PHYSICS

VOULME II

QUESTION BANK

LESSON-6

OPTICS

POINTS TO PONDER

- Bouncing back of light into the same medium form a reflecting surface is called refection.
- Laws of reflection:

  i) Incident ray reflected ray and normal – lie in same plane.

  ii) i = r
- Reflecting surface is tilted by an angle θ , reflected light will be tilted by an angle 2 θ.
- Characteristics of image formed by plane mirror:

  Virtual, erect, laterally inverted, equal size as object, image distance equal to object distance, magnification is unity.

N -no. of images		
	Odd	Even
Object symmetrically placed	n-1	n-1
Object asymmetrically placed	n	n-1

- Size of the plane mirror needed to see the full size of the object is half the size of the object.
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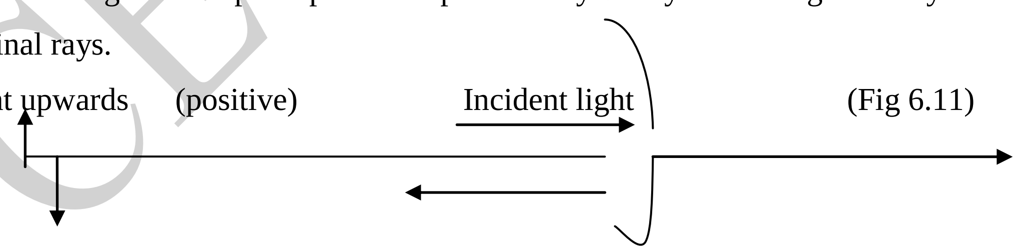
	Object	image
Red	Rays actually diverge from the object	Rays actually converge at the image
Virtual	Rays appear to converge at the object	Rays appear to diverge from the image

- Rays travelling close to principal axis – paraxial rays. Rays travelling far away from principal axis – Marginal rays.
- Height upwards (positive) Incident light (Fig 6.11)



Height downwards (negative) Distance to the Left form the pole(negative) Distance to the right from the pole

- Speed of light is different and lever in any medium than vaccum.

  Speed of light in air - determined by Fizeau's method is $2.99792X10^{8}ms^{-1}$

- Refractive index of vaccum is 1

  Refractive index of other medium is > 1

  If the refractive index of a medium is more optical density is more and speed of light in the medium is less.
- Distance travelled in any medium is less than the distance travelled by light in vaccum.
- Snell's law of refraction:

  i. Incident ray, refracted ray and normal – lie in the same plane.

  ii. $\frac{\sin i}{\sin r} = \frac{n2}{n1}$
- When light travels from denser to rarer medium it bends away from the normal.

  When light travels from rarer to denser medium it bends towards the normal.
- Principle of reversibility: In both reflection and refraction, light will follow exactly the same path if its direction of travel is reversed.
- Relative refractive index:

  1.$n_{21} = \frac{n_2}{n_1}$ 2.$n_{12} = \frac{n}{n_{21}}$ 3.$n_{32} = n_{31} \times n_{12}$
- Apparent depth is always less than the actual depth.
- Conditions for total internal reflection:

  i. high must travel from denser to racer medium.

  Ii. $i > i_c$
- Critical angle is different for different materials . ('.' Of refractive index)
- Mirage and looming are optical illusions due to total internal reflection.
- When light source is inside water the entire surface of water appears illuminated. When light enters water from outside and seen from inside water the restricted illuminated circular area is called Snell's window.
- Acceptance angle: The angle at which light must be incident at the end of the optical fibre to ensure the critical angle incidence in the core – cladding boundary inside the optical fibre.
- Acceptance cone: $i_a = \sin^{-1}(\sqrt{n1^2 + n2^2}$

  Light can have any angle of incidence from 0 to i_a with normal at the end of the optic fibre forming a conical shape.
- Lateral displacement in glass slab will be more for thicker slab and greater angle of incidence.
- Primary focus F1 :point where object should be placed to give parallel emergent rays to the principal axis.

  Secondary focus F2: Point where all the parallel rays travelling close to the principal axis converge to form an image on the principal axis.
- Focal length of converging lens is positive.

Focal length of diverging lens is negative.

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	Convex lens	Concave lens
Real image	m is negative	m is positive
Virtual image	m is positive	m is positive

- Power of converging lens is positive.
  Power of diverging lens is negative.
- Power of lens is larger for larger refractive index and smaller radius of curvature.
- Power of lens is a measure of degree of convergence or divergence of light.
- Lenses are combined to obtain desired magnification and enhance sharpness of images.
- Total magnification of combination of lenses in contact is $m = m_1 X m_2 X m_3$ ……..
- Angle of deviation of a prism depends on
  i. angle of incidence ii. Angle of prism
  iii. refractive index iv.wavelength of light
- Conditions for minimum deviation: i. $i_1 = i_2$ ii. $r_1 = r_2$ iii. Refracted ray inside the prism is parallel to the base.
- Refractive index is different for different colours. $n_{v>}n_r$
- Vaccum is the non – dispersive medium in which all colours travel with the same speed.
- Dispersive power is always positive and independent of angle of prism.
- Ray leigh scatlering law is applicable for atoms and molecules of size a <<
- For atoms and molecules of size a >> the intensity of scattering is equal for all the wavelengths.
- Corpuscular theory : Light is tiny massless perfectly elastic particles
  Wave theory : Light is a disturbance that travels as longitudinal mechanical waves through ether medium.
  Electromagnetic theory : Light is an electromagnetic wave which is transverse in nature, which does not require any medium to propagate.
  Quantum theory : Light interacts with matter as photons of energy E = h2
- Light propagates as a wave and interacts with matter as a particle.
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Type of source	Wave front shape
Point source	Spherical
Line source	Cylindrical
Source at infinity	Plane

- Huygen's principle is a geometrical construction to give the shape of wave front at any time.

- If a light of particular frequency travels through different media, its frequency remains unchanged but its wavelength changes according to the speed of light in the medium.
- Two independent monochromatic sources can never be coherent because they are not in phase, even though they may have same frequency and amplitude.
- Techniques to obtain coherent sources:

  i. Intensity or amplitude division

  ii. Wave front division

  iii. Source and images.
- To get clear, broad interference pattern as $\beta = \frac{\lambda D}{d}$

  D should be large, λ should be large and d must be small.
- Bandwidth β will decrease if young's double slit experiment apparatus is immersed in water of refractive index n.

  As $\beta^1 = \beta/n$
- When white light is used in young's double slit experiment, central fringe is white with coloured fringes of different widths on either side.
- Diffraction in light can be observed when the wavelength.
- Angular spread of first minimum $\sin\theta = \frac{\lambda}{a}$

  i. $a < \lambda$ - diffraction not possible

  ii. $a \geq \lambda$ -diffraction is possible

  iii. $a >> \lambda$ - diffraction not noticeable
- Fresnel's distance – Distance upto which ray optics is obeyed beyond which wave optics becomes significant.
- The inverse of resolution is called resolving power.
- Resolution pertains to quality of the image and resolving power is associated with ability of the optical instrument.
- Polarization techniques: polarization by

  1. Selective absorbtion, 2.reflection, 3.double refraction, 4.Scattering
- For every rotation of 90^0 of the analyser – if the intensity of light varies from a. maximum to zero - polarized

  b. maximum and minima - partially polarized

  c.remains constant - unpolarised

- If the intensity of the light falling on first Polaroid is I, the intensity of polarized light emerging from it will be I/2
- At polarizing angle, the reflected and refracted rays are perpendicular to each other.
- Brewster's angle depends upon the nature of the refracting medium and wavelength of light used.
- Larger the number of plates in pile of plates, greater is the intensity of the reflected plane polarized light.
- Inside the doubly refracting crystal, the ordinary and extra ordinary ray travel with the same velocity in a particular direction called optic axis.
- Light scattered by molecules at 90^0 to the incident light is plane polarized..
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Near point focusing	Normal focusing
1.Image is formed at near point (25 cm)	Image is formed at infinity
2.Eye is strained	Eye is relaxed.

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	Compound microscope	Astronomical telescope
objective	short focus	long focus
Eye piece	Long focus	Short focus

- In compound microscope the tube length 'L" is the distance between first focal point of eyepiece and second focal point of the objective.
- In terrestrial telescope, there is an addition erecting lens to make the final image erect.
- Telescope with mirror objectives are called reflecting telescopes.
- Refractive index of liquid can be determined by using hollow prism filled with given liquid in spectrometer.
- For a normal human eye,
  a. when the object is at ∞ , f max = 2.5 cm
  b. when the object is at near point, f min = 2.27 cm
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Defects of Eye	Remedy (Correcting lens used)
Farsightedness(hypermetropia)	convex
Nearsightedness(myopia)	concave
Presbyopia(farsightedness due to aging)	convex
Astigmatism	Cylindrical

- Due to aging, combination of more than one defect farsightedness of more than one defect farsightedness and nearsightedness happens which can be corrected by Biofocal lens and progressive lens.

IMPORTANT FORMULAE:

1.Angle of deviation due to reflection,

i. d=180 – 2i

ii. d = 2α

2.The number of images formed in plane mirror is

N=$\frac{360}{\theta}$ - 1 when 360/θ is even and 360/θ is odd when objects placed symmetrical.

N=$\frac{360}{\theta}$when 360/θ is odd when objects placed symmetrical.

3.Radius of curvature, R=2f (or) f=R/2.

