: (d)

7. **The length of a conducting wire be made half and the area of cross section be made double, the specific resistance is-**
   (a) unchanged
   (b) halved
   (c) doubled
   (d) quadrupled
   Explanation: For particular material specific resistance is constant. It does not depend on dimension of material i.e. length, area of cross section, etc.
   Answer: (a)

8. A carbon resistor has three strips of red colour and a gold strip. What is the value of the resistor?
(a) $(200 \pm 5\%)\Omega$
(b) $(2000 \pm 5\%)\Omega$
(c) $(2200 \pm 5\%)\Omega$
(d) $(2220 \pm 5\%)\Omega$

Explanation:
First band represents the first significant figure of resistor value. Second band represents the second significant figure of resistor value. Third band represents the decimal multiplier after the first-two significant figures of resistor value. Fourth band represents the tolerance of resistor. According to colour code : red (2), gold (5 %).
Thus resistance value is $(22 \times 10^2 \pm 5\%)\Omega$
$= (2200 \pm 5\%)\Omega$
Answer: (c)

9. The specific resistance of copper depends on-
(a) length
(b) area of cross section
(c) temperature
(d) all of these

Explanation: The resistivity or specific resistance of a material is an intensive property and depend only on material and temperature.
Answer: (c)

10. The resistance 6Ω and 3Ω are connected in parallel and the combination is connected in series with a 4Ω resistance. A battery of emf 6V is connected across the combination. current passing through the battery is-
(a) 1A
(b) >1A
(c) <1A
(d) none of these

Solution:
The equivalent resistance of 6Ω and 3Ω are connected in parallel are-
$R_p = \frac{6\times3}{6+3} = \frac{6\times3}{9} = 2\Omega$
2Ω and 4Ω resistance connected in series then equivalent resistance $R = 2 + 4 = 6\Omega$
Given voltage $V = 6V$
∴ Current passing through battery
$I = \frac{V}{R} = \frac{6}{6} = 1\text{A}$
Answer: (a)

11. A bulb rated 60W-240V is connected to a 160V main. The current through the bulb is-
(a) 1/2 A
(b) 1/3 A
(c) 1/6 A
(d) 1/12 A

Solution: Rating of bulb 60W-240V
∴ Resistance of bulb $R = \frac{V^2}{P} = \frac{240^2}{60}$
$= \frac{240\times240}{60} = 960\Omega$
Now, voltage of main 160V
So, current $I = \frac{V}{R} = \frac{160}{960} = \frac{1}{6}A$
Answer: (c)

12. Two resistances of 6Ω and 8Ω are connected in parallel and the combination is connected across 24V battery. The total power consumed is-
(a) 48W
(b) 84W
(c) 168W
(d) 36W

Solution:
Given, $R_1 = 6\Omega, R_2 = 8\Omega, V = 24V$
Now, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{8} = \frac{8+6}{8\times6} = \frac{14}{8\times6} = \frac{7}{24}$
$\Rightarrow R = \frac{24}{7}$
So, power $P = \frac{V^2}{R} = \frac{24^2}{\frac{24}{7}} = 168W$
Answer: (c)

13. The ratio of resistances of two bulbs of powers 40W and 60W, designed to operate at 110V and 220V respectively, is –
(a) 3 : 8
(b) 3 : 4
(c) 3 : 2
(d) 3 : 1

Solution: Given,
$P_1 = 40W, P_2 = 60W$
$V_1 = 110V, V_2 = 220V$
Now, $R = \frac{V^2}{P}$
$\therefore R_1 : R_2 = \left(\frac{V_1^2}{P_1}\right) : \left(\frac{V_2^2}{2}\right)$
$= \frac{110^2}{40} : \frac{220^2}{60}$
$= \frac{110\times110}{40} : \frac{220\times220}{60}$
$= \frac{1\times1}{2} : \frac{2\times2}{3}$
$= \frac{1}{2} : \frac{4}{3} = 3 : 8$
Answer: (a)

14. When current is passed through a junction of two dissimilar metals, heat is evolved or absorbed at the junction. This process is called-

(a) Seeback effect
(b) Joule effect
(c) Peltier effect
(d) Thomson effect

Explanation:

Peltier Effect: When an electric current is passed through two dissimilar conductors connected to form a thermocouple, heat is evolved at one junction and absorbed at the other end. The absorption and evolution of heat depends on the direction of flow of current.

Answer: (c)

15. State Ohm's law. Point out the limitation of this law.

Answer:

Ohm's Law: According to ohm's law, voltage induced across a conductor is proportional to the current it carries. i.e. $V \propto I$

$$\Rightarrow V = IR$$

Where

R: Resistance which is constant for a given conductor of fixed geometry and at fixed temperature.

Limitations of Ohm's law are:

(i) It is applicable only for linear conductors.

(ii) It is not applicable if temperature is not constant.

16. State Joule's law in current electricity.

or

State Joule's law of heating.

Answer:

Joule's Law: Joule's law of heating states that when current flows through a conductor, the amount of heat produced (H) in it is directly proportional to

1) Square of current (I^2) flowing through the conductor for a given resistance and time.
2) Resistance (R) of the conductor for a given current and time.
3) Time (t) for which current is passed through a given conductor.

The expression for the amount of heat produced is given by $H = \frac{1}{J} I^2 Rt$ [$J = constant = 4.2\, J/cal$]

17. Define the term electrical resistivity of a material. Write its SI unit.

Answer: The electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section. It is denoted by ρ.

Mathematically, $\rho = \frac{RA}{l}$ [As usual notation]

The unit of ρ is ohm.m or Ωm

18. Write down the relation between resistance of a conductor and temperature.

Answer:

The relation between resistance and temperature of a conductor is

$$R_t = R_0(1 + \alpha\Delta t)$$

Where,

R_t = Resistance at t°C

R_0 = Resistance at 0°C

α = Temperature coefficient of resistance

Δt = Rise in temperature

19. Define temperature coefficient of resistance.

Answer: The temperature coefficient of resistance is defined as the change in resistance per unit resistance per degree rise in temperature based upon the resistance at °C.

20. What is super conductivity?

Answer:

Superconductivity: Superconductivity simply states that there is no resistance or almost zero resistance in the material or any object. A material or an object that shows such properties is known as a superconductor.

21. State Kirchhoff's rules for an electric network.

Answer:

Kirchhoff's Current Law: The algebraic sum of currents entering and leaving a node of an electrical network is zero.

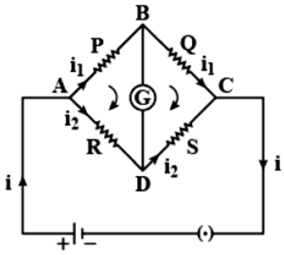
$$\therefore \sum I = 0$$

Kirchhoff's Voltage Law: The algebraic sum of I.R products is equal to the algebraic sum of emfs, in any closed mesh of an electrical network.

$$\therefore \sum(I.R) = \sum E$$

22. Draw a circuit diagram for a Wheatstone bridge. For a Wheatstone bridge, use Kirchhoff's law to obtain its balance condition.

Answer:



The potential at B is equal to potential at D. So no, current flows through the galvanometer. This is called balanced condition of Wheatstone's bridge.

In closed circuit ABDA applying Kirchhoff's rule,

$i_1 P - i_2 R = 0$ or $i_1 P = i_2 R$ …… (1)

In closed mash BCDB,

$i_1 Q - i_2 S = 0$ or, $i_1 Q = i_2 S$ …… (2)

Dividing equation (1) by equation (2)

$\frac{i_1 P}{i_1 Q} = \frac{i_2 R}{i_2 S} \Rightarrow \frac{P}{Q} = \frac{R}{S}$

i.e. if the ratio of the resistance connected in the circuit in this way are equal then the galvanometer will be in its balanced condition.

23. Explain Peltier effect.

Answer:

Peltier Effect: According to this effect, when electric current passes through a part of a circuit consisting of dissimilar conductors, there is a temperature difference at the junction of the two conductors.

Example: If a circuit wire is made by joining a small piece of Bismuth wire in between the copper circuit wire, the temperature rises in the junction where the current goes from copper to bismuth and a temperature drop is observed at the junction where electric current passes from bismuth to copper.

24. Explain Seebeck effect.

Answer:

Seebeck Effect: When heat is applied to one of the two conductors or semiconductors, that metal heats up. Consequently, the valence electrons present in this metal flow toward the cooler metal. This happens because electrons move to where energy (in this case, heat) is lower. If the metals are connected through an electrical circuit, direct current flows through the circuit.

However, this voltage is just a few microvolts per kelvin temperature difference. The Seebeck effect and its resultant thermoelectric effect is a reversible process.

25. Distinguish between Peltier effect and Joule effect.

Answer:

Difference between Peltier effect and Joule effect:

Peltier Effect	Joule Effect
It is a reversible process	Is an irreversible process
It takes place only at one junction	It takes place throughout the conductor
Heat is either evolved or absorbed	Heat is only evolved
Two different materials are required in it	Single material is sufficient for it

26. Seebeck effect is a _____ process.

Answer:

Seebeck effect is a <u>thermoelectric</u> process.

27. Give two practical applications of thermoelectricity.

Answer: Practical application of thermoelectricity are-

(i) Thermoelectric Generator: It is generate electric power using Seebeck effect.

(ii) Thermoelectric Reffigerator: It based on Peltier Effect.

28. If the voltage across the bulb is decreased by 1%, what will be the percentage change in its power?

Answer:

Power, $P = \frac{V^2}{R}$ [As usual notation]

$\Rightarrow \log P = \log\left(\frac{V^2}{R}\right)$

$\Rightarrow \log P = \log V^2 - \log R$

$\Rightarrow \log P = 2\log V - \log R$

$\therefore \frac{dP}{P} = 2\frac{dV}{V} - 0$ [$\because$ R is constant]

$\Rightarrow \frac{dP}{P} = 2 \times 1\%$ $\left[\text{Given} \frac{dV}{V} = 1\%\right]$

$\Rightarrow \frac{dP}{P} = 2\%$

$\therefore$ Power of the bulb decreased by 2% (Ans)

29. Out of resistance (R) and specific resistance (ρ), which is more fundamental and why?

Answer: Specific resistance is more fundamental than resistance. Because for particular material specific resistance is constant. It does not depend on dimension of material i.e. length, area of cross section, etc. like resistance. But only depends on temperature.