4.Mirror equation:

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

5.Magnification in spherical mirrors:

$$M = \frac{h}{h} = \frac{-v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$$

6.Refractive index, n of a medium = c/v

C – Speed of light in vaccum

V – Speed of light in medium

7. Optical path, d^1 = nd

8.Snell's law:

$$\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$$

9.Angle of deviation due to refraction:

d = i – r if $n_1 < n_2$

d = r – i if $n_1 > n_2$

10.InFizeaus' method, the velocity of light is V = $\frac{2dNw}{n}$

11.The equation for apparent depth,

d= $\frac{n_2}{n_1}$ d

12.Critical angle,

$i_c=\sin^{-1}(\frac{n_2}{n_1})$

13.Radius of illumination,

$$R = \sqrt[d]{\frac{n_2^2}{(n_1^2-n_2^2)}}$$

14.Acceptance angle,

$$i_a = \sin^{-1}\left[\sqrt{\frac{n_1^2 - n_2^2}{n_3^2}}\right]$$

15.Lateral displacement,

$$L = t\left[\frac{\sin(i-r)}{\cos r}\right]$$

16.Equation for refraction at single spherical surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

17.Lateral magnification in single spherical surface,

$$m = \frac{h_2}{h_1} = \frac{n_1}{n_2}\frac{v}{u}$$

18.Len's makers' formula,

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left({}^{1}/_{R_1} - {}^{1}/_{R_2}\right)$$

19.Lens equation,

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

20.Magnification in thin lens,

$$M = \frac{v}{u} = \frac{h_2}{h_1} = \frac{f}{f+u} = \frac{f-v}{f}$$

21.Power of a lens,

$$P = 1/f$$

22.Focal length of lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} \ldots\ldots$$

23.Power of combination of lenses

$$P = P_1 + P_2 + P_3 + \ldots..$$

24.Equivalent focal length of combination of lenses out of contact,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

25.Angle of deviation produced by prism

$$d = i_1 + i_2 - A$$

26. Refractive index of a prism,

$$N = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

27.Dispersive power, $W = \frac{n_v - n_R}{n-1} = \frac{\delta_v - \delta_R}{\delta}$

28.Energy of a photon, $E = h\gamma$

29.Resultant intensity,

$I = 4 I_0 \cos^2 \emptyset/2$

30.Resultant amplitude,

$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\emptyset}$

31.Relation between path difference and phase difference,

$\delta = \frac{\lambda}{2\pi} \times \emptyset$ $\qquad$ $\emptyset = \frac{2\pi}{\lambda} \times \delta$

32.In youngs double slit experiment,

* The path difference ,$\delta = \frac{dy}{D}$
* Condition for nth bright fringe

  $Y_n = n\frac{\lambda D}{2}$ where n=0,1,2,3……
* Condition for nth dark fringe

  $Y_n = \frac{(2n-1)}{2}\frac{\lambda D}{d}$ where n = 1, 2, 3 …….
* Bandwidth ,$\beta = \frac{\lambda D}{d}$

33.For a transmitted ray,

* Condition for constructive interference

  $2\mu d = n\lambda$
* Condition for destructive interference

  $2\mu d = (2n - 1)\lambda/2$

34.For a reflected ray,

* Condition for constructive interference

  $2\mu d + \lambda/2 = n\lambda$ or $2\mu d = (2n-1)\lambda/2$
* Condition for destructive interference

  $2\mu d + \lambda/2 = (2n+1)\lambda/2$ or $2\mu d = n\lambda$

35.For diffraction at single slit,

* Condition for nth minimum is

  $a \sin\theta = n\lambda$
* Condition for nth maximum is

  $a \sin\theta = (2n+1)\lambda/2$
* Angular spread of central maximum

  $\theta = \sin^{-1}(\lambda/a)$

36.Fresnels' distance,

$Z = a^2/2\lambda$

37.Equation for diffraction maximum in grating is,

$\sin\theta = Nm\lambda$

38.Angular resolution

$\theta = \frac{1.22\lambda}{a} = \frac{r_0}{f}$

39.According to Malus' law,

$I = I_0\cos^2\theta$

40.From Brewster's law,

$\tan i_p = n$

41.In simple microscope,

*The magnification for near point focusing is,

$M = 1 + \frac{D}{f}$

* The magnification for normal focusing is,

$M = \frac{\theta_i}{\theta_0} = \frac{h/f}{h/D} = \frac{D}{f}$

*Difference between the two points on the object to be resolved is,

$d_{min} = \frac{1.22\lambda}{2n\sin\beta} = \frac{1.22\lambda}{2(NA)}$

42.In compound microscope,

*The total magnification 'm' in near point focusing is,

$M = m_0 m_e = \left(\frac{L}{f_0}\right)\left(1+\frac{D}{f_e}\right)$

* The total magnification 'm' in normal focusing is,

$M = m_0 m_e = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$

43.In astronomical telescope,

*magnification is

$M=\frac{\beta}{\alpha} = \frac{h/f_e}{h/f_0} = \frac{f_0}{f_e}$

*Approximate Length of the telescope is

$L = f_0 + f_e$

44.The focal length of the correcting lens for a myopic eye is $f = -x$

45.The focal length of the corrects lens for a hypermetropic eye is $f = \frac{y \times 25\ cm}{y - 25\ cm}$

Multiple choice questions

1. The speed of light in an isotropic medium depends on,

   (a) its intensity

   (b) its wavelength

   (c) the nature of propagation

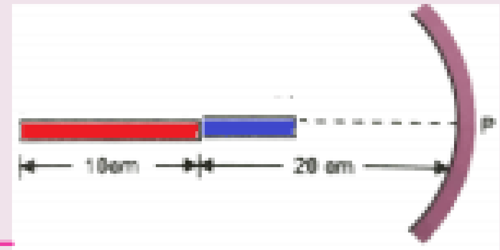
   (d) the motion of the source w.r.to medium

(b) wavelength

2. A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is, (AIPMT Main 2012)

   (a) 2.5 cm (b) 5cm

   (c) 10 cm (d) 15cm



The End A of the rod is at 20 cm from the pole i.e at 2F, Hence the image of the end A is 2F itself, denoted as A_1

The other end B of the rod is at (20+10)=30 cm from the pole, its image is at B_1

By Lens makers formula

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

For the end B $u = -30cm$, $f = -10\ cm$

$$\frac{1}{-10} = \frac{1}{-30} + \frac{1}{v}$$

$$-\frac{1}{10} = -\frac{1}{30} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{30} - \frac{1}{10} = \frac{1-3}{30} = -\frac{2}{30}$$

$$v = -15cm.$$

length of the rod $A_1B_1 = 20 - 15 = 5\ cm$

3. An object is placed in front of a convex mirror of focal length of f and the maximum and minimum distance of an object from the mirror such that the image formed is real and magnified. (IEE Main 2009)]

   (a) $2f$ and c (b) c and ∞

   (c) f and O (d) None of these

For Convex mirror for all the position of the object, the image obtained is virtual only and no real image,

Hence option (d) none of these

4. For light incident from air onto a slab of refractive index 2. Maximum possible angle of refraction is,

   (a) 30° (b) 45°

   (c) 60° (d) 90°

$$\mu = \frac{\sin i}{\sin r} ==> \sin r = \frac{\sin i}{\mu}$$

For maximum possible angle of refraction sini = 1

$$\sin r = \frac{1}{2} ==> r = 30^\circ$$

5. If the velocity and wavelength of light in air is V_a and λ_a and that in water is V_w and λ_w, then the refractive index of water is,

(a) $\frac{V_w}{V_a}$ (b) $\frac{V_a}{V_w}$

(c) $\frac{\lambda_w}{\lambda_a}$ (d) $\frac{V_a\lambda_a}{V_w\lambda_w}$

$$\mu = \frac{\text{velocity in vacuam}}{\text{velocity in water}} = \frac{V_a}{V_w}$$

Hence Option (b)

6. Stars twinkle due to,

(a) reflection

(b) total internal reflection

(c) refraction

(d) polarisation

(c) refraction

7. When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index,

(a) less than one

(b) less than that of glass

(c) greater than that of glass

(d) equal to that of glass

By Lens makers formula

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

When biconvex lens is dipped in liquid it act as a plane sheet of glass, hence $f = \infty \rightarrow \frac{1}{f} = 0$

$$0 = \left(\frac{\mu_g}{\mu_l} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\left(\frac{\mu_g}{\mu_l} - 1\right) = 0 ==> \frac{\mu_g}{\mu_l} = 1$$

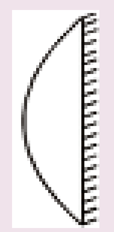
$\mu_g = \mu_l$ Option (d) equal to that of glass

8. The radius of curvature of curved surface at a thin planoconvex lens is 10 cm and the refractive index is 1.5. If the plane surface is silvered, then the focal length will be,

(a) 5 cm (b) 10 cm

(c) 15 cm (d) 20 cm

The silvered Plano convex lens behaves as a concave mirror whose focal length is given by $\frac{1}{F} = \frac{2}{f_1} + \frac{1}{f_m}$



If the plane surface is silvered $f_m = \frac{R_2}{2} = \frac{\infty}{2} = \infty$

$$\therefore \frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= (\mu - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) = \frac{\mu - 1}{R}$$

$$\therefore \frac{1}{F} = \frac{2(\mu - 1)}{R} + \frac{1}{\infty} = \frac{2(\mu - 1)}{R}$$

$$F = \frac{R}{2(\mu - 1)}$$

Here R = 10 cm, $\mu = 1.5$

$$\therefore F = \frac{10}{2(1.5 - 1)} = 10\,\text{cm}$$

9. An air bubble in glass slab of refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness of the slab is,

(a) 8 cm (b) 10 cm

(c) 12 cm (d) 16 cm

By seeing through one side

$$d_{ap} = \frac{d_1}{\mu} => d_1 = \mu d_{ap} = 1.5x5 = 7.5cm$$

By seeing through anotherside

$$d_{ap} = \frac{d_2}{\mu} => d_2 = \mu d_{ap} = 1.5x3 = 4.5cm$$

Thickness of the slab = 7.5 cm + 4.5 cm = 12 cm

10. A ray of light travelling in a transparent medium of refractive index n falls, on a surface separating themedium from air at an angle of incidents of 45°. The ray can undergo total internal reflection for the following n,

(a) $n = 1.25$ (b) $n = 1.33$

(c) $n = 1.4$ (d) $n = 1.5$

For Total internal reflection to occur i > C

$$\mu \geq \frac{1}{\sin C} ===> \mu > \frac{1}{\sin 45}$$

$$\mu > \sqrt{2} ==> \mu > 1.414$$

11. A plane glass is placed over a various coloured letters (violet, green, yellow, red) The letter which appears to be raised more is,

(a) red (b) yellow

(c) green (d) violet

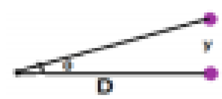
The letter violet is raised more, because the wavelength is least for violet colour, it deviate more than other colours

12. Twopoint white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm approximately. The maximum distance at which these dots can be resolved by the eye is, [take wavelength of light, $\lambda = 500$ nm]

(a) 1 m (b) 5 m

(c) 3 m (d) 6m

$$Resolution\ limit = \frac{1.22\lambda}{d}$$



Also the resolution limit

$$\sin\theta = \frac{y}{D} ==> \theta = \frac{y}{D}$$

$$\frac{y}{D} = \frac{1.22\lambda}{d}$$

$$D = \frac{yd}{1.22\lambda}$$

$$D = \frac{3x10^{-3}x1x10^{-3}}{1.22x500x10^{-9}} = 5m$$

13. In a Young'sdouble-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to,

(a) $2D$ (b) $\frac{D}{2}$

(c) $\sqrt{2}D$ (d) $\frac{D}{\sqrt{2}}$

$$Given\ d' = 2d \quad \beta' = \beta \quad then\ D' = ?$$

$$\beta' = \beta$$

$$\frac{\lambda D'}{d'} = \frac{\lambda D}{d} ==> D' = \frac{Dd'}{d} = \frac{D2d}{d} = 2D$$

14. Two coherent monochromatic light beams of intensities I and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are [IIT-JEE 1988]