30. State the factors on which the thermo-emf developed in a thermocouple depends.

Answer: The origin of thermo emf in a thermocouple depends on the following factors:

1) Nature of the metals and

2) Temperature difference maintained between the junctions

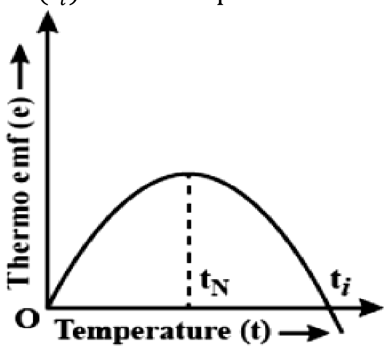
31. How is emf different from potential difference? Explain.

Answer: Potential difference refers to the difference in voltages between any two given points in a circuit. It depends on the resistance of the circuit.

Electromotive force(emf) refers to the voltage developed by an electrical source like cell/ battery/ generator in a circuit. It does not depend upon the resistance of the circuit.

32. Define neutral temperature, inversion temperature in respect to thermo-emf. What is relation between them?

Answer: Keeping the temperature of the cold junction constant, the temperature of the hot junction is gradually increased. The thermo emf rises to a maximum at a temperature (t_N) called neutral temperature and then gradually decreases and eventually becomes zero at a particular temperature (t_i) called temperature of inversion.



The variation of thermo emf(e) with temperature(t) is as shown in the curve and the relationship between them is

$e = \alpha t + \frac{1}{2}\beta t^2$

when the cold junction is at 273K

When the temperature at cold junction is increased, the neutral temperature is the same while the inversion temperature $t_i = (2t_n - t_0)$ decreases.

33. Write the differences between Peltier effect and Joule effect.

Answer:

The major differences of these two effects are:-

1) The Peltier effect is thermally reversible. But Joule effect is not reversible.

2) In the Peltier effect the heat is generated at one junction and absorbed at another junction. While in Joule effect the heat is generated throughout the wire.

34. What is an equipotential surface? Mention properties of equipotential surface.

Answer: Equipotential surface is a surface obtained by joining all the points in an electric field having same electric potential.

Properties of equipotential surface are given below,

(i) Electric field is always perpendicular to the equipotential surface at every point.

(ii) Work done on moving a charge on an equipotential surface is zero.

35. Why work done on moving a charge on an equipotential surface is zero.

Answer: We also know that when the work done is zero because the direction of electric field and the displacement of the charge are perpendicular.

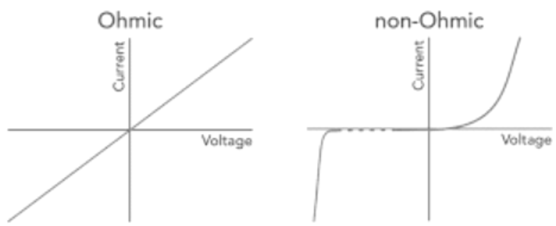
36. What are meant by ohmic and non-ohmic resistor?

Answer:

(a) Ohmic resistors are the resistors which obey ohms law. Non ohmic resistors are those which do not obey ohms law.

(b) In ohmic resistors current is directly proportional to voltage. In non ohmic resistors there is no linear relationship.

(c) Examples of ohmic resistors are carbon and metals. Examples of non ohmic resistors are semiconductors.



37. A wire of 15Ω resistance is gradually stretched to double to its original length. It is then cut into two equal parts. These parts are then connected in parallel across a 3V battery. Find the current drawn from the battery.

Solution: When a resistor is stretched to double in original length its cross-section area is reduced to half of its original value so that the volume remains same. The new resistance

$R' = \rho \frac{2l}{\frac{A}{2}} = 4\left(\rho \frac{l}{A}\right) = 4R = 4 \times 15 = 60\Omega$

Resistance of each part $= \frac{60}{2} = 30\Omega$

i.e. $R_1 = 30\Omega$ and $R_2 = 30\Omega$

When they are connected in parallel the effective resistance $R_p = \frac{R_1 R_2}{R_1 + R_2} = \frac{30 \times 30}{30 + 30} = \frac{30 \times 30}{60} = 15\Omega$

$\therefore$ Current $I = \frac{V}{R_p} = \frac{3}{15} = \frac{1}{5} = 0.2A$ (Ans)

38. The ratios between the lengths, diameters, and resistivities of two wires are each equal to 1:2. If the thinner wire has been the resistance 20Ω, find the resistance of the other wire.

Solution:

Given, $R_1 = 20\Omega$

$\frac{l_1}{l_2} = \frac{d_1}{d_2} = \frac{\rho_1}{\rho_2} = \frac{1}{2}$

As area $A \propto d^2$ $\therefore \frac{A_1}{A_2} = \frac{d_1^2}{d_2^2}$

We know resistance $R = \rho \frac{l}{A}$ [As usual notation]

$\therefore \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \frac{A_2}{A_1}$

$\Rightarrow \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \frac{d_2^2}{d_1^2} = \frac{1}{2} \times \frac{1}{2} \times \frac{2^2}{1^2} = 1$

$\Rightarrow R_1 = R_2 = 20\Omega$

So, resistance of the other wire is 20Ω. (Ans)

39. Find the equivalent resistance in parallel combination of three resistances 7Ω, 5Ω and 3Ω.

Solution:

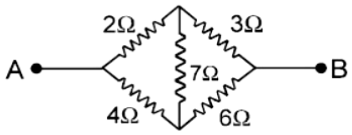
Let, the equivalent resistance is R.

$\therefore \frac{1}{R} = \frac{1}{7} + \frac{1}{5} + \frac{1}{3}$

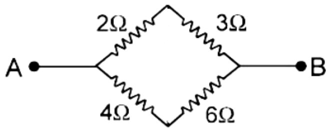
$\Rightarrow \frac{1}{R} = \frac{15+21+35}{7 \times 5 \times 3} = \frac{71}{105}$

$\Rightarrow R = \frac{105}{71} = 1.48\Omega$ (Ans)

40. Five resistances are connected as shown in the figure. The potential difference between A and B is 4V. Find the current drawn in the given network.



Solution: In the given circuit, the arrangement of resistances is a form of Wheatstone's bridge. Hence no current will flow through 7Ω resistor. So the given circuit can be shown as below



The resistances between A and B will be parallel combination of each other.

Let, the equivalent resistance is R.

$\therefore \frac{1}{R} = \frac{1}{2+3} + \frac{1}{4+6}$

$\Rightarrow \frac{1}{R} = \frac{1}{5} + \frac{1}{10} = \frac{2+1}{10} = \frac{3}{10}$

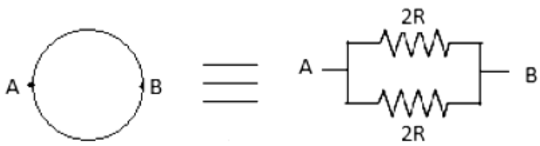
$\therefore R = \frac{10}{3}\ \Omega$

Now, given potential difference $V = 4V$

$\therefore$ Current $I = \frac{V}{R} = \frac{4}{\frac{10}{3}} = \frac{6}{5} = 1.2A$ (Ans)

41. A wire of resistance 4RΩ is bent in the form of a circle. What is the effective resistance between the ends of the diameter?

Solution: When a wire of resistance 4R is bent in the form of circle, then the resistance of each segment across the diameter becomes 2R as shown in the figure.



If equivalent resistance between A and B be R_{AB}

$\therefore \frac{1}{R_{AB}} = \frac{1}{2R} + \frac{1}{2R}$

$\Rightarrow \frac{1}{R_{AB}} = \frac{2}{2R}$

$\Rightarrow R_{AB} = R$ (Ans)

42. An electric heater of resistance 200Ω connected to 220V power supply is immersed in water of mass 1kg. How long the electrical heater has to be switched on to increase the temperature of water from 30°C to 80°C. (The specific heat of water is $\boldsymbol{s = 4200 Jkg^{-1}}$).

Solution:

Let, t second time is required to warm the water.

Since, we know $H = I^2Rt$

$\Rightarrow H = \frac{V^2}{R} \times t \;\; [\because V = IR]$

$\Rightarrow H = \frac{(220)^2}{200} \times t = 242t$

Change in temperature $\theta = \theta_2 - \theta_1$

$= 80 - 30$

$= 50°C$

Now, we have $H = ms\theta$

$\Rightarrow 242t = 1 \times 4200 \times 50$

$\Rightarrow t = \frac{4200 \times 50}{242}$ sec.

$\Rightarrow t = \frac{4200 \times 50}{242 \times 60}$ min. = 14.46 min. (Ans)

43. An electric bulb is rated 60W-220V. Calculate the resistance of the bulb. If the bulb be connected across a 200V supply calculate the current through the bulb and electric energy consumed by the bulb in 1 hour.

Solution:

Given, power of bulb $P = 60W$

Voltage rating $V = 220V$

$\therefore$ Resistance of bulb $R = \frac{V^2}{P}$

$= \frac{220^2}{60} = 806.67\Omega$ (Ans)

If the bulb connected across 200V supply then

Current $I = \frac{V}{R} = \frac{200}{806.67} = 0.25A$ (Ans)

Power, $P = VI = 200 \times 0.25 = 50W$

$\therefore$ Electric energy consumed by the bulb in 1 hour

$= 50W \times 1hr$

$= 50\, W.hr$

$= 50 \times 3600$ J = 180 kJ (Ans)

44. A heating element of a boiler rated at 220V gives of 580kJ of heat in 10 minutes. What is the resistance of the element?

Solution:

Given, voltage $V = 220V$

Time taken, $t = 10$ min $= 10 \times 60 = 600$ sec.

Amount of heat transfer $H = 580kJ = 580 \times 10^3\, J$

So, power $P = \frac{H}{t} = \frac{580 \times 10^3}{600} = 966.67$ W

$\therefore$ Resistance $R = \frac{V^2}{P} = \frac{220^2}{966.67} = 50.06\Omega$ (Ans)

45. An electric kettle is rated 1kW-220V. Using this kettle, 20 minutes will be required to heat 2kg of water from 25°C to 100°C. What percentage of heat developed is utilized for heating water.

Solution:

Mass of water $m = 2$kg

Change in temperature $\Delta t = 100 - 25 = 75°C$

Specific heat of water $s = 4200\, Jkg^{-1}K^{-1}$

$\therefore$ Heat energy required

$H = ms\Delta t = 2 \times 4200 \times 75$ J

$= \frac{2 \times 4200 \times 75}{1000}$ kJ

$= 630$ kJ

Power of kettle $P = 1kW = 1000W$

Time taken $T = 20$ min. $= 20 \times 60 = 1200$ sec.

$\therefore$ Electric energy consumed $= PT$

$= 1000 \times 1200$ J

$= 1200$ kJ

So % of heat developed is utilized for heating water $= \frac{630}{1200} \times 100 = 52.5\%$ (Ans)

46. The resistance of a coil at 30°C is 15Ω. If the resistance of the coil at 100°C be 18Ω, calculate the value of the temperature coefficient of resistance of the coil.

Solution:

Given, $R_1 = 15\Omega$, $R_2 = 18\Omega$

Change in temperature $\Delta T = 100 - 30 = 70°C$

Now, $R_2 = R_1(1 + \alpha\Delta T)$

$\Rightarrow 18 = 15(1 + \alpha \times 70)$

$\Rightarrow 18 = 15 + 1050\alpha$

$\Rightarrow 1050\alpha = 3$

$\Rightarrow \alpha = \frac{3}{1050} = 2.85 \times 10^{-3}$

$\therefore$ The temperature coefficient of resistance of the coil is $2.85 \times 10^{-3}\, °C^{-1}$ (Ans)

47. Calculate the voltage of a battery connected to a parallel plate capacitor with a plate area 2.0 $\boldsymbol{cm^2}$ and a plate separation 2.0 $\boldsymbol{mm}$ if the charge stored on the plate is 4.0 $\boldsymbol{pC}$.

Solution:

Given, $q = 4.0\, pC = 4 \times 10^{-12} C$

$d = 2.0\, mm = 2 \times 10^{-3}\, m$

$A = 2.0\, cm^2 = 2 \times 10^{-4}\, m^2$

$\epsilon_0 = 8.854 \times 10^{-12}\, C^2N^{-1}m^{-2}$

From the formula of capacitance we know

$C = \frac{q}{V} = \frac{\epsilon_0 A}{d}$

$\Rightarrow V = \frac{qd}{\epsilon_0 A} = \frac{4 \times 10^{-12} \times 2 \times 10^{-3}}{8.854 \times 10^{-12} \times 2 \times 10^{-4}}$

$= 4.52\, V$ (Ans)

1. **The formula for the magnetic field well inside a long solenoid of length L and total number of turns N, carrying a current I is-**
   (a) $\mu_0 NI/2$
   (b) $\mu_0 NI/2L$
   (c) $\mu_0 NI/L$
   (d) none of these
   Explanation:
   Number of turns per unit length is, $n = \frac{N}{L}$
   Where, L is the length of the solenoid.
   Magnetic field inside the solenoid is,
   $B = \mu_0 nI$
   $\Rightarrow B = \mu_0 \frac{N}{L} I = \mu_0 NI/L$
   Answer: (c)

2. **Lenz's law in electromagnetic induction is another form of the law of-**
   (a) conservation of energy
   (b) conservation of charge
   (c) conservation of mass
   (d) none of these
   Explanation: Lenz's law in electromagnetic induction is another form of the law of conservation of energy. When a current is induced by moving a wire through a magnetic field, is that we are converting mechanical energy into electrical energy.
   Answer: (a)

3. **A moving charge produces-**
   (a) an electric field only
   (b) a magnetic field only
   (c) both (a) and (b)
   (d) none of these
   Explanation: A stationary charge produces only electric field whereas a moving charge produces both electric as well as magnetic fields.
   Answer: (c)

4. **Which of the following does not exist?**
   (a) static charge
   (b) moving charge
   (c) magnetic dipole
   (d) magnetic monopole
   Explanation: Hypothetically, the magnetic monopole is similar to the electric charge particle like an electron. In the case of magnets, no magnetic monopole is exists. The magnet always has two poles:
   Answer: (d)

5. **The SI unit of magnetic flux is-**
   (a) Weber
   (b) Gauss
   (c) Oersted
   (d) Tesla
   Explanation: Mathematically it is represented as
   $$B = \Phi/A$$
   where B is magnetic flux density in teslas (T), Φ is magnetic flux in webers (Wb), and A is area in square meters (m^2). The SI unit for magnetic flux density is the tesla which is equivalent to webers per square meter.
   Answer: (a)

6. **The SI unit of magnetic flux density is-**
   (a) Weber
   (b) Gauss
   (c) Oersted
   (d) Tesla
   Explanation: Mathematically it is represented as
   $$B = \Phi/A$$
   where B is magnetic flux density in teslas (T), Φ is magnetic flux in webers (Wb), and A is area in square meters (m^2). The SI unit for magnetic flux density is the tesla which is equivalent to webers per square meter.
   Answer: (d)

7. **The SI unit of self inductance is Henry which can also be expressed as-**
   (a) $Volt.s.Amp$
   (b) $Volt.s.Amp^{-1}$
   (c) $Volt.s^{-1}.Amp^{-1}$
   (d) $Volt.s.Amp^{-2}$
   Explanation: Inductance can be written as the ratio of magnetic flux to the current flowing. So, the unit, henry can be written as $\frac{weber}{Ampere}$. The unit weber can be written as the product of volt and second, so the unit, henry becomes $\frac{Volt.second}{Ampere}$ or $Volt.s.Amp^{-1}$.
   Answer: (b)

8. **SI unit of magnetic pole strength is**
   (a) Am (b) Am^{-1} (c) Am^{-2} (d) Am^2
   Explanation:
   Magnetic pole strength is the strength of a magnetic pole to attract magnetic materials towards itself. S.I. unit of magnetic pole strength is Ampere-meter (Am).
   Answer: (a)

9. The induced emf in a 1 milihenry inductor in which the current changes from 5A to 3A in 10^{-3} sec. is –

(a) $2 \times 10^{-6}\ V$
(b) $8 \times 10^{-6}\ V$
(c) $2\ V$
(d) $8\ V$

Explanation:
Given, $L = 1mH = 10^{-3}H$
Change in current $dI = 3 - 5 = -2A$
Change in time $dt = 10^{-3}$ sec.
∴ Induced emf $e = -L\frac{dI}{di}$
$\Rightarrow e = -10^{-3} \times \frac{-2}{10^{-3}} = 2\ V$
Answer: (c)

10. If a conductor moves across a magnetic field, the direction of induced emf is obtain from-

(a) Laplace's law
(b) Fleming's left hand rule
(c) Flemings right hand rule
(d) none of these

Explanation: The direction of induced emf is determined by right hand rule. As per the the rule, if the thumb is pointed in the direction of motion of the conductor and the first finger is pointed in the direction of the magnetic field (north to south), then the second finger represents the direction of the induced current.
Answer: (c)

11. What is magnetic flux?
Answer:
Magnetic Flux: Magnetic flux is defined as the number of magnetic field lines passing through a given closed surface. Here, the area under consideration can be of any size and under any orientation with respect to the direction of the magnetic field.
Magnetic Flux Unit:
The SI unit of magnetic flux is Weber (Wb).
The fundamental unit is Volt-seconds.
The CGS unit is Maxwell.

12. Mention the working principle of a moving coil galvanometer.
Answer: The working principle of a moving coil galvanometer is when a current-carrying coil is placed in a magnetic field, it will experience a torque.

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13. What is magnetic flux density? Write its SI unit.
Answer:
Magnetic flux density: Magnetic flux density is defined as the force acting per unit current per unit length on a wire placed at right angles to the magnetic field. It is a vector quantity. Magnetic flux is denoted by "B".
$B = \frac{F}{IL}$ [As usual notation]
The SI unit is Tesla(T) or $Kgs^{-2}A^{-1}$.
The CGS unit is Gauss (G)

14. If a static charge is placed inside a magnetic field, will there be any force acting on it?
Answer: Magnetic field has no action in static charge. But in moving charge force will act on it.

15. What is induced emf?
Answer:
Induced emf: When we pass the current through a solenoid/coil, then the magnetic flux associated with this coil will change, and to oppose this change in flux a potential difference is generated in the opposite direction which is known as induced emf.

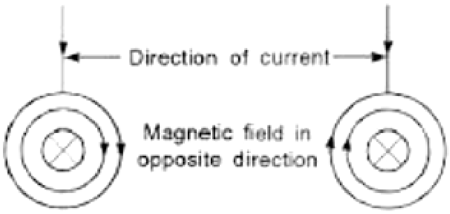
16. Why induced emf is also called back emf?
Answer:
Reasons why induced emf is called back emf:
(i) There is a current associated with this induced emf called induced current.
(ii) The direction of induced current in the solenoid is such that it opposes the change in magnetic flux in the coil.
(iii) The polarity of induced emf is such that it does not allow the magnetic flux to change in the solenoid.

17. Two parallel wires carry same current in same direction. What will happen?
Answer: Two current carrying conductors attract each other when the current is in the same direction and repel each other when the current is in opposite direction. This can be verified using Fleming's left-hand rule.