(a) $5I$ and I (b) $5I$ and $3I$

(c) $9I$ and I (d) $9I$ and $3I$

Resultant Intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

for MaximumIntensity

$\phi = 0$ and $\cos\phi = 1$

$$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$$

$$I_{max} = 4I + I + 2\sqrt{4I^2}$$

$$I_{max} = 4I + I + 4I = 9I$$

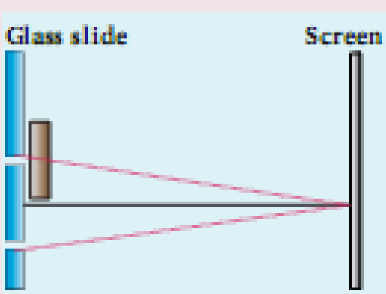
for Minimum intensity

$\phi = 180$ and $\cos\phi = -$

$$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$$

$$I_{min} = 4I + I - 2\sqrt{4I^2}$$

$$I_{min} = 4I + I - 4I = I$$

15. When light is incident on a soap film of thickness 5×10^{-5}cm, the wavelength of light reflected maximum in the visible region is 5320 Å. Refractive index of the film will be, (a) 1.22 (b) 1.33 (c) 1.51 (d) 1.83.	For thin films , condition for maximum intenstity when light is reflected from the film $2\mu t\cos r = (2n+1)\frac{\lambda}{2}$ *for n = 0, 1, 2...* for maximum intensity cos r = 1 $2\mu t = (2n+1)\frac{\lambda}{2} ==> \mu = \frac{(2n+1)\lambda}{4t}$ $\mu = \frac{(2n+1) \times 5320 \times 10^{-10}}{4 \times 5 \times 10^{-7}} = \frac{(2n+1)x1.33}{5}$ when n = 0 μ = 0.2x1.33 = 0.266 not possible when n = 1 μ = 0.6 x1.33=0.798 not possible when n = 2 μ = 1x1.33= 1.33
16. First diffraction minimum due to a single slit of width 1.0×10^{-5} cm is at 30°. Then wavelength of light used is, (a) 400 Å (b) 500 Å (c) 600 Å (d) 700 Å	for single slit $a\sin\theta = n\lambda$ $\lambda = \frac{a\sin\theta}{n} = \frac{1.0x10^{-7} x\sin 30}{1} = 0.5x10^{-7}$ $\lambda = 500A^{\circ}$
17. A ray of light strikes a glass plate at an angle 60°. If the reflected and refracted rays are perpendicular to each other, the refractive index of the glass is, (a) $\sqrt{3}$ (b) $\frac{3}{2}$ (c) $\sqrt{\frac{3}{2}}$ (d) 2	If the reflected and refracted rays are perpendicular, then the angle of incidence is equal to polarising angle By Brewsters law $\mu = \tan i_p = \tan 60 = 1.732$
18. One of the of Young's double slits is covered with a glass plate as shown in figure. The position of central maximum will,  (a) get shifted downwards (b) get shifted upwards (c) will remain the same (d) data insufficient to conclude	The position of central maximum Get shifted in the side of slits in which glass plate is covered, as the distance travelled from the slit is more. In this case, the position of central maximum get shited upward

19. Light transmitted by Nicol prism is, (a) partiallypolarised (b) unpolarised (c) plane polarised (d) elliptically polarised	Plane polarised
20. The transverse nature of light is shown in, (a) interference (b) diffraction (c) scattering (d) polarisation	polarisation

SHORT ANSWER QUESTIONS:-

2 MARKS

1. State the laws of reflection? [page no-2]
2. What is angle of deviation due to reflection? [page no – 2]
3. What are the differences between real image and virtual image? [page no-4]
4. What are paraxial rays and marginal rays? [page no – 7]
5. Define refractive index of a medium? [page no – 14]
6. State the laws of refraction. [page no – 15]
7. What is angle of deviation due to refraction? [page no – 16]
8. What is principle of reversibility? [page no – 17]
9. What is relative refractive index? [page no – 18]
10. Why do stars twinkle? [page no – 20]
11. What is critical angle? [page no – 20]
12. What is called total internal reflection? [page no – 20]
13. What are the conditions for total internal reflection? [page no – 20]
14. What is mirage? [page no – 22]
15. What is called looming? [page no – 22]
16. What is shell's window? [page no – 23]
17. Explain the working of an endoscope. [page no – 27]
18. What are primary focus and secondary focus? [page no – 32]
19. Obtain lens equation for lateral magnification for thin lens. [page no – 33]
20. Obtain lens equation from lens makers formula. [page no – 33,34]
21. What is power of a lens? Write its unit. [page no – 35]
22. What is angle of minimum deviation of a prism? [page no – 42]
23. What are the conditions for the angle of deviation to be minimum? [page no – 42]
24. What is dispersion? [page no –43]
25. How are rainbows formed? [page no – 46]
26. What is rayleighs scattering? [page no – 46]
27. Why does sky appear blue? [page no – 46]
28. What is the reason for reddish appearance of sky during sunset and sunrise? [page no – 46,47]
29. Why do clouds appear? [page no – 47]
30. What is wave theory of light? [page no – 48]
31. What is electromagnetic wave theory of light? [page no – 48]

32. Write short note on quantum theory of light? [page no – 48]
33. What is a wavefornt? [page no – 49]
34. What is Huygen's principle? [page no – 49]
35. What is interference of light? [page no – 52]
36. What is phase of a wave? [page no – 54]
37. Obtain the relation between path difference and phase difference? [page no – 54,55]
38. What are coherent sources? [page no – 55]
39. What is intensity division? [page no – 55]
40. How does the shape of the wavefront observed for

    a.point source b.Line source c.source at infinity? [page no – 49]
41. How does wavefront division provide coherent sources? [page no – 56]
42. How do source and images behave as coherent sources? [page no – 56]
43. What are the conditions for obtaining clear and broad interference band? [page no – 59]
44. What is bandwidth of interference pattern? [page no – 59]
45. What is diffraction? [page no – 63]
46. What is the diffraction grating? [page no – 68]
47. What is grating element and corresponding points? [page no – 68]
48. What is resolving power of the instrument? [page no – 72]
49. What is resolution? [page no – 72]
50. What is Rayleighs criterion? [page no – 72]
51. What is polarization? [page no – 73]
52. Write different techniques to produce polarized light. [page no – 74]
53. Differentiate between polarised and unpolarised light? [page no – 74]
54. Discuss polarization by selective apsorption. [page no – 74]
55. What is polarizing angle? [page no – 78]
56. State Brewsters' law. [page no – 78]
57. What is double refraction? [page no – 80]
58. Mention the types of optically active crystals with example. [page no – 80]
59. What are the differences between ordinary and extraordinary? [page no – 80]
60. What is optic axis? [page no – 80]
61. How is polarization of light obtained by scattering of light? [page no – 81]
62. What are near point and normal focusing? [page no – 82]
63. Why is oil immersed objective preferred in a microscope? [page no – 84]

64. What is the use of an erecting lens in a terrestrial telescope? [page no – 87]
65. What is the use of collimator? [page no – 87]
66. What are the uses of spectrometer? [page no – 87]
67. What is Presbyopia? [page no – 91]
68. What is Astigmatism? [page no – 92]
69. How will you calculate the focal length of the correcting lens for a myopic eye? [page no – 90]
70. How will you calculate the focal length of the correcting lens for hypermetropic eye? [page no – 91]

3 MARKS:-

1. Give the characteristics of image formed by plane mirror. [page no – 4]
2. Derive the relation between f and R for a spherical mirror. [page no – 7]
3. What are Cartesian sign convention for a spherical mirror? [page no – 9]
4. What is optical path of a medium of thickness d and refractive index n? [page no – 15]
5. Obtain the equation for apparent depth. [page no – 18]
6. Obtain the equation for critical angle. [page no – 21]
7. Explain the reason for glittering of diamond. [page no – 21]
8. Write a short notes on the prisons making use of total internal reflection. [page no – 23]
9. Write a note on optical fibre. [page no – 25]
10. Obtain the equation for lateral displacement of light passing through a glass slab. [page no – 27]
11. What are the sign conventions followed for lences? [page no – 32]
12. Derive the equation for effective focal length for lenses in contact. [page no – 36]
13. What are the salient features of corpuscular theory of light? [page no – 47]
14. Differenciate between Fresnel and Fraunhofer diffraction. [page no – 63]
15. Mention the difference between interference and diffraction. [page no – 68]
16. Discuss the special cases on first minimum in Fraunhofer diffraction. [page no – 67]
17. Obtain the equation for special resolution and angular resolution. [page no – 72]
18. What are polarizer and analyser? [page no – 75]
19. What are the plane polarize ,u npolarised and partially polarised light? [page no – 75]
20. State and obtain Malus law?[page no – 75]
21. List the uses of polaroids. [page no – 78]
22. What is angle of polarization and obtain the equation for angle of polarization? (Or)
    State & prove Brewster's law. [page no – 78]
23. Discuss about pile of plates. [page no – 79]
24. Explain polarization by double refraction. [page no – 80]

25. Discuss about Nicol prison. [page no – 81]
26. What are the uses and drawbacks of Nicol prison? [page no – 81]
27. Discuss about terrestrial telescope. [page no – 87]
28. What are the advantages and disadvantages of using a reflecting telescope? [page no – 87]
29. What is myopia? What is its remedy? [page no – 90]
30. What is hypermetropia? What is its remedy? [page no – 91]

5 MARKS:-

1. Derive the mirror equation and the equation for lateral magnification. [page no – 9&10]
2. Describe the Fizeau's method to determine speed of light. [page no – 12&13]
3. Obtain the equation for radius of illumination (Or) snell's window. [page no – 23&24]
4. Derive the equation for acceptance angle and numerical aperture, of optical fibre. [page no – 25-26]
5. Derive the equation for refraction at a single spherical surface. [page no – 29]
6. Derive an expression for lateral magnification in single spherical surface. [page no – 30]
7. Obtain lens makers formula and mention its significance. [page no – 32-33]
8. Derive the equation for thin lens and obtain its magnification. [page no – 33-34]
9. Derive the equation for angle of deviation produced by a prism and thus obtain the equation for refractive index of material of the prism. [page no – 37&38]
10. Derive the equation for angle of deviation produced by a prism and thus obtain the equation for refractive index of material of the prism. [page no – 41&43]
11. What is dispersion? Obtain the equation for dispersive power of a medium page. [page no – 43,44,45]
12. Prove laws of reflection using Huygens principle. [page no – 50]
13. Prove laws of refraction using Huygens principle. [page no – 51]
14. Obtain the equation for resultant intensity due to interference of light. [page no – 53]
15. Explain the youngs double slit experimental setup and obtain the equation for path difference. [page no – 57-58]
16. Obtain the equation for bandwith in young's double slit experiment. [page no – 58-59]
17. Obtain the equations for constructive and destructive interference for transmitted and reflected waves in thin films. [page no – 61-62]
18. Discuss diffraction at single slit and obtain the condition for n^{th} minimum. [page no – 64-65]
19. Discuss the diffraction at a grating and obtain the condition for the m^{th} maximum. [page no – 68-69]
20. Discuss the experiment to determine the wavelength of monochromatic light using diffraction grating. [page no – 70-71]

21. Discuss the experiment to determine the wavelength of different colours using diffraction grating. [page no – 70]
22. Obtain the equation for resolving power of optical instrument. [page no – 72]
23. Discuss about simple microscope and obtain the equations for magnification for near point focusing and normal focusing. [page no – 82-83]
24. Explain about compound microscope and obtain the equation for magnification. [page no – 85]
25. Obtain the equation for resolving power of microscope. [page no – 84]
26. Discuss about astronomical telescope. [page no – 86]
27. Mention different parts of spectrometer and explain the prelimnary adjustment. [page no – 88]
28. Explain the experimental determination of material of the prism using spectrometer. [page no – 88-89]

NUMERICAL PROBLEMS:

1.An object is 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.