18. Give two example of magnetic dipole.
Answer: Examples of magnetic dipole are-
(i) Every atom of para and diamagnetic substance,
(ii) A loop of current

19. Two long parallel conductors carrying currents in the same direction attract each other. Explain.

Answer:

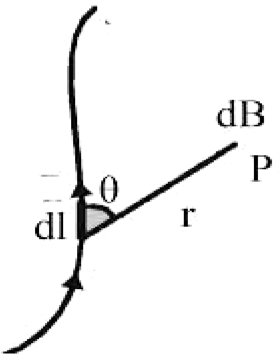


Two parallel wires carrying currents in the same direction attract each other due to magnetic interaction between two wires carrying currents because the current in a wire produces a magnetic field and the magnetic interaction is of attractive nature when current in the two parallel wires is in the same direction.

20. State Biot-Savart's law and write down its mathematical form in SI unit.

Answer:

Biot-Savart Law: Consider a wire carrying an electric current I and also consider an infinitely small length of a wire dl at a distance r from point P.



Biot Savart Law states that magnetic intensity dB at a point P due to current I flowing through a small element dl is-

a) Directly proportional to current (I)
b) Directly proportional to the length of the element (dl)
c) Directly proportional to the sine of angle θ between the direction of current and the line joining the element dl from point A.
d) Inversely proportional to the square of the distance (r) of point A from the element dl.

Combining we get, $dB \propto \frac{Idl \sin\theta}{r^2}$

$\Rightarrow dB = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{r^2}$ (In SI unit)

Where, $\mu_0 =$ Permeability of vacuum or air.

In SI system, $\mu_0 = 4\pi \times 10^{-7}\ WbA^{-1}m^{-1}$

21. Write down Biot-Savart law in vector form.

Answer:

Biot-Savart law, in vector form, can be written as-

$d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{l}\vec{r}\sin\theta}{r^3}$ [As usual notation]

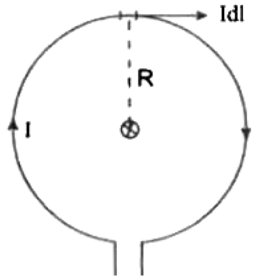
$\Rightarrow d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{l}\times\vec{r}}{r^3}$

$\Rightarrow d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{l}\times\hat{r}}{r^2}$ $\left[\because\ \hat{r} = \frac{\vec{r}}{|r|}\right]$

The direction of $d\vec{B}$ is perpendicular to the plane containing $d\vec{l}$ and $\vec{r}$.

22. A circular coil of radius *R* carries a current *I*. Derive the expression for the magnetic field due to this coil at its centre.

Answer:



Consider one such current element of length dl as shown in fig. Magnetic field at the centre point O of the loop due to this element, as per Bio-Sarvart's law is-

$dB = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{R^2}$

$\Rightarrow dB = \frac{\mu_0}{4\pi}.\frac{Idl}{R^2}$ $[\because \theta = 90°, \Rightarrow \sin 90° = 1]$

For whole circular loop,

$B = \int_0^B dB = \frac{\mu_0}{4\pi}.\frac{I}{R^2}\int_0^{2\pi R} dl$

$\Rightarrow B = \frac{\mu_0}{4\pi}.\frac{I}{R^2} \times 2\pi R$

$\Rightarrow B = \frac{\mu_0}{4\pi}.\frac{2\pi I}{R}$ Tesla

For N number of turns of coil,

$B = \frac{\mu_0}{4\pi}.\frac{2\pi NI}{R}$ Tesla

The magnetic field is directed perpendicular to the plane of paper directed inward.

23. Write an expression for magnetic field due to long straight conductor.

Answer:

Magnetic field $B = \frac{\mu_0}{4\pi}.\frac{2I}{R}$

Where

μ is the permeability of free

B is the magnetic field measure in tesla.

I is the current intensity flowing in the long wire.

R is the distance of the magnetic field from the wire.

24. State Faraday's laws of electromagnetic induction.

Answer:

Faraday's laws of electromagnetic induction:

First law: It states that whenever there is a change in magnetic flux associated with a coil, EMF is induced in that coil.

Second law: It states that the magnitude of EMF induced in the coil is directly proportional to the rate of change of magnetic flux associated with that coil.

Mathematically, it can be expressed as $\varepsilon = -\frac{d\phi}{dt}$, where ε is the induced EMF and $\frac{d\phi}{dt}$ is the rate of change of magnetic flux. For n number of turns in the coil, the expression is given as $\varepsilon = -n\frac{d\phi}{dt}$.

25. State Lenz's law.

Answer:

Lenz's Law: It states that when an emf is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced emf is such, that it produces a current whose magnetic field opposes the change which produces it. Mathematically,

$$\varepsilon = -n\frac{d\phi}{dt}$$

Here the negative sign is due to the Lenz's law.

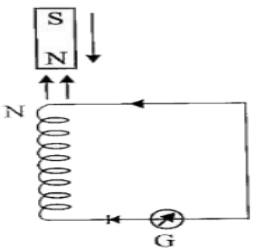
ε =emf, n = no. of turns,

$d\phi$ = Change in magnetic flux

dt = Change in times

26. Show that Lenz's law is in accordance with the law of conservation of energy.

Answer:



When N-pole of magnet is moved towards the coil, the upper face of the coil acquires north polarity. Therefore, work has to be done against the force of repulsion, in bringing the magnet closer to the coil. It is this mechanical work done in moving the magnet with respect to the coil that changes into electrical energy producing induced current. Thus, energy is being transformed only. Hence, Lenz.s law obey the principle of energy conservation.

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27. Define self inductance.

Answer:

Self Inductance: Self-inductance is the property of the current-carrying coil that resists or opposes the change of current flowing through it. This occurs mainly due to the self-induced emf produced in the coil itself.

28. Define mutual inductance.

Answer:

Mutual Inductance: When two coils are brought in proximity to each other, the magnetic field in one of the coils tends to link with the other. This further leads to the generation of voltage in the second coil. This property of a coil which affects or changes the current and voltage in a secondary coil is called mutual inductance.

SI unit of mutual inductance is Henry (H)

29. State Fleming's left hand rule.

Answer:

Fleming's Left Hand Rule: According to Fleming's left hand rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the first finger points in the direction of magnetic field and the second finger in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor.

30. State Fleming's right hand rule.

Answer:

Fleming's Right Hand Rule:

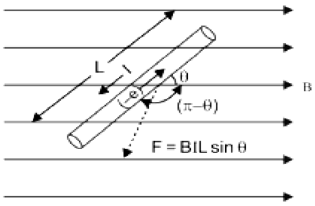
Fleming's Right hand rule shows the direction of induced current when a conductor attached to a circuit moves in a magnetic field. The thumb is pointed in the direction of the motion of the conductor relative to the magnetic field. The first finger is pointed in the direction of the magnetic field. Then the second finger represents the direction of the induced current.

31. What are ferromagnetic materials? Give an example.

Answer: The materials that can be permanently magnetized due to the presence of unpaired electrons are called ferromagnetic materials. Iron is an example of ferromagnetic material.

32. What is the magnitude of force on a current carrying conductor placed in a magnetic field?

Answer: The magnitude of force experienced by a current carrying conductor placed in a magnetic field is $F = BIL \sin\theta$



The direction of force is perpendicular to L and B.
F is maximum when $\theta = 90°$
F is minimum when $\theta = 0°$

33. What Is Lorentz Force?

Answer:

Lorentz Force: Lorentz force is defined as the combination of the magnetic and electric force on a point charge due to electromagnetic fields. It is used in electromagnetism and is also known as electromagnetic force.

Lorentz Force Formula:
$F = q(E + v \times B)$
Where,
F is the force acting on the particle
q is the electric charge of the particle
v is the velocity
E is the external electric field
B is the magnetic field

34. Define magnetic dipole and dipole moment?

Answer:

Magnetic Dipole: An arrangement of two magnetic poles of equal and opposite strength separated by a finite distance is called magnetic dipole.

Dipole Moment: The strength of a magnetic dipole is defined by its magnetic dipole moment, denoted as m, which is a vector quantity. The dipole moment is the product of the pole strength and the distance between the poles. The direction of the magnetic dipole moment points from the south pole to the north pole.

35. What are diamagnetic materials?

Answer: Diamagnetic materials are those that are not attracted to magnets and magnetic fields.

36. Give a few examples of diamagnetic materials.

Answer: Copper, Water, Bismuth, Zinc, Marble, Glass and Gold are a few examples of diamagnetic materials.

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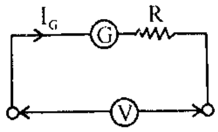
37. A proton enters a uniform magnetic field of strength 0.500T with a velocity of $2 \times 10^5\ ms^{-1}$. The magnetic field is directed along the Y-axis and the velocity is directed along X-axis. Find the magnitude of the force acting on the proton and its acceleration. (charge of proton $= 1.6 \times 10^{-19} C$, mass of proton $= 1.67 \times 10^{-27}\ kg$)

Solution: Given, magnetic field $B = 0.500\ T$
Velocity $v = 2 \times 10^5\ ms^{-1}$
Charge of proton $e = 1.6 \times 10^{-19} C$
Mass of proton $m = 1.67 \times 10^{-27}\ kg$
Now we have formula of $F = Bev$
$\Rightarrow F = 0.500 \times 1.6 \times 10^{-19} \times 2 \times 10^5$
$= 1.6 \times 10^{-14}\text{N}$ (Ans)
$\therefore$ Acceleration $a = \frac{F}{m}$
$\Rightarrow a = \frac{1.6\times10^{-14}}{1.67\times10^{-27}} = 0.96 \times 10^{12}\ ms^{-2}$ (Ans)

38. A galvanometer of resistance 50Ω gives full scale deflection when a current of 5001μA passes through it. It is to be converted into a voltmeter reading up to 10V. Explain this can be done. Circuit diagram is essential.

Solution:



Now, galvanometer resistance is 50Ω
and full scale deflection current is 5001μA
Now we have to convert it into a voltmeter of range 10V therefore resistance of galvanometer is to be made,
$G = \frac{V}{I_{full\ scale}} = \frac{10}{500\times10^{-6}} = 20000\Omega$
Therefore additional resistance in series required is $R = 20000 - 50 = 19950\Omega$ (Ans)

39. Explain what paramagnetic materials are.

Answer: Due to the presence of unpaired electrons in paramagnetic materials, the net magnetic moment of all electrons in an atom does not equal zero. As a result, atomic dipoles exist. The atomic dipoles align in the direction of the applied external magnetic field when it is applied. Paramagnetic materials are weakly magnetized in the direction of the magnetizing field.