F = + 20 cm

Magnification m = ± 4

u = ?

m = $\frac{f}{f+u}$

i. For real image m = -4

$-4 = \frac{20}{20+u}$

-80 -4u = 20

4u = -100

u= -25 cm

ii. For virtual image m = +4

$4 = \frac{20}{20+u}$

80 + 4u = 20

4u = 60

u = $\frac{-60}{4}$

u = -15 cm

2. A compound microscope has a magnification of 30. The focal length of eye – piece is 5 cm. Assuming the final image to be at least distance of distinct vision. Find the magnification produced by the objective.

m=30

fe = +5cm

D=25cm

m_0 =?

$m = m_0 x m_e$

$m = m_0(1+ \frac{D}{f_e})$

$30 = m_0 (\frac{25}{5})$

$m_0 = \frac{30}{6}$

$m_0 = 5$.

3. An object is placed infront of a concave mirror of focal length 20cm. The image formed is three times the size of the object. Calculate two possible distances of the object from the mirror.

f = -20 cm

m = ± 3

for real image m = -3

m= $\frac{f}{f-u}$

-3 = $\frac{-20}{-20-u}$

60 + 3u = -20

3u = -80

u = $\frac{-80}{3}$ cm

for virtual image m = + 3

+3 = $\frac{-20}{-20-u}$

-60 -3u = -20

-3u = 40

-3u =40

u= $\frac{-40}{3}$ cm.

4.A small bulb is placed at the bottom of a tant containing water to a depth of 80cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33(consider the bulb to be a point source.

Actual depth d = 80cm = 0.8 m

Radius of circular surface of water through which the light form the bulb can emerge. R = $\frac{d}{\sqrt{n^2-1}}$

R = $\frac{0.8}{\sqrt{(1.33)^2-1}}$ = $\frac{0.8}{\sqrt{0.7684}}$

= $\frac{0.8}{\sqrt{0.87686}}$ = 0.9123 m.

Area of surface = πR^2

=3.14 x 0.9123 x 0.9123

= 2.613 m^2

5.A thin converging glass with refractive index 1.5 has a power of +5.0D. When this lens is immersed in a liquid of refractive index n, it acts as a divergent lens of focal length 100cm. What must be the value of n.

Pa = +5D

Pe = $\frac{1}{\frac{-100}{100}}$ = -1 D

n_e = ?

Pa = $(\frac{n_g}{n_a} - 1)\ (\frac{1}{R_1} - \frac{1}{R_2})$ ---------------1

Pe = $(\frac{n_g}{n_e} - 1)\ (\frac{1}{R_1} - \frac{1}{R_2})$ ----------------2

Equ 1 ÷ 2

$\frac{P_a}{P_b} = (\frac{n_g}{n_a} - 1)\ /\ (\frac{n_g}{n_e} - 1)$

$\frac{+5}{-1} = \frac{1.5-1}{\frac{1.5}{n_e}-1}$

$5\,(\frac{1.5}{n_e} - 1)$ = -1 x 0.5

$\frac{1.5}{n_e} = 1^{-0.1}$

$n_e = \frac{1.5}{0.9}$

n_e = 5/3

6.If the distance D between an object and screen is greater than 4 times the focal length of a convex lens, then there are two positions of the lens for which images formed on the screen. This method is called conjugate foci method. If d is the distance between the two positions of the lens, obtain the equation for focal length of the convex lens.

For enlarged image u = -x

For diminished image u = -x + d

By the principle of reversibility of light

X should the distance between lens and image in case ii) Apply lens equation for case ii)

u = - (x+d) v = x

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{x} + \frac{1}{x+d}$

x + d + x = D

2x + d = D

X = $\frac{D-d}{2}$

$\frac{1}{f} = \frac{1}{\frac{D-d}{2}} + \frac{1}{\frac{D-d}{2}+d}$

$= \frac{2}{D-d} + \frac{2}{D+d}$

$= \frac{2(D+d)+2(D-d)}{D^2-d^2}\frac{2(D+d)+2(D-d)}{D^2-d^2}$

$= \frac{1}{f} \quad = \frac{4D}{D^2-d^2}$

$f = \frac{D^2-d^2}{4D}$

7.A beam of light of wavelength 600nm from a distance source falk on a single strl – 1mm distance between the first dark fringe on either side of the central bright fringe?

Distance of the first dark fringe from central maximum = $\frac{2\lambda D}{d}$

D = 1 mm = 1 x 10 $^{-3}$ m

λ = 600 mm = 600 x 10 $^{-9}$m

D = 2 m

Width of central maximum = $\frac{2x600x10^{-9}x2}{1x10^{-3}}$

=24x10^{-3} m

=2.4 mm

8.In young's double slit experiment the slits are illuminated with a mixture of two wavelength λ_0=750nm and λ = 900nm. What is the minimum distance from the common central bright fringe on a screen 2m from the axis where a bright fringe from one interference pattern coincides with a bright fringe from the other?

λ = 2mm = 2 x 10 $^{-3}$m

D = 2m

λ_0=750 nm = 750 x 10 $^{-9}$m

λ = 900nm = 900 x 10 $^{-9}$m

Total extent of fringes y = $\frac{n\lambda D}{d}$

For a given y $\quad \lambda_0 < \lambda$

$n_0 > n$

(n+1) > n

Let nth order bright fringe of λ coincides with (n+1)th order bright fringe of λ_0

$y = \frac{n\lambda D}{d} = \frac{(n+1)\lambda_0 D}{d}$

$n\lambda = (n+1)\lambda_0$

nx900x10^{-9} = (n+1) 750 X 10 $^{-9}$

n= $\frac{750}{150}$

n=5

$y = \frac{5x900x10^{-9}x2}{2x10^{-3}}$

$= 4500 \times 10^{-6}$

$= 4.5 \times 10^{-3}$m

Minimum distance y= 4.5 mm

9.In young's double slit experiment 62 fringes are seen in visible region for sodium light of wavelength $5893A^0$. If violet light of wavelength 4359 A^0 is used in place of sodium light.

What is the number of fringe seen.

$\lambda_1 = 5893A^0 = 5893 \times 10^{-10}$m

$n_1= 4359\ A^0 = 4359 \times 10^{-10}$m

n_2 =?

$62x5893 \times 10^{-10} = n_2x4359 \times 10^{-10}$

$n_2 = \frac{62x5893}{4359}$

$n_2 = 84$

10.A compound microscope has a magnifying power of 100 when the image is formed at infinity. The objective has a focal length of 0.5cm and the tabe length is 6.5 cm. What is the focal length of the eyepiece?

$f_0 = 0.5$ cm

L = 6.5 cm

f_e =?

$m = m_0 \times m_e = (\frac{V_0}{u_0}) \times \frac{D}{fe}$

$L = V_0 + f_e$ = cm --------------------------------1

From lens eqution

$\frac{V_0}{u_0} = (1 - \frac{V_0}{u_0})$

$m = (1 - \frac{V_0}{u_0}) \times \frac{D}{f_e}$

$-100 = (1 - \frac{V_0}{0.5}) \times \frac{25}{f_e}$

$2V_0 - 4f_e$ 1 --2

Solving equs 1 & 2

$V_0 = 4.5$ cm

$f_e = 2$ cm.

BOOK BACK CONCEPTUAL QUESTIONS:

1.Why are dish antennas are parabolic in shape?

Solution:

Dish antenna is parabolic so to receive parallel signal rays coming from same direction. These signal rays are reflected from parabolic dish and gathered at main antenna part. This increases the directivity of antenna and gives amplitude signal sufficiently.

2.What type of lens is formed by a bubble inside water?

Solution:

Air bubble was spherical surface and is surrounded by medium of higher refractive index. When light passes from water to air, it gets diverged. Hence the air bubble behaves like concave lens.

3.Is it possible for two lenses to produce zero power?

Yes. It is possible for two lenses to produce zero power. Both the surfaces of lenses are equally curved.

ie. $R_1 = R_2$ in a convexo concave lens.

Here $R_1 = -R$

$R_2 = -R$

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

$= 0.$

4.Why does sky took blue and clouds look white?

According to Rayleigh scattering the intensity of scattered light,

$I \;\alpha\; 1/\lambda^4$. So, blue light of shorter wavelength is much more scattered then red light of larger wavelength. So the blue component is proportionally more in light coming from different parts of the sky. That is why the sky appear blue.

Clouds have large particles like dust and water droplets which scatter light of all colours almost equally. Hence clouds appear white.

5.Why is yellow light preferred to during fog?

Solution:

Yellow light has longer wavelength than green, blue or violet components of white light. According to Rayleigh law, $I \;\alpha\; 1/\lambda^4$, yellow colour is least scattered and produce sufficient illumination.

6.Two independent monochromatic sources cannot act as coherent sources. Why?

Solution:

This is because light is emitted by individual atoms. When they return to ground state, even the smallest source of light contain billions of atoms which obviously cannot emit light waves in the same phase.

7.Does diffraction takes place in young double slit?

solution:

Both diffraction and interference takes place in double slit experiment. The wavefront is diffracted as it passes through each of the slits. The diffraction causes the wavefronts to spread out as if they were coming from light source located at the slits. These two wavefronts overlap and interference occurs.

8.Is there any difference between coloured light obtained from prism and colours of soap bubble?

Solution:

Yes. There is a difference between coloured light obtained from prism is and colours of soap bubble.

Coloured light obtained form prism is the phenomenon of 'dispersion of light'. Colours obtained form soap bubble is the phenomenon of 'interference of light'

9.A small disc is placed in the path of the light from distance source. Will the center of the shadow be bright or dark?

Solution:

When a tiny circular small disc is placed in the path of the light from a distant source, a bright spot is seen at the center of the shadow of the disc because, wave diffracted from the edge of the cirucular disc interface constructively at the centre of the shadow, which produces bright spot.

10.When a wave undergoes reflection at a denser medium, what happens to its phase?

Solution:

When a wave undergoes reflection at a denser medium, then it's crest reflected as through and vice versa. So, its phase change at 180^0.

ADDITIONAL CONCEPTUAL QUESTIONS:

1.You are given following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope.

LENSES	POWER (P)	APERTURE (A)
A	1D	10CM
B	5D	1CM
C	10D	1CM

Solution:

C is used as an eyepiece and A is used as an objective to construct an astronomical telescope.

Reason:

The objective of the astronomical telescope should be of large focal length and large aperture. Eyepiece should have less focal length (more power)

2.Why reflecting telescope is preferred over refracting telescope?

Solution:

*To avoid spherical aberration (optical defect), that occur in refracting telescope.

*Lenses of large size used is very expensive and heavy are used in refractive telescope.

3.How does the focal length of the convex lens change when a red light is replaced by blue light?

Solution:

Focal length decreases.

Reason:

Blue light has lesser wave length and hence its refractive index is high. Therefore focal length decreases.

4.In youngs double slit experiment, if monochromatic light is replaced by a white light, what will be the coloured central fringe?

Solution:

White colour.

Justification:

All the seven colours in white light interfere constructively at the center as the path difference is zero. Therefore, it is white.

5.How would the bandwidth of the interference fringes youngs double slit experiment change when

i.Distance bet the plane of the slit and the screen is increased?

ii.If the distance between the slits is halved?

Solution:

i.Bandwidth increases

Reason:

β =λ/d. $\beta\alpha$

Where D → Distance bet the plane of the slit and the screen.

ii.Doubled we know that β =λ/d.

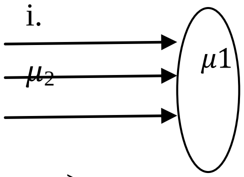
Reason:

β' =λ/d'

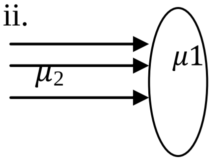
d`= d/2 ie. β' = 2λ/d = 2 β

6.Complete the path of the ray for the following diagrams:

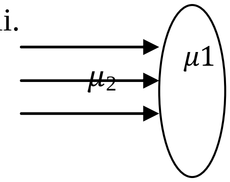
i.



ii.



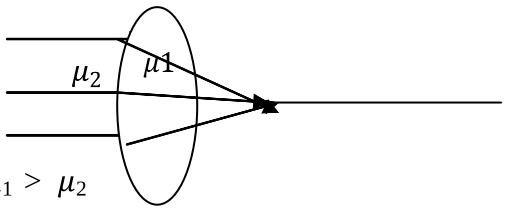
iii.



$\mu_1 > \mu_2$ $\mu_1 < \mu_2$ $\mu_1 = \mu_2$

solution:

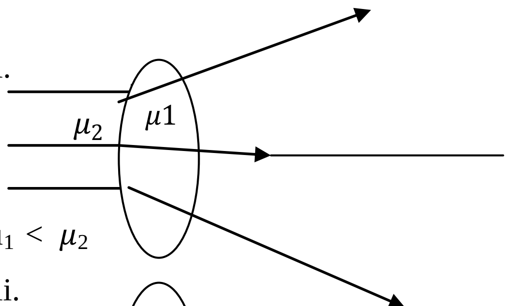
i.



[converge]

$\mu_1 > \mu_2$

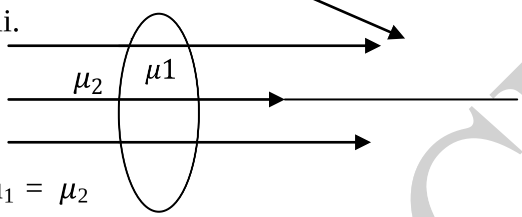
ii.



[diverge]

$\mu_1 < \mu_2$

iii.



[undeviated]

$\mu_1 = \mu_2$

LESSON 7

DUAL NATURE OF RADIATION AND MATTER.

POINTS TO PONDER:

- Particle is a material object which is considered as a tiny concentration of matter (localized in space and time).
- Wave is a broad distribution of energy (not localized in space and time)
- Surface barrier - The potential barrier which prevents free electrons from leaving the metallic surface.
- Electron emission - The liberation of electrons from any surface of a substance.
- SI unit of energy – joule.
- Commonly used unit of energy – electron volt
- The material with smaller work function is more effective in electron emission.
- Cesium has lesser work function.
- Platinum has greater work function

Photosensitive material:

- Materials which eject photoelectrons upon irradiation of electromagnetic wave of suitable wavelength.
- Photocurrent-number of electrons emitted per second.
- Photocurrent is directly proportional to the intensity of incident light.
- At stopping potential, even the most energetic electron is brought to rest.
- The maximum kinetic energy of the photoelectrons is independent of intensity of the incident light.
- When the frequency is increased , retarding potential is greater.
- Light behaves as a wave during propagation and behaves as a particle during interaction with matter.
- Photo cell – converts light energy in to electrical energy.
- De Broglie hypothesis – all matter particles like electrons, protons, neutrons in motion are associated with waves.
- The wave nature of electron is used in electron microscope.
- X-rays are electromagnetic waves of short wavelength ranging from $0.1A^0$ to $100A^0$.
- The intensity of x-rays depends on the number of electrons striking the target.
- X-ray spectrum – intensity of x-rays when plotted against its wavelength.
- Bremsstrahlung or braking radiation-Radiation produced from decelerating electron.
- Experimental verification of De Broglie hypothesis – Davisson Germer experiment.

- Types of electron emission:
    - Thermionic emission
    - Field emission
    - Photoelectric emission
    - Secondary emission.

IMPORTANT FORMULAE:

1.Stopping potential $eV_0=k_{max}=\frac{1}{2}mv^2_{max}$

2.Energy $E_{n=}nh$

3.Einstein's photoelectric equation

$h \quad = \Phi_o+\frac{1}{2}\,mv^2$

$k_{max}=h \; -\Phi_o$

4.Momentum $p=\frac{h}{c}=\frac{h}{\lambda}$

5.De Broglie wavelength $\lambda=\frac{h}{p}$

6.De Broglie wavelength of electrons:

$\lambda=\frac{h}{\sqrt{2emv}} \quad = \frac{12.27}{\sqrt{v}}$

$\lambda=\frac{h}{\sqrt{2mk}}$

7.cut-off wavelength:

$\lambda_o=\frac{hc}{ev}$

8.Duane-Hunt Formula:

$\lambda_o=\frac{12400}{v}$ A°

I Multiple Choice Questions

1. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by (NEET 2013)

a. $\lambda_p \propto \lambda_e$ b. $\lambda_p \propto \sqrt{\lambda_e}$

c. $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$ d. $\lambda_p \propto \lambda_e^2$

De broglie wavelength for photon

$$\lambda_p = \frac{hC}{E} \Longrightarrow E = \frac{hC}{\lambda_p}$$

For electron

$$\lambda_e = \frac{h}{\sqrt{2mE}} \Longrightarrow \lambda_e^2 = \frac{h^2}{2mE}$$

$$\lambda_e^2 = \frac{h^2\lambda_p}{2mhC} \Longrightarrow \lambda_p = \frac{2mC}{h}\lambda_e^2$$

$$\lambda_p = k\lambda_e^2 \Longrightarrow \lambda_p \propto \lambda_e^2$$

2. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de Broglie wavelength associated with the electrons would

a. increase by 2 times

b. decrease by 2 times

c. decrease by 4 times

d. increase by 4 times

$$\lambda_e = \frac{12.27 A^\circ}{\sqrt{V}} \Longrightarrow \lambda_e \propto \frac{1}{\sqrt{V}}$$

$$\frac{\lambda'}{\lambda} = \sqrt{\frac{V}{V'}} = \sqrt{\frac{14}{224}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$$

$$\lambda' = \frac{\lambda}{4}$$

3. A particle of mass 3×10^{-6} g has the same wavelength as an electron moving with a velocity $6 \times 10^6 \, m\,s^{-1}$. The velocity of the particle is

a. $1.82 \times 10^{-18} \, m\,s^{-1}$

b. $9 \times 10^{-2} \, m\,s^{-1}$

c. $3 \times 10^{-31} \, m\,s^{-1}$

d. $1.82 \times 10^{-15} \, m\,s^{-1}$

$$\lambda' = \lambda \qquad \lambda = \frac{h}{mv}$$

$$mv_2 = m_e v_e$$

$$v = \frac{9x10^{-31}x6x10^6}{3x10^{-9}} = 18x10^{-16}$$

$$v = 1.82x10^{-15} ms^{-1}$$

4. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is (NEET 2016)

a. 4λ b. 5λ

c. $\frac{5}{2}\lambda$ d. 3λ

By Einstein photo electric equation

$$h(\nu - \nu_o) = eV_o$$

$$hC\left[\frac{1}{\lambda} - \frac{1}{\lambda_o}\right] = eV \text{ ------------(i)}$$

$$hC\left[\frac{1}{2\lambda} - \frac{1}{\lambda_o}\right] = \frac{eV}{4} \text{ --------(ii)}$$

Solving (i) and (ii)

$$\frac{1}{2\lambda} - \frac{1}{\lambda_o} = \frac{1}{4\lambda} - \frac{1}{4\lambda_o}$$

$$\lambda_o = 3\lambda$$

5. If a light of wavelength 330 nm is incident on a metal with work function 3.55 eV, the electrons are emitted. Then the wavelength of the emitted electron is (Take $h = 6.6 \times 10^{-34}\ Js$)

a. $< 2.75 \times 10^{-9} m$ b. $\geq 2.75 \times 10^{-9} m$

c. $\leq 2.75 \times 10^{-12} m$ d. $< 2.5 \times 10^{-10} m$

By Einstein photoelectric equation

$$h\nu - \phi = \frac{1}{2} m v^2_{max} = E_{max}$$

$$E_{max} = \frac{hC}{\lambda} - \phi$$

$$E_{max} = \frac{6.6x10^{-34} x3x10^{8}}{3.3x10^{-7}} - 3.55x1.6x1 0^{-19}$$

$$E_{max} = 6x10^{-19} - 5.68x10^{-19} = 0.32x10^{-19} J$$

De broglie wavelength of electron

$$\lambda = \frac{h}{\sqrt{2mE}}$$

For maximum energy, the wavelength of electron is minimum

$$\lambda_{min} = \frac{6.6x10^{-34}}{\sqrt{2x9x10^{-31}x0.32x10^{19}}} = \frac{6.6x10^{-34}}{3x8x10^{-26}}$$

$$\lambda_{min} = 0.275x10^{-8} ms^{-1}$$

the emitted electrons will have wavelength

$$\geq 0.275x10^{-8} ms^{-1}$$

6. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\lambda/2$. If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function at the surface of material is (NEET 2015)