40. Give examples of paramagnetic substances.

Answer: Tungsten, Caesium, Aluminium, Lithium, Magnesium and sodium are a few examples of paramagnetic substances.

1. **In germanium crystal, the energy band gap is-**
   (a) 0.068 eV
   (b) 6.8 eV
   (c) 68 eV
   (d) 0.68 eV
   Explanation: Energy band gap is the minimum energy required for shifting electrons from valence band to conduction band is called energy band gap. The energy band gaps of silicon and germanium are 1.1eV and 0.68eV respectively.
   Answer: (d)

2. **In a junction diode the holes are due to-**
   (a) protons
   (b) extra electrons
   (c) neutrons
   (d) missing electrons
   Explanation: A hole is an area in an atom where there isn't an electron. In the same way that an electron is a physical particle, a hole is not, but it can move from atom to atom in a semiconductor material.
   Answer: (d)

3. **In transistor the base is doped-**
   (a) heavily
   (b) moderately
   (c) lightly
   (d) randomly
   Explanation: In most transistors, emitter is heavily doped. Its job is to emit or inject electrons into the base. These bases are lightly doped and very thin, it passes most of the emitter-injected electrons on to the collector.
   Answer: (c)

4. **If I_{diff} and I_{drift} are diffusion current and drift current in an unbiased p-n junction diode, then-**
   (a) $I_{diff} = I_{drift}$
   (b) $I_{diff} > I_{drift}$
   (c) $I_{diff} < I_{drift}$
   (d) $I_{diff} \gg I_{drift}$
   Explanation: In an unbiased diode, these two currents are equal and opposite, leading to a momentary equilibrium where there is no net current flow. This is known as the zero bias condition. At this point, the total current is zero, and the drift current equals the diffusion current.
   Answer: (a)

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5. **If the forward bias voltage across a p-n junction be increased, the width of the depletion region-**
   (a) decrease
   (b) increase
   (c) remain same
   (d) increases proportionally to applied voltage
   Explanation: When, a voltage applied to the terminals of diode, the width of depletion region slowly starts decreasing. The reason for this is that in forward bias the direction of applied voltage always be opposite to that of barrier potential.
   Answer: (a)

6. **In the depletion region of a p-n junction, there is a shortage of-**
   (a) Acceptor ions
   (b) Holes and electrons
   (c) Donor ions
   (d) None of these
   Explanation: In the depletion region of an unbiased p-n junction there are shortage of free charge carriers like electrons and holes and there are only immobile charged ions.
   Answer: (b)

7. **Temperature coefficient of resistance of semiconductor is-**
   (a) positive
   (b) zero
   (c) constant
   (d) negative
   Explanation: The temperature coefficient of resistance of a semiconductor is negative. It means that resistance decrease with increase of temperature.
   Answer: (d)

8. **The output of a full wave rectifier is-**
   (a) an AC voltage
   (b) a constant DC voltage
   (c) zero
   (d) a pulsating unidirectional voltage
   Explanation: The output of a full wave rectifier is a unidirectional voltage that has ripples. This is because the rectifier circuit does not completely smooth out the AC signal. The ripples are caused by the fact that the rectifier only conducts during half-cycles of the AC signal.
   Answer: (d)

9. For obtaining a p-type semiconductor, doping is to be done with impurity material which is–
(a) tetravalent
(b) pentavalent
(c) trivalent
(d) none of these
Explanation: In a p-type semiconductor, a tetravalent semiconductor like silicon or germanium is doped with a trivalent impurity like aluminium, gallium, or boron.
Answer: (c)

10. What kind of impurity is chosen to make n-type and p-type semiconductors? Give examples.
Answer:
- For n-type semiconductor, pentavalent impurities like Arsenic, Antimony, Phosphorous and Bismuth are used.
- For p-type semiconductor, trivalent impurities like Gallium, Indium and Boron are used.

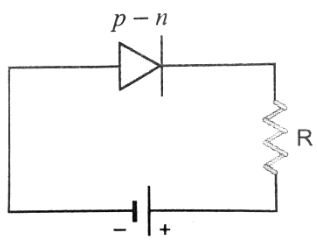
11. Doping of silicon with indium leads to which type of semiconductors?
Answer: Indium is a trivalent impurity atom. When added to an intrinsic semiconductor forms a semiconductor having holes as majority carriers and electrons as minority carriers. So p-type semiconductor is formed.

12. Which type of semiconductor is formed when silicon is doped with arsenic?
Answer: Whenever a pentavalent impurity would be introduced to an intrinsic or perfect semiconductor, the consequence is an n-type semiconductor. Donor impurities include pentavalent impurity or defects like phosphorus, arsenic, and antimony.

13. Which one of Silicon or Germanium has higher energy band gap?
Answer: A band gap, also called an energy band, is an energy range in a solid where no electron states can exist. It generally refers to the energy difference (in eV) between the top of the valence band and the bottom of the conduction band in insulators and semiconductors. The energy band gaps of silicon and germanium are 1.1eV and 0.7eV respectively. Therefore Silicon has higher energy band gap.

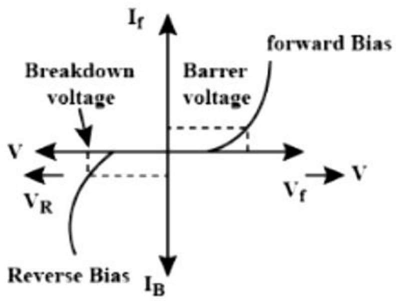
14. Which bias causes breakdown in p-n junction diode? Why?
Answer: Reverse bias causes breakdown in p-n junction diode. During reverse biasing, ionization of the atoms takes place. Since, the polarity of the voltage applied is negative, the minority charge carriers are accelerated. When the doping concentration is small, these minority charge carriers collide with other atoms releasing new electrons and thus producing more charge carriers, which causes breakdown.

15. Which type of biasing gives a semiconductor diode very high resistance? Draw a diagram showing this bias.
Answer: Reverse biasing gives a semiconductor diode very high resistance. The depletion layer of a diode is substantially thinner while in forward bias and much thicker when in reverse bias. Forward bias decreases a diode's resistance, and reverse bias increases a diode's resistance.



Reverse biased p-n junction diode

16. Draw the necessary circuit diagram for studying the forward bias and reverse bias characteristic curve (V-I curve) of a p-n junction diode.
Answer:



V - I characteristics of a p-n junction diode

17. Which band determines the electrical conductivity of a solid?
Answer: The forbidden band determines the conductivity of a solid.

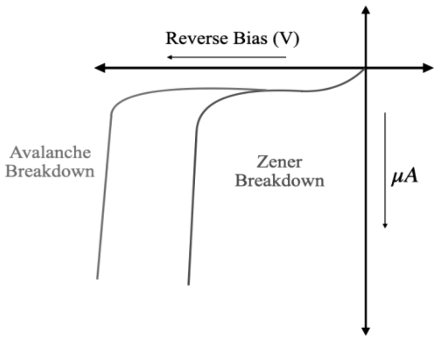
18. What are different types of breakdown in p-n junction diode?

Answer: There are two types of breakdowns in p-n junctions.

(1) Avalanche breakdown occurs due to the rapid collision of electrons with other atoms.

(2) Zener breakdown occurs because of the high electric field.

Zener breakdown is the controlled version of Avalanche breakdown in a modified p-n junction.



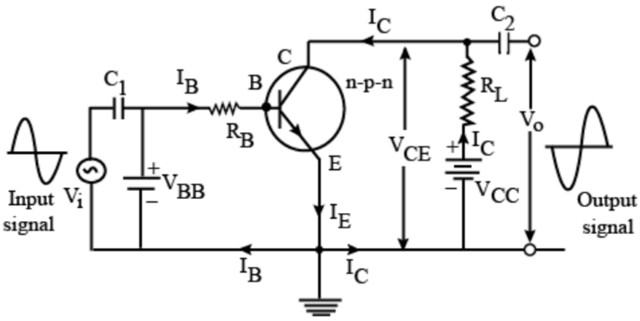
19. Define Zener breakdown?

Answer:

Zener Breakdown: The process in which the electrons move across the barrier from the valence band of p-type material to the conduction band of n-type material is known as Zener breakdown.

20. Draw the circuit diagram of a CE mode amplifier using n-p-n transistor. Show the input and output waveforms.

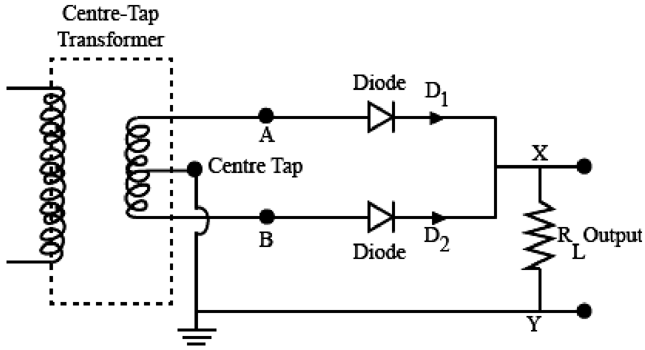
Answer:



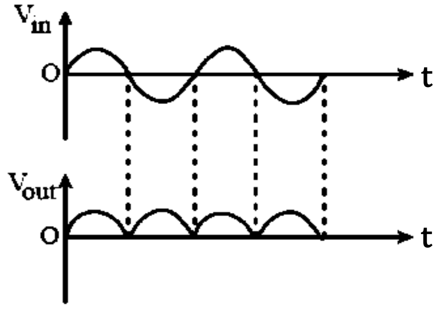
The purpose of this circuit is to amplify a small AC input signal, such as an audio or radio signal. A small AC voltage is applied to the input through a coupling capacitor. The ratio of the AC component of the output to the AC component of the input, is shown as gain.