a) $\frac{hc}{\lambda}$ b) $\frac{2hc}{\lambda}$

c) $\frac{hc}{3\lambda}$ d) $\frac{hc}{2\lambda}$

By Einstein photoelectric equation

For first case

$$\frac{hC}{\lambda} - \phi = \frac{1}{2} m v_{max}^2$$

For second case

$$\frac{hC}{\lambda/2} - \phi = 3\left(\frac{1}{2} m v_{max}^2\right)$$

$$\frac{2hC}{\lambda} - \phi = 3\left(\frac{hC}{\lambda} - \phi\right)$$

$$3\phi - \phi = 3\frac{hC}{\lambda} - 2\frac{hC}{\lambda}$$

$$2\phi = \frac{hC}{\lambda} ==> \phi = \frac{hC}{2\lambda}$$

7. In photoelectric emission, a radiation whose frequency is 4 times threshold frequency of a certain metal is incident on the metal. Then the maximum possible velocity of the emitted electron will be

a) $\sqrt{\frac{h\nu_0}{m}}$ b) $\sqrt{\frac{6h\nu_0}{m}}$

c) $2\sqrt{\frac{h\nu_0}{m}}$ d) $\sqrt{\frac{h\nu_0}{2m}}$

$$h\nu - h\nu_o = \frac{1}{2} m v^2_{max}$$

$$h4\nu_o - h\nu_o = \frac{1}{2} m v^2_{max}$$

$$3h\nu_o = \frac{1}{2} m v^2_{max}$$

$$v^2_{max} = \frac{6h\nu_o}{m} ==> v = \sqrt{\frac{6h\nu_o}{m}}$$

8. Two radiations with photon energies 0.9 eV and 3.3 eV respectively are falling on a metallic surface successively. If the work function of the metal is 0.6 eV, then the ratio of maximum speeds of emitted electrons will be a) 1:4 b) 1:3 c) 1:1 d) 1:9	By Einstein photo electric equation $h\nu - h\nu_o = \frac{1}{2}mv_{max}^2$ $(0.9-0.6)eV = \frac{1}{2}mv_1^2$ $(3.3-0.6)eV = \frac{1}{2}mv_2^2$ Dividing $\frac{0.3}{0.27} = \left(\frac{v_1}{v_2}\right)^2 ==> \frac{v_1}{v_2} = \sqrt{\frac{30}{27}} = 1.11$
9. A light source of wavelength 520 nm emits 1.04×10^{15} photons per second while the second source of 460 nm produces 1.38×10^{15} photons per second. Then the ratio of power of second source to that of first source is a) 1.00 b) 1.02 c) 1.5 d) 0.98	Power of the source = no of photons emitted /s x energy of photon $P_1 = n_1 \times \frac{hC}{\lambda_1}$ $\frac{P_2}{P_1} = \frac{n_2 \lambda_1}{n_1 \lambda_2} = \frac{1.38 \times 10^{15} \times 520 \times 10^9}{1.04 \times 10^{15} \times 460 \times 10^9} = 1.5$
10. The mean wavelength of light from sun is taken to be 550 nm and its mean power is $3.8 \times 10^{26} W$. The number of photons received by the human eye per second on the average from sunlight is of the order of a) 10^{45} b) 10^{42} c) 10^{54} d) 10^{51}	$E = \frac{hC}{\lambda} = \frac{6.6x10^{-34}x3x10^8}{5.5x10^{-7}} = \frac{18}{5}x10^{-19}J$ No of photons emitted per second $n = \frac{\text{power of sun (W)}}{\text{Energy of photon}} = \frac{3.8x10^{26}}{3.6x10^{-19}} \equiv 10^{45}$
11. The threshold wavelength for a metal surface whose photoelectric work function is 3.313 eV is a) 4125 $\mathring{A}$ b) 3750 $\mathring{A}$ c) 6000 $\mathring{A}$ d) 2062.5 $\mathring{A}$	$\phi = h\nu_o = \frac{hC}{\lambda_o}$ $\lambda_o = \frac{hC}{\phi} = \frac{6.6x10^{-34}x3x10^8}{3.313x1.6x10^{-19}} = 3750x10^{-10}$ $\lambda_o = 3750 A^o$
12. A light of wavelength 500 nm is incident on a sensitive plate of photoelectric work function 1.235 eV. The kinetic energy of the photo electrons emitted is be (Take $h = 6.6 \times 10^{-34}$ Js) a) 0.58 eV b) 2.48 eV c) 1.24 eV d) 1.16 eV	$\frac{hC}{\lambda} - \phi = \frac{1}{2}mv_{max}^2 = E$ $E = \left(\frac{6.6x10^{-34}x3x10^8}{500x10^{-9}x1.6x10^{-19}} - 1.235\right)eV$ $E = 2.472 - 1.235 = 1.24eV$

13. Photons of wavelength λ are incident on a metal. The most energetic electrons ejected from the metal are bent into a circular arc of radius R by a perpendicular magnetic field having magnitude B. The work function of the metal is (KVPY-SX 2016) a. $\frac{hc}{\lambda}-m_e+\frac{e^2B^2R^2}{2m_e}$ b. $\frac{hc}{\lambda}+2m_e\left[\frac{eBR}{2m_e}\right]^2$ c. $\frac{hc}{\lambda}-m_ec^2-\frac{e^2B^2R^2}{2m_e}$ d. $\frac{hc}{\lambda}-2m_e\left[\frac{eBR}{2m_e}\right]^2$	By Einstein equation $\frac{hC}{\lambda}-\phi=\frac{1}{2}mv^2$ $\frac{mv^2}{R}=Bev ==> v=\frac{BeR}{m}$ $\frac{hC}{\lambda}-\phi=\frac{1}{2}m\left(\frac{BeR}{m}\right)^2$ $\phi=\frac{hC}{\lambda}-\frac{B^2e^2R^2}{2m}$
14. The work functions for metals A, B and C are 1.92 eV, 2.0 eV and 5.0 eV respectively. The metals which will emit photoelectrons for a radiation of wavelength 4100 $Å$ is/are a. A only b. both A and B c. all these metals d. none	$(\lambda_o)_A=\frac{hC}{\phi_A}=\frac{6.6x10^{-34}x3x10^8}{1.92x1.6x10^{-19}}=6445A^o$ $(\lambda_o)_B=\frac{hC}{\phi_B}=\frac{6.6x10^{-34}x3x10^8}{2.0x1.6x10^{-19}}=6100A^o$ $(\lambda_o)_C=\frac{hC}{\phi_C}=\frac{6.6x10^{-34}x3x10^8}{5.0x1.6x10^{-19}}=2480A^o$ *For photo electric effect to occur,* $\lambda<\lambda_o$ Here $\lambda<(\lambda_o)_A : \lambda<(\lambda_o)_B : \lambda>(\lambda_o)_B$
15. Emission of electrons by the absorption of heat energy is called……..emission. a. photoelectric b. field c. thermionic d. secondary	Thermionic emission

<u>SHORT ANSWER QUESTIONS</u>:-

2 MARKS:

1. Distinguish particle from wave. (Pg.105)

2. Why do metals have a large number of electrons? (Pg.106)

3. What is electron emission ? (Pg.106)

4. What do you mean by surface barrier?(Pg.106)

5. Define work function of a metal. Give its unit (Pg.106)

6. Define One electron volt. (Pg.106)

7. Why materials with smaller work function is more effective in electron emission?(Pg.106)

8. Give four types of electron emission?(Pg.107)

9. What is photoelectric effect? (Pg.109)

10. What are photosensitive materials?(Pg.110)

11. How does photocurrent vary with the intensity of the incident light?(Pg.111)

12. Define stopping potential.(Pg.112)

13. How does stopping potential vary with the given frequency of incident radiation?(pg.113)

14. How will you define threshold frequency?(pg.113)

15. What is Quantization of energy?(pg.115)

16. How is the energy of a photon determined?(pg.116)

17. Give the definition of intensity of light and its unit (Pg.116)

18. What is a photo cell? Mention the different types of photocells?(Pg.118)

19. On what factors does the magnitude of current depend in a photo emissive cell?(Pg.119)

20. State De Broglie hypothesis. (pg.121)

21. Give the expression for de Broglie wavelength.(pg.121)

22. Write the expression for the de Broglie wavelength associated with a charged particle of charge q and mass m, when it is accelerated through a potential V(pg .122)

23. What is the principle used in electron microscope?(Pg 123)

24. Why microscopes employing de Broglie waves of electrons have higher resolving power that optical microscope?(pg .123)

25. How x-rays are produced? (pg.126)

27. What are X-rays?(pg.126)

28. What is continuous x-ray spectrum ? (pg.127)

29. What is characteristic x-ray spectrum?(pg.128)

30. Write Duane-hunt formula (pg.128)

31. Write the relationship of a de Broglie wavelength associated with a particle of mass m in terms of its kinetic energy.(pg 122)

32. Name an experiment which shows wave nature of the electron. Which phenomenon wa s observed in this experiment using an electron beam?

3 MARKS:

1. What is thermionic emission? (pg.107)
2. What is field emission ? (pg.107)
3. What is photo electric emission ? (pg.108)
4. What is secondary emission? (pg.108)
5. What are the postulates of Planck's concept of quantization of energy?(pg.115)
6. What are the applications of photocells?(pg.119)
7. Derive the expression for de Broglie wavelength of matter waves? (pg.121)
8. What are the features of x-ray spectra that cannot be explained by classical electromagnetic theory?(pg.127)
9. What is Bremsstrahlung (braking) radiation?(pg.128)
10. What are the applications of x-rays? (pg.129)
11. Why we do not see the wave properties of a base ball?

The mass of a baseball is very high compared to the mass of an electron .As the wavelength of matter waves is inversely proportional to mass, the wavelength of baseball is very much small.

So, we do not see the wave properties of a base ball.

12. A proton and electron have some kinetic energy. Which one has greater de Broglie wavelength? Justify.

$\lambda p=\frac{h}{\sqrt{2mk}}$ $\lambda_e=\frac{h}{\sqrt{2mk}}$

$\frac{\lambda p}{\lambda e}=\sqrt{\frac{m}{m}}$

The wavelength is inversely proportional to mass. As the mass of electron is lesser that the mass of proton, the wavelength of electron is greater than that of proton.

13. An electron and an alpha particle have same kinetic energy. How are the de Broglie wavelength associated with them related?

$\lambda e=\frac{h}{\sqrt{2mk}}$ $\lambda_\alpha=\frac{h}{\sqrt{2mk}}$

$\frac{\lambda e}{\lambda \alpha}=\sqrt{\frac{m\alpha}{me}}$

The de Broglie wavelength is inversely proportional to the square root of mass.

14. What are the properties of x-rays?(pg.126)

LONG ANSWER QUESTION:

1. What do you mean by electron emission? Explain briefly various methods of electron emission (pg.107,108).
2. Briefly discuss the observation of Hertz, Hallwachs and Lenard.(pg.108,109)
3. Explain the effects of potential difference on photoelectric current(pg.111)
4. Explain how frequency of incident light varies with stopping potential (Pg.112)
5.List out the laws of photoelectric effect.
6. Explain why photoelectric effect cannot be explained on the basis of wave nature of light.(pg.113)
7. Explain the quantum concept of light (pg.116, 117)
8. Obtain Einstein's photoelectric equation with necessary explanation (pg.116, 117)
9. Explain experimentally observed facts of photoelectric effect with the help of Einstein's explanation.
10. Give the construction and working of a photo emissive cell. (pg.118)
11. Derive an expression for de Broglie wavelength of electrons. (pg.121)
12. Briefly explain the principle and working of electron microscope.(pg.123)
13. Describe briefly Davisson-Germer experiment which demonstrated the wave nature of electrons. (Pg.122)
14. Explain the effect of intensity of incident light on photoelectric current(pg.111)
15. What are the characteristics of photons?(Pg.116)
16. Explain the production of x-rays (pg.126)
17. Explain continuous of x-ray spectra (pg.128)
18. Explain characteristic x-ray spectra (pg.128)

Physics – Dual nature problems

1. How many photons per second emanate from a 50-mW laser of 640 *nm*?

Ans: $n = \frac{P}{E} = \frac{P\lambda}{hc} = \frac{50\times10^{-3}\times640\times10^{-9}}{19.878\times10^{-26}}$

$= \frac{32000}{19.878} \times 10^{14} = 1609.8 \times 10^{14}$

$n = 1.61 \times 10^{17} s^{-1}$

2. Calculate the maximum kinetic energy and maximum velocity of the photoelectrons emitted when the stopping potential is 81*V* for the photoelectric emission experiment.

Ans: $KE = ev = 1.6 \times 10^{-19} \times 81$

$KE = 129.6 \times 10^{-19} = 1.29 \times 10^{-17} J$

$KE = 1.3 \times 10^{-17} J$

$\longrightarrow \frac{1}{2}mv^2 = 1.3 \times 10^{-17}, v^2 = \frac{2\times1.3\times10^{-17}}{9.11\times10^{-31}}$

$v = \sqrt{\frac{2.6}{9.11}\times 10^{14}} = 0.53 \times 10^7$

$v = 5.3 \times 10^6 m/s$

3. Calculate the energies of the photons associated with the following radiation: (i) violet light of 413 *nm* (ii) X-rays of 0.1 *nm* (iii) radio waves of 10 *m*.

Ans: (i) $E = \frac{hc}{\lambda} = \frac{19.878\times10^{-26}}{413\times10^{-9}\times1.6\times10^{-19}} = 0.03 \times 10^2 = 3\ eV$

(ii) $E = \frac{hc}{\lambda} = \frac{19.878\times10^{-26}}{1\times10^{-10}\times1.6\times10^{-19}} = 12.4 \times 10^3 = 12423\ eV$

(iii) $E = \frac{hc}{\lambda} = \frac{19.878\times10^{-26}}{10\times1.6\times10^{-19}} = 12.4 \times 10^{-8}\ eV$

4. A 150 *W* lamp emits light of mean wavelength of 5500 Å. If the efficiency is 12%, find out the number of photons emitted by the lamp in one second.

Ans: $n = \frac{P}{E} = \frac{12}{100}\left(\frac{P}{E}\right) = \frac{12}{100} \times \frac{P\lambda}{hc} = \frac{12}{100} \times \frac{150\times5500\times10^{-10}}{19.878\times10^{-26}}$

$n = 4.98 \times 10^{19}$

5. How many photons of frequency 10^{14} *Hz* will make up 19.86 *J* of energy?

Ans: $n = \frac{P}{E}, Where\ P = \frac{Energy}{t}$

$n = \frac{E}{t\times h\nu} = \frac{19.86}{1\times6.626\times10^{-34}\times10^{14}} = 3 \times 10^{20}$

6. What should be the velocity of the electron so that its momentum equals that of 4000 Å wavelength photon.

Ans: $\lambda = \frac{h}{p}$

$p = \frac{h}{\lambda}$

$Mv_e = \frac{h}{\lambda}$

$v_e = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 4 \times 10^{-7}} = 0.1820 \times 10^4\ m/s$

7. When a light of frequency $9 \times 10^4\ Hz$ is incident on a metal surface, photoelectrons are emitted with a maximum speed of $8 \times 10^5 ms^{-1}$. Determine the threshold frequency of the surface.

Ans: Work function $W = h\upsilon - \frac{1}{2}mv^2$

$= 6.626 \times 10^{-34} \times 9 \times 10^{14} - \frac{1}{2} \times 9.11 \times 10^{-31} \times 64 \times 10^{10}$

$= 59.63 \times 10^{-20} - 291.52 \times 10^{-21}$

$W = 30.478 \times 10^{-20} J$

$\nu_0 = \frac{W}{h} = \frac{30.478 \times 10^{-20}}{6.626 \times 10^{-34}} = \mathbf{4.6 \times 10^{14}\ HZ}$

8. When a 6000 Å light falls on the cathode of a photo cell and produced photoemission. If a stopping potential of 0.8 V is required to stop emission of electron, then determine the (i) frequency of the light (ii) energy of the incident photon (iii) work function of the cathode material (iv) threshold frequency and (v) net energy of the electron after it leaves the surface.

Ans:

(i) $\nu = \frac{c}{\lambda} = \frac{3\times10^8}{6\times10^{-7}} = \mathbf{5 \times 10^{14} Hz}$

(ii) $E = h\upsilon = \frac{6.626\times10^{-34}\times5\times10^{14}}{1.6\times10^{-19}} = 20.7 \times 10^{-1} = \mathbf{2.07\ eV}$

(iii) $\emptyset = h\upsilon - eV_o = 2.07 - 0.8 = \mathbf{1.27\ eV}$

(iv) $V_o = \frac{\emptyset}{h} = \frac{1.27\times1.6\times10^{-19}}{6.626\times10^{-34}} = 0.306 \times 10^{15} = \mathbf{3.06 \times 10^{14} Hz}$

(v) $KE = h\upsilon - w = 2.07 - 1.27 = \mathbf{0.8\ eV}$ (or)

$KE = stopping\ potental$, Stopping potential = 0.8 V, $\therefore KE = \mathbf{0.8\ V}$

9. A 3310 Å photon liberates an electron from a material with energy $3 \times 10^{-19} J$ while another 5000 Å photon ejects an electron with energy $0.972 \times 10^{-19} J$ from the same material. Determine the value of Planck's constant and the threshold wavelength of the material.

Ans: $\frac{hc}{\lambda_1} = w + E_1, hc = w\lambda_1 + E_1\lambda_1, hc = w\lambda_2 + E_2\lambda_2,$

$w\lambda_1 + E_1\lambda_1 = w\lambda_2 + E_2\lambda_2 \Longrightarrow w = \frac{E_1\lambda_1 - E_2\lambda_2}{\lambda_1 - \lambda_2}$

$w = \frac{3\times10^{-19}\times3310\times10^{-10} - 0.972\times10^{-19}\times5\times10^{-7}}{5\times10^{-7} - 3.31\times10^{-7}} = \frac{9930\times10^{-29} - 4860\times10^{-29}}{1690\times10^{-10}} = \frac{5070\times10^{-19}}{1690}$

$\mathbf{w = 3 \times 10^{-19} J}$

$w = \frac{hc}{\lambda_0}, \lambda_0 = \frac{hc}{w} = \frac{19.878\times10^{-26}}{3\times10^{-19}} = 6.626 \times 10^{-7} = \mathbf{6626 \times 10^{-10} m}$

$w = \frac{hc}{\lambda_0}, h = \frac{w\lambda_0}{c} = \frac{3\times10^{-19}\times6626\times10^{-10}}{3\times10^{8}} = 6626 \times 10^{-37} = \mathbf{6.626 \times 10^{-34} Js}$

10. At the given point of time, the earth receives energy from sun at $4 cal\ cm^{-2} min^{-1}$. Determine the number of photons received on the surface of the Earth per cm^2 per minute. (Given: Mean wavelength of sun light=5500 Å)

Ans: Energy received from the sun $= 4 cal\ cm^{-2} min^{-1}$

$$= 16.8\, cal\ cm^{-2} min^{-1} (1\ cal = 4.2 J)$$

Energy of one photon $E = \frac{hc}{\lambda} = \frac{19.878 \times 10^{-26}}{5500 \times 10^{-10}} = 3.6 \times 10^{-19} J$

$$n = \frac{\text{Energy received from the sun}}{\text{Energy of one photon}} = \frac{16.8}{3.6 \times 10^{-19}} = 4.66 \times 10^{19}$$

11. UV light of wavelength 1800 Å is incident on a lithium surface whose threshold wavelength 4965 Å. Determine the maximum energy of the electron emitted.

Ans: $E = \emptyset + K.E$

$$h\theta = h\theta_o + K.E$$

$$\frac{hc}{\lambda} = \frac{hc}{\lambda o} + K.E$$

$$K.E = \frac{hc}{\lambda} - \frac{hc}{\lambda o} = \frac{19.878 \times 10^{-26}}{18 \times 10^{-8} \times 1.6 \times 10^{-19}} - \frac{19.878 \times 10^{-26}}{4965 \times 10^{-10} \times 1.6 \times 10^{-19}}$$

$$6.902 - 2.50 = 4.40 \text{ eV}$$

12. Calculate the de Broglie wavelength of a proton whose kinetic energy is equal to 81.9 × 10–15 J. (Given: mass of proton is 1836 times that of electron).

Ans: $\lambda = \frac{h}{\sqrt{2mK}} = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 81.9 \times 10^{-15}}} = 4 \times 10^{-14} m$

13. A deuteron and an alpha particle are accelerated with the same potential. Which one of the two has i) greater value of de Broglie wavelength associated with it and ii) less kinetic energy? Explain.

Ans: ${}_1H^2, {}_2He^4$

$$\lambda_d = \frac{h}{\sqrt{2.2m.eV}} = \frac{h}{\sqrt{4meV}}$$

$$\lambda_\alpha = \frac{h}{\sqrt{2.4m.2eV}} = \frac{h}{\sqrt{4}\sqrt{4m.eV}} = \frac{\lambda_d}{2} \longrightarrow \lambda_d = 2\lambda_\alpha$$

$$K_d = \frac{1}{2}.2m.V^2 \text{ and } K_\alpha = \frac{1}{2}.4m.V^2 = \frac{1}{2}.2m.V^2.2 = K_d.2$$

$$K_d = \frac{K_\alpha}{2}$$

14. An electron is accelerated through a potential difference of 81 V. What is the de Broglie wavelength associated with it? To which part of electromagnetic spectrum does this wavelength correspond?