21. Draw the circuit diagram of a full wave rectifier (Centre taped) using p-n junction diode and give its input and output wave forms.

Answer:



A full wave rectifier consists of two diodes connected in parallel across the ends of secondary winding of a centre tapped step down transformer. The load resistance R_L is connected across secondary winding and the diodes between A and B as shown in the circuit.



Input-Output waveforms

22. Write advantage and disadvantage of solar sell.

Answer: Solar cells, also known as photovoltaic cells, have several advantages and disadvantages.

Advantages:

(1) It is a renewable energy source.

(2) It is environmentally friendly

(3) Operating cost of solar cell is low.

(4) It can provide power in remote areas.

(5) Solar cells have a long lifespan.

Disadvantages:

(1) Solar energy is not available at night and can be reduced during cloudy or rainy weather.

(2) The initial investment for solar cell installation is high.

(3) Storing excess energy generated by solar cells can be costly.

(4) Large-scale solar farms require significant land area.

(5) The production of solar cells and their components can have environmental impacts.

23. Distinguish between an intrinsic semiconductor and p-type (extrinsic) semiconductor.

Answer:

Intrinsic Semiconductors	Extrinsic Semiconductors
Semiconductor in its purest form.	Semiconductor in its impure form.
It has low conductivity.	It has a higher conductivity.
The band gap between the conduction and valence bands is quite narrow.	The energy gap is greater than that of an intrinsic semiconductor.
Electrical conductivity depends on temperature only.	Electrical conductivity depends on temperature as well as amount of impurity.
Pure Silicon and Germanium crystalline forms are examples.	Impurities such as As, Sb, P, In, Bi, Al, and others are doped with Germanium and Silicon atoms.

24. Distinguish between p-type and n-type semiconductors.

Answer:

Differences between the P and N-type semiconductors:

P-type Semiconductor	N-type semiconductor
The p-type semiconductor is formed due to the dopping of III group elements i.e., Boron, aluminum, sodium, Thallium.	The n-type semiconductor is formed due to dopping of Nitrogen, Phosphorus, Arsenic, Antimony, Bismuth.
These are also known as Trivalent semiconductors.	These are also known as pentavalent semiconductors.
P-type semiconductors are positive type semiconductor it means it a deficiency of 1 electron is required.	The n-type semiconductor is negative type semi-conductor it means an excess of 1 electron is required.
In P-type semiconductor majority, charge carriers are holes and minority charge carriers are electrons	In N-type semiconductors majority charge carriers are electrons and minority charge carriers are a hole.
A hole indicates a missing electron. In this, no. of holes is more than the no. of electrons.	In N-type semiconductor, the no. of holes is less than the no. of free electrons.
In this trivalent impurities are added to pure elements.	In this pentavalent impurities are added to pure elements.

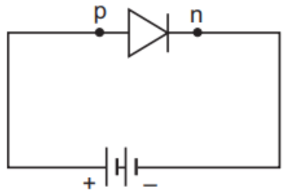
25. With the help of circuit diagram, distinguish between forward biasing and reverse biasing of a p-n junction diode.

Answer:

Forward biasing:

(i) When positive terminal of the battery is connected to p-region and the negative terminal of the battery is connected to n-region of the junction diode, it is said to be forward biasing.

(ii) The forward bias narrows the depletion region, due to the carriers from the battery terminals

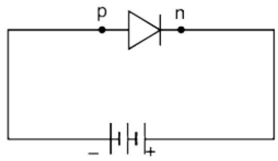


Forward biasing

Reverse biasing:

(i) When the positive terminal of the battery is connected to n-region & the negative terminal is connected to p-region of the p-n junction it is said to be reverse biasing.

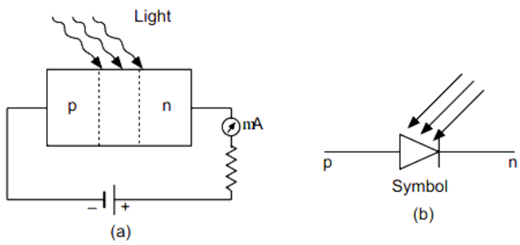
(ii) When the diode is reversed biased, more ions are left at the junction. This widens the depletion region



Reverse biasing

26. Draw the circuit diagram of an illuminated photodiode in reverse bias. How is photodiode used to measure light intensity?

Answer:



Photodiode

It is a reversed biased p-n junction, illuminated by radiation. When p-n junction is reversed biased with no current, a very small reverse saturated current flows across the junction called the dark current. When the junction is illuminated with light, electron-hole pairs are created at the junction, due to which additional current begins to flow across the junction; the current is solely due to minority charge carriers.

27. Draw a labelled diagram of a full wave rectifier. Show how output voltage varies with tine, if input voltage is a sinusoidal voltage.

Answer: The full wave rectifier and the variation of output voltage with time if input voltage is a sinusoidal voltage is as shown in the figure.

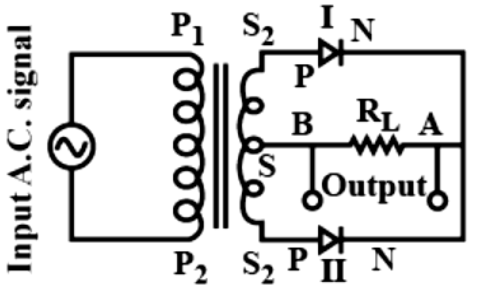


Figure A

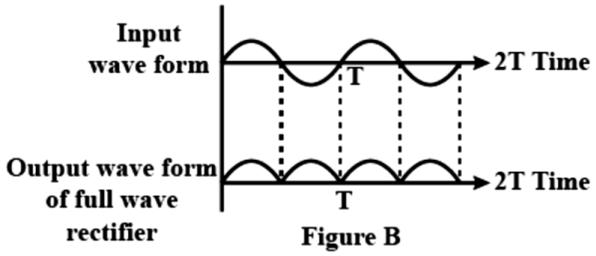


Figure B

28. State advantages of LED lamps over conventional incandescent lamps.

Answer:

Advantages of LED lamps over conventional incandescent lamps-

(i) LEDs have longer life as compared to incandescent lamps.

(ii) LEDs require low operational voltage and less power as compared to incandescent lamps.

(iii) LEDs also have fast on-off switching capabilities.

29. Why GaAs is most commonly used in making of a solar cell?

Answer: GaAs (gallium arsenide) is most commonly used in making of a solar cell because it absorbs relatively more energy from the incident solar radiations being of relatively higher absorption coefficient.

30. Write any two distinguishing features between insulators, semiconductors and conductors on the basis of energy band diagrams.

Answer:

Insulators :

(i) In case of insulators, the energy gap between the conduction and valence bands is very large and the conduction band is practically empty.

(ii) When an electric field is applied to such kind of material, the conduction band remains to be empty. That is why no current flows through insulators.

Semiconductors:

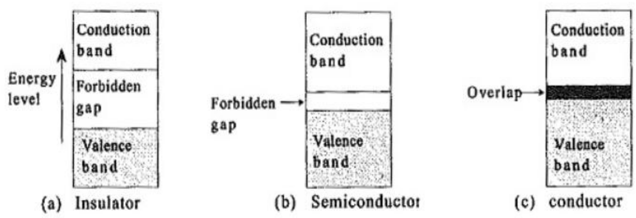
(i) In case of semiconductor, the energy band structure is similar to insulator but in this case, the size of forbidden energy gap is quite smaller than that of the insulators.

(ii) When an electric field is applied to a semiconductor, the electrons in the valence band find it relatively easier to jump to the conduction band. So, the conductivity of semiconductors lies between the conductivity of conductors and insulators.

Conductors:

(i) In the case of a conductor there is no forbidden gap, and the valence and conduction energy bands overlap. For this reason, very large numbers of electrons are available for conduction.

(ii) Even when a small current is applied, conductors can conduct electricity.



31. What is a transistor?

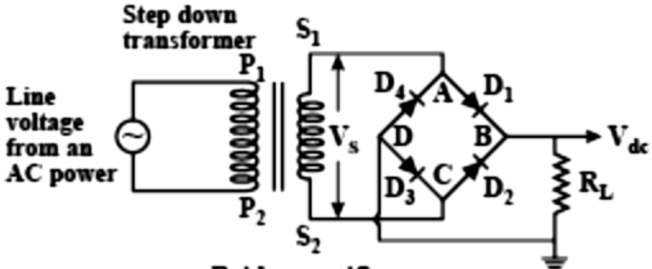
Answer:

Transistor: A transistor is a semiconductor device that transfers a weak signal from a low resistance circuit to a high resistance circuit. In simple words, what it means is that it regulates and amplifies electrical signals such as voltage or current.

32. Explain full wave rectification by bridge rectifier.

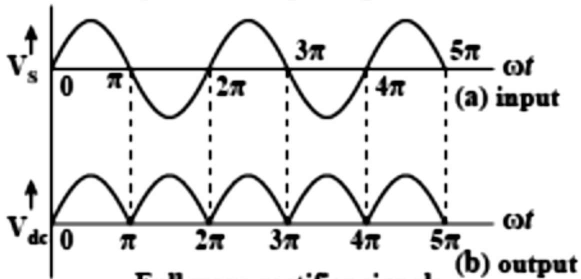
Answer:

Full wave rectification by Bridge Rectifier: The process in which alternating current (AC) is converted into direct current (DC) is known as rectification. The device used for this process is called rectifier.



Bridge rectifier

Imput and Output Signal

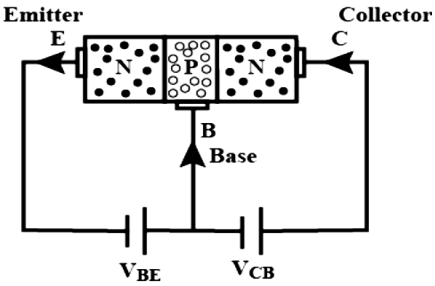


Full wave rectifier signals

The bridge rectifier circuit is made of four diodes D_1, D_2, D_3, D_4, and a load resistor R_L. The four diodes are connected in a closed-loop configuration to efficiently convert the alternating current (AC) into Direct Current (DC). The main advantage of this configuration is the absence of the expensive centre-tapped transformer. Therefore, the size and cost are reduced.

33. Draw a circuit diagram of an n-p-n transistor with its emitter-base junction forward biased and base-collector junction reverse biased.

Answer:

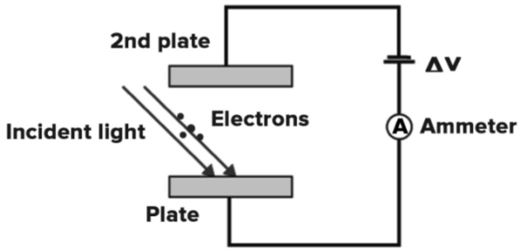


n-p-n transistor with its emitter -base junction forward biased and base collector junction reversed bias

34. What is the principle of photocell?

Answer:

Principle of Photocell: Photocell acts on the principle of the Photoelectric effect. It converts light energy to electrical energy. Photocell works on the principle that electron leaves the metal surface whenever photons of sufficient energy strike the surface, thus converting light energy into electric energy.



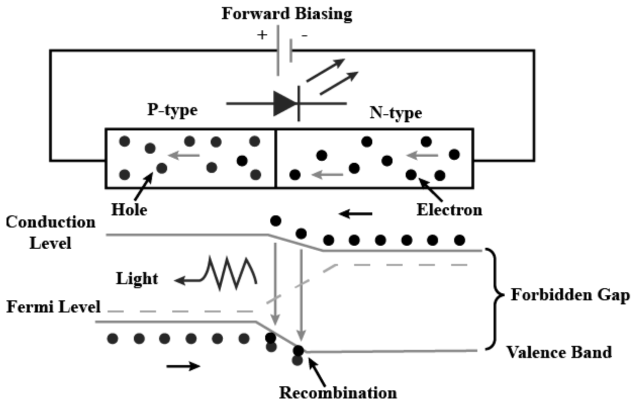
35. What is the full form of an LED?

Answer: Light-Emitting Diode is the full form of LED.

36. Explain the working of a LED.

Answer:

Working of LED: The LED is connected in the forward-biased, which allows the current to flows in the forward direction. The flow of current is because of the movement of electrons in the opposite direction. The recombination shows that the electrons move from the conduction band to valence band and they emit electromagnetic energy in the form of photons. The energy of photons is equal to the gap between the valance and the conduction band.



37. What are the common uses of LEDs?

Answer: LEDs are used in TV backlighting, smartphone backlighting, LED displays, automotive lighting, etc.

1. **The energy of the first excited state of hydrogen atom is-**
   (a) -13.6 eV
   (b) -3.4 eV
   (c) -1.51 eV
   (d) none of these
   Explanation: From Bohr's postulates, we know the total energy of n^{th} orbit,
   $E_n = -\frac{13.6}{n^2}\ eV$
   As first excited state will be 2nd orbit, so $n = 2$.
   $\Rightarrow E_n = -\frac{13.6}{2^2}\ eV = -3.4\ eV$
   Answer: (b)

2. **Staying time of atoms in metastable states is normally _____ seconds.**
   (a) 10^{-2}
   (b) 10^{-3}
   (c) 10^{-4}
   (d) 10^{-6}
   Explanation: Metastable state is an excited state of an atom or other system with a longer lifetime than the other excited states. Atoms in the metastable remain excited for a considerable time in order of $10^{-3}\ s$.
   Answer: (b)

3. **X-rays are deflected by-**
   (a) electric field
   (b) magnetic field
   (c) both electric and magnetic field
   (d) neither electric nor magnetic field
   Explanation: X-rays aren't deflected by electrons and magnetic fields because X-rays do not carry charge. They are electro-magnetic radiations and therefore cannot be deflected by electronic or any magnetic fields.
   Answer: (d)

4. **The penetrating power of X-rays produced by an X-ray tube can be increased by-**
   (a) increasing the filament current
   (b) increasing the tube voltage
   (c) decreasing the filament current
   (d) decreasing the tube voltage
   Explanation: With the increase in potential difference or voltage between anode and cathode energy of striking electrons increases which in turn increases the energy (penetrating power) of X-rays.
   Answer: (b)

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5. **In X-ray experiment K_α, K_β denotes-**
   (a) Characteristic lines
   (b) Continuous wavelength
   (c) α, β emissions respectively
   (d) None of these
   Explanation: When an electron vacancy in the K shell is filled by an electron from the L shell, the characteristic energy / wavelength of the emitted photon is called the K_α spectral line, and when the K shell vacancy is filled by an electron from the M shell, the characteristic energy / wavelength of the emitted photon is called the K_β. Hence, in X-ray experiment K_α K_β denotes α, β emissions.
   Answer: (c)

6. **The intensity of X-rays produced by an X-ray tube can be increased by-**
   (a) increasing the tube voltage
   (b) decreasing the tube voltage
   (c) decreasing the filament current
   (d) increasing the filament current
   Explanation: If we increase the filament current, the temperature of the filament rises and so the number of thermionic electrons emitted per second increases. These results increase in number of electrons striking the target per second, and hence number of X-ray photons emitted per second increases.
   Answer: (d)

7. **The characteristic X-ray depends on-**
   (a) nature of the target material
   (b) velocity of electron
   (c) number of electron striking the target
   (d) none of these
   Explanation:
   Characteristic wavelength $\lambda = \frac{hc}{E_K - E_L}$
   E is energy of particular shell.
   ΔE depends upon materials. So X-rays also depend upon material of target.
   Answer: (a)

8. The pumping method used in He-Ne laser is-
(a) optical pumping
(b) gas dynamic pumping
(c) chemical pumping
(d) electrical pumping
Explanation: Helium-neon lasers are the most widely used gas lasers. These lasers have many industrial and scientific uses and are often used in laboratory demonstrations of optics. In He-Ne lasers, the optical pumping method is not used instead an electrical pumping method is used.
Answer: (d)

9. The lasing action is based on-
(a) stimulated emission
(b) spontaneous emission
(c) absorption
(d) none of these
Explanation: As the lasing action converts electrical energy to light energy which is based on the phenomenon of stimulated emission.
Answer: (a)

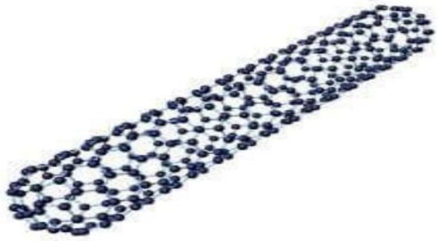
10. The frequencies of X-rays, Gamma rays and visible light waves rays are a, b and c respectively, then:
(a) a<b, b>c
(b) a<b, b<c
(c) a>b>c
(d) a>b, b<c
Explanation:
Frequencies of given rays:
X-rays, $a = 3 \times 10^{19}$ to 1×10^{16}
γ-rays, $b = 3 \times 10^{22}$ to 3×10^{18}
Visible light, $c = 8 \times 10^{14}$ to 4×10^{14}
So, a<b, b>c
Answer: (a)

11. What is Laser?
Answer: LASER is an abbreviation of Light Amplification by Stimulated Emission of Radiation. Lasers are light beams so powerful that they can travel miles into the sky, and they can also cut through the surfaces of metals.

12. Name types of pumping mechanism in laser production.
Answer:
Types of Pumping Mechanism in LASER:
1) Optical Pumping
2) Electrical Pumping
3) Chemical Pumping

13. Write the full form of CNT in respect to nanotechnology.
Answer: Full form of CNT is Carbon NanoTube.

14. What are Carbon Nanotubes?
Answer:
Carbon Nanotube: A carbon nanotube is a carbon allotrope that resembles a tube of carbon atoms. Carbon nanotubes are extremely robust and difficult to break, but they are still light.



Carbon Nanotube (CNT)

15. Define spontaneous and stimulated emission.
Answer:
Spontaneous Emission: It is a process in which a transition of an atom/ molecule/ subatomic particles take place from an excited energy state to a lower energy state (i.e. ground state) and emits quantum in the form of photon. Spontaneous emission is responsible for most of the light we see all around us.
Stimulated Emission: It is a process by which an incoming photon of a specific frequency can interact with an exited atomic electron, causing it to drop to a lower energy state. This is a principle behind the working of a laser.

16. Describe briefly the phenomenon of stimulated emission.
Answer:
Phenomenon of stimulated emission:
1) Initially the atom must be in preferred higher energy states (excited state).
2) Stimulating photons of equal energy to that of energy difference of excited state (metastable) and ground state are incident on it. So the incidents photons and stimulated photons are in same phase.
3) All stimulated photons are unidirectional.
4) Intensity of light is strong enough.
5) Due to high degree of directionality can be focused into a very small region by convex lens.
6) Stimulated emission is highly monochromatic.

17. What is meta-stable state in lasing action?

Answer:

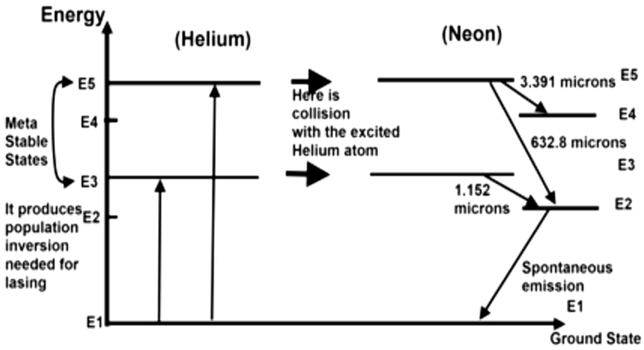
Meta-Stable State: Metastable state is an excited state of an atom or other system with a longer lifetime than the other excited states.