Ans: $\lambda = \frac{12.27Å}{\sqrt{v}} = \frac{12.27Å}{\sqrt{81}} = \frac{12.27Å}{9} = 1.36Å$

It belongs to x-ray (spectrum-see 5th lesson)

15. The ratio between the de Broglie wavelengths associated with protons, accelerated through a potential of 512 V and that of alpha particles accelerated through a potential of X volts is found to be one. Find the value of X.

Ans: For photon ${}_1H^1$, For $\alpha -$ particle ${}_2He^4$

$$\lambda_p = \frac{h}{\sqrt{2meV_1}}$$

$$\lambda_\alpha = \frac{h}{\sqrt{2.4m.2eX}} = \frac{h}{\sqrt{8}\sqrt{2meX}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{h}{\sqrt{2meV_1}} \times \frac{\sqrt{8}\sqrt{2meX}}{h} = \sqrt{\frac{8X}{V_1}} \Longrightarrow \qquad 1 = \sqrt{\frac{8X}{V_1}}$$

Squaring on both sides,

$$1^2 = \frac{8X}{V_1} \Longleftrightarrow \quad 1 = \frac{8X}{512}$$

$$X = \frac{512}{8} = 64V$$

LESSON :8

ATOMIC AND NUCLEAR PHYSICS

POINTS TO PONDER

- A device used to study the conduction of electricity through gases is known as gas discharge tube.
- When the Pressure reaches 0.01mm of Hg walls of the tube appear with green colour. At this stage, some invisible rays emanate from cathode called cathode rays
- The Speed of cathode rays is up to $\left(\frac{1}{10}\right)^{th}$ of the speed of light.
- Charge per unit mass is Known as Specific charge or normalized charge, and it is independent of gas used and also nature of electrodes used
- The Value of Specific charge $\frac{e}{m} = 1.7 \times 10^{11} C\ kg^{-1}$
- From classical electrodynamics, no stable equilibrium point existin electrostatic configuration and this is known as Earnshaw's theorem
- The minimum distance between the centre of the nucleus and the alpha particle just before it gets reflected back through 180` is defined as the distance of closest approach ro
- The impact parameter is defined as the perpendicular distance between the centre of the gold nucleus and the direction of Velocity Vector of alpha parficle when it is at a large distance
- Coulomb force gives necessary centripetal force for the electron to undergo circular motion in Bohr atom model
- According to Bohr atom model angular momentum is quantized
- The radius of the orbit in Bohr atom model is $r_n = a_0 \frac{n^2}{Z}$
- I Rydberg = -13.6eV
- deuterium has an electron, a proton and a neutron
- Excitation Potential is denfined as excitation energy per Unit charge
- The life time of electrons in the excited state is $10^{-8} s$
- The number of protons in the nucleus – Atomic number
- Mass number= no of protons + no of neutrons
- Mass of a proton is $1.6726 \times 10^{-27} kg$
- Mass of a neutron is $1.6749 \times 10^{-27} kg$
- The nucleus of element X having atomic number Z and mass number A is represented by ${}_Z^AX$
- The density of nucleus ρ=$2.3 \times 10^{17} Kgm^{-3}$

- The binding energy per nucleon ismaximum for iron is 8.8 Mev
- Alpha decay : ${}_{Z}^{A}X \rightarrow {}_{Z-2}^{A-4}Y + {}_{2}^{4}He$
- β^- decay : ${}_{Z}^{A}X \rightarrow {}_{Z+1}{}^{A}Y + e^- +_{\gamma}^{-}$
- $\beta^+ decay$: ${}_{Z}^{A}X \rightarrow {}_{Z-1}{}^{A}X + e^+ + \gamma$
- Gamma decay :${}_{Z}^{A}X \rightarrow {}_{Z}^{A}X + \gamma$
- If a heavier nucleus decays into lighter nuclei, nuclear fission
- if two lighter nuclei fuse to heavier nuclei nuclear fusion
- In nuclear reactors, the nuclear chain reaction is controlled.
- In stars, the energy generation is through nuclear fusion. 1Ci=$3.7 \times 10^{10}\,Bq$.
- One Becquerel is equal to one decay per second
- half-life of carbon 14 is 5730 years
- atom bomb- an example for uncontrolled chain reaction
- The moderator is used to convert fast neutrons into slow neutrons.
- Cadmiymand boron acts as control rod in Nuclear reactor
- In Nuclear reactor, Ordinary water, heavy water and liquid sodium are used as coolant
- Charge of up quark is $+\frac{2}{3}e$
- Charge of down quark is $-\frac{1}{3}e$
- Kinetic energy of slow neutrons O-1000ev
- Kinetic energy of fast neutrons – 0.5 Mev to 10 Mev
- The neutrons with average energy of about 0.025ev in thermal equilibrium are called thermal neutron

IMPORTANT FORMULAS

- Velocity of electron, V=$\frac{E}{B}$
- Specific charge of an electron, $\frac{e}{m}$=$\frac{1}{2V}\frac{E^2}{B^2}$
- Charge of an electron – oil drop experiment q =$\frac{18\pi}{E}\left(\frac{\eta^3 v^3}{2(\rho-0)g}\right)^{1/2}$
- Angulor momentum is given by, l = nh = $\frac{nh}{2\pi}$, mvr = $\frac{nh}{2\pi}$
- The difference in energy (ΔE) between the two orbital levels,

$$\Delta E = Efinal - E\ initial = hv = \frac{hc}{\lambda}$$

- Distance of closest approach,

  r_0= $\frac{1}{4\pi\epsilon_0}\frac{2Ze^2}{\epsilon_k}$ = 9× 10^9 × $\frac{2Ze^2}{Ek}$ = 4.608×10-28× $Z/_{Ek}$
- Impact parameter, b= k cot $\left(\frac{\theta}{2}\right)$

  Where k = $\frac{1}{4\pi\epsilon o}\frac{2Ze^2}{mvo^2}$
- Radius of the orbit of the electron,

  r_n=$\left[\frac{\epsilon_0 h^2}{\pi m e^2}\right]\frac{n^2}{Z} = a_0\frac{n^2}{z}, a_0 = 0.529A^\circ$
- Velocity of electron in n^{th} orbit,

  V_n=$\frac{h}{2\pi m a_o}\frac{z}{n}$,$V_n \propto \frac{1}{n}$
- Energy of electron in the n^{th} orbit,

  E_n= $-\frac{me^4}{8\epsilon_0{}^2 h^2}\frac{1}{n^2}$joule :$E_n = \frac{-13.6}{n^2}ev$
- Ionization Potential,

  $V_{inonization} = \frac{E_{ionization}}{e} = \frac{13.6}{n^2}Z^2$ volt
- $\bar{v} = \frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$ where $\bar{v}$ is known as wave number
- Nuclear radius, R= $R_0 A^{1/3}$:$R_0 = 1.2F$

  Where $R_0 = 1.2 \times 10^{-15}$m
- Nuclear density, ρ=$\frac{Nuclear\ \ Mass}{Nuclear\ \ Volume}$= $\frac{m}{\frac{4}{3}\pi R_0^3}$
- Mass defect, $\Delta m = (Zmp + Nmn) - M$
- Binding energy, BE=(Zmp+Nmn$-M)C^2$
- Average binding energy Per nucleon $\overline{BE,}$

$$\overline{BE,} = \left[\frac{Zm_p + Nm_n - M_A}{A}\right]c^2$$

- One atomic mass unit (u) = $\frac{mass\ \ of\ \ ^{12}_{6}c\ atom}{12}$
- Disintegration energy Q= $(m_x - m_y\ - m_2)c^2$
- Radioactive decay law

(i) $\frac{dN}{dt} = \ -\lambda N$ (iv) R=$R_0 e^{-\lambda t}$

(ii) $N = N_0 e^{-\lambda t}$ (v) $R_0\ = \lambda No$

(iii) $R\ =\ \frac{dN}{dt}$ (vi) R=λN

- Half –life $T_{1/2}$= $\frac{0.6931}{\lambda}$
- The number of nuclei remaining undecayed is given by

$$N=\left(\frac{1}{2}\right)^n N_0$$

- The activity or decay rate of any radioactive sample is

$$R=\left(\frac{1}{2}\right)^n R_0$$

- Mean life $\tau = \frac{1}{\lambda} : T_{1/2}$= 0.6931 τ
- The radius of the oil drop.

$$r= \left[\frac{9\eta v}{2(\rho-\sigma)g}\right]^{1/2}$$

SHORT ANSWER QUESTIONS

2 &3 MARKS

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13. Explain Proton-Proton cycle.181

5 MARKS

1. Explain the J J Thomson experiment to determine the specific charge of electrons (140 to 142)
2. Discuss the Millikan's oil drop experiment to determine the charge of an electron (143-144)
3. Derive the energy expression for hydrogen atom using Bohr atom model.(152)
4. Discuss the spectral series of hydrogen atom (159-160)
5. Explain the variation of average binding energy with the mass number by graph and discuss ifs features (164-165)
6. Explain in detail the nuclear force (165-166)
7. Discuss the alpha decay process with examples (166-167)
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ADDITIONAL QUESTIONS

18. Explain the Process of electric discharge through gasses (139-140)
19. Derive an expression for the radius of the orbit of the electron using Bohr atom model (150-151)
20. Explain the discovery of neutrons and list out the properties of neutrons (176)
21. Describe chain reaction and the two kinds of reactions (177-178)

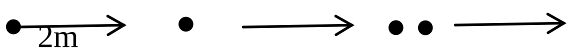
BOOK BACK PROBLEMS

1. Consider two hydrogen atoms H_A and H_B in ground state. Assume that hydrogen atom H_A is at rest and hydrogen atom H_B is moving with a speed and make head-on-collision on the stationary hydrogen atom H_A. After the Strike, both of them move together. What is minimum value of the kinetic energy of the moving hydrogen atom H_B, such that any one of the hydrogen atoms reaches one of the excitation state

Ans Let the Mass of H_A and H_B be 'm' each. H_A is at rest and H_B is moving with a kinetic energy K. H_B makes a head on collision with H_A
and move together with a kinetic energy K'

K $\qquad\qquad$ K^1

mm $\qquad$ 2m



According to law of conservation of momentum

$$P = P^1$$

$$\sqrt{2mk} = \sqrt{2(2m)K^1}$$

$$K = 2K^1 \qquad \text{Eq 1}$$

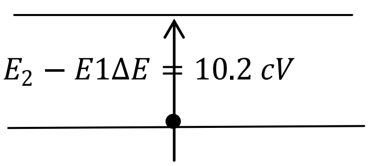
According to law of conservation of energy

$$K = K^1 + \Delta E \qquad \text{Eq 2}$$

From 1 $\quad K = \frac{K}{2} + \Delta E$

$\Delta E = \frac{K}{2} \Rightarrow K = 2\Delta E$

First excitation energy