18. Explain the working of He-Ne LASER.

Answer: The helium-neon (He-Ne) laser operates on the principle of stimulated emission of radiation. It uses a mixture of helium and neon gases to produce a low-power continuous laser beam at a visible red wavelength. The process begins with an electrical discharge that excites the helium atoms, which then transfer their energy to the neon atoms. This causes the neon atoms to emit photons at a specific wavelength, resulting in the coherent light output characteristic of a laser.

19. Draw the energy level diagram of He-Ne LASER.

Answer:



He-Ne Laser Energy Level Diagram

20. How He-Ne laser pumping is done.

Answer:

Principle of He-Ne Laser: He-Ne laser pumping is done by atom-atom inelastic collision through electrical discharge.

21. What are characteristics of laser?

Answer: The characteristics of laser are:

1) **Superior Monochromatism:** Laser lights are single wavelength light.
2) **Superior Directivity:** Laser beam is emitted in a specific direction.
3) **Superior Coherence:** Laser lights have the same phase difference.
4) **Collimation:** All rays are parallel to each other and do not diverge significantly even over long distances.

22. Distinguish between ordinary light and laser light.

Answer:

Ordinary light:

1) It is a mixture of electromagnetic waves of different wavelength
2) It is non-directional and inconsistent, which means it travels without following any direction.
3) Ordinary light has a wide spectrum of light that moves irregularly at different wavelengths.
4) Ordinary light does not contain photons of the same frequency.
5) Example for ordinary light, sunlight, fluorescent and incandescent etc.
6) The intensity of light decreases rapidly as it travels a long distance.

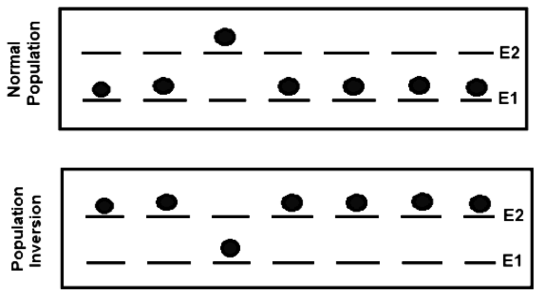
Laser light:

1) Laser light is monochromatic (containing only one colour)
2) Laser light shows directional and highly consistent distribution.
3) It has a focused beam in which all photons move at the same wavelength and same direction.
4) Laser light are spectrally pure.
5) Lasers have narrow frequency range and directional distribution.
6) In contrast, laser light is emitted from a narrow beam. Since energy is concentrated in a narrow area, looking at the laser light with naked eye can damage the eye.

23. What is meant by population inversion and optical pumping?

Answer:

Population Inversion: A situation which is not at equilibrium must be created by adding energy in the higher energy level such that the higher energy level will have more number of atoms or electrons than the lower energy level. This is called Population inversion and the process by which population inversion is done using light is called optical pumping.



24. Mention important application of LASER.

Answer:

Application of LASER:

(i) Laser in Medical: Used for bloodless surgery, used to destroy kidney stones, used in cancer diagnosis and therapy, used to remove tumours.

(ii) Lasers for Welding and Cutting: Carbon dioxide lasers used in the automotive sector for computer-controlled welding on vehicle assembly lines.

(iii) Surveying and Ranging: Helium-neon and semiconductor lasers are now standard components of field surveyor equipment.

(iv) Lasers in Communication: Fiber optic cables are a popular means of communication because light traveling through the fibers allows many signals to be transferred with high quality and minimal loss.

(v) Heat Treatment: Heat treatments for hardening or annealing have been used in metallurgy for a long time.

25. How continuous and characteristic X-rays are produced in Coolidge tube? Explain.

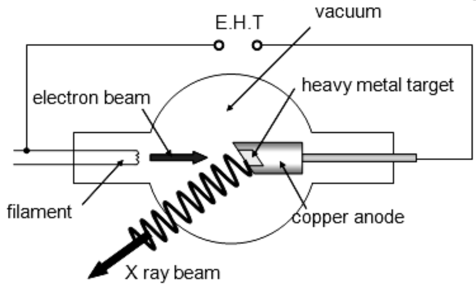
Answer: High energy electrons are made to interact with the target atom in an X-ray tube. This interaction makes the electrons lose their energy. When they lose their energy, two kinds of X-rays are produced

(i) Continuous X-rays: When the electrons lose their entire energy in a single interaction, the X-rays of continuous spectrum are generated. In this case the attacking electrons are scattered elastically by the target atom. So the electrons are get decelerated and as we know that when a charged particle accelerates, it emits radiation. So, it emits a continuous X-ray spectrum.

(ii) Characteristic X-rays: It also happens that the attacking electrons knock out the inner shell electrons from the target atom, thereby creating a vacancy. The atom rearranges its electronic configuration to fill this vacancy. For this, an electron inside the atom makes a transition from the higher energy level to the lower energy level. Thus, the characteristic X-rays are emitted which have a linear spectrum.

26. How X-rays are produced in Coolidge tube?

Answer: In the Coolidge tube the electrons are produced by thermionic effect from a tungsten filament heated by an electric current. The filament is the cathode of the tube. The high voltage potential is between the cathode and anode, the electrons are thus accelerated and then hit the anode. The kinetic energy of the free electrons of the target is the source of energy of photon of characteristic X-ray from a cooling tube.



<u>Coolidge Tube</u>

27. Write the properties of X-ray.

Answer:

Properties of X-rays:

1) X-rays are electromagnetic waves of very short wavelength. They travel in straight lines with the velocity of light. They are invisible to eyes.
2) They undergo reflection, refraction, interference, diffraction and polarisation.
3) They are not deflected by electric and magnetic fields. This indicates that X-rays do not have charged particles.
4) They ionize the gas through which they pass.
5) They affect photographic plates.
6) X-rays can penetrate through the substances which are opaque to ordinary light e.g. wood, flesh, thick paper, thin sheets of metals.
7) When X-rays fall on certain metals, they liberate photo electrons(photo electric effect).

28. Mention important uses of X-rays.

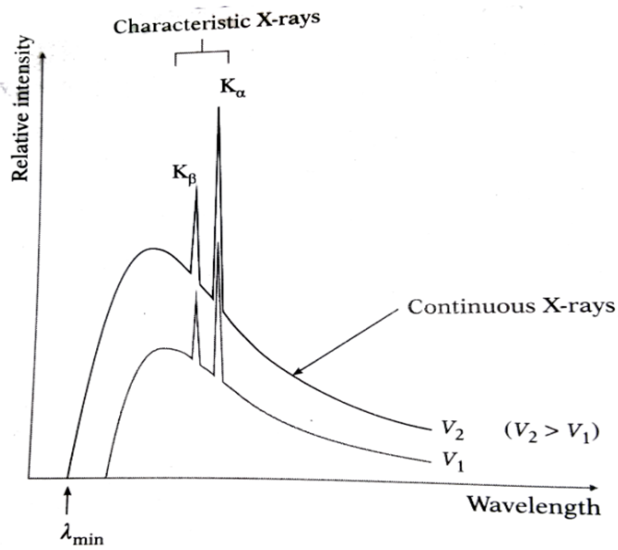
Answer:

Uses of X-rays:

1) X-rays are used to check the bags at the airport.
2) X-rays help in identifying the infection in the bones, teeth, etc.
3) To observe defect in lungs.
4) To diagnose cancer of oesophagus.
5) To diagnose physical disabilities.

29. Draw a curve showing the variation of intensity with wavelength of X-rays obtained from X-ray tube and mark cut-off wavelength, continuous and characteristic X-rays.

Answer:



Important features of a typical X-ray spectrum:

(1) There is abroad continuous distribution of wavelengths of the X-rays, called as continuous X-rays.

(2) Superimposed on the continuous distribution are peaks of sharply defined wavelengths, called the characteristic X-rays, because they are unique characteristics of the element used as the target metal.

(3) There is a sharply defined minimum or cutoff wavelength, λ_{min} below which the continuous spectrum does not exist. On increasing the kinetic energy E of the electrons striking the target, λ_{min} decreases but the wavelengths of the characteristic X-rays remain unchanged. The intensity at all wavelengths increases.

30. How much voltage be applied in X-ray tube such that the minimum wavelength of the emitted X-ray will be 1 Å?

Answer:

$\lambda_{mim} = 1\text{ Å} = 10^{-10}$ m

$h = 6.63 \times 10^{-34}$ Js

$c = 3 \times 10^8\ ms^{-1}$

$e = 1.6 \times 10^{-19}\ C$

Now, $\lambda_{mim} = \frac{hc}{eV}$

$$V = \frac{hc}{e\lambda_{mim}} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times10^{-10}}$$

$$= 12.43 \times 10^3\ V$$

$$= 12.43\ kV \quad \text{(Ans)}$$

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31. An X-ray tube operates a potential difference V. What is the minimum wave length of X-rays?

Answer:

Minimum wavelength of X-ray

$\lambda_{mim} = \frac{hc}{eV}$

Where, h =Plank's constant

e = Charge of electron

c = Velocity of light in vacuum

32. What is hologram?

Answer:

Hologram: A photograph of an interference pattern which, when suitably illuminated by laser light, produces a three dimensional image is known as hologram. A laser beam is split into two identical beams and redirected by the use of mirrors. The two beams intersect and interfere with each other. The interference pattern is what is imprinted on the recording medium to recreate a virtual image for our eyes to see.

33. What is nanotechnology?

Answer:

Nanotechnology: Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale, i.e. having one or more dimensions of the order of 100 nanometres or less.

34. How are Applications of Nanotechnology Used?

Answer: Nanotechnology's applications span various sectors:

(i) Electronics: Carbon nanotubes and graphene are paving the way for faster, more efficient microprocessors and flexible touchscreens.

(ii) Energy: Innovations like new semiconductors for solar panels and improved wind turbines are making renewable energy more viable and efficient.

(iii) Environment: From air purification to wastewater treatment, nanotechnology offers environmentally friendly solutions.

(iv) Food: Nanobiosensors detect pathogens, while nanocomposites improve food packaging.

(v) Textiles: Smart fabrics that resist stains and wrinkles, and materials that enhance the durability of sports equipment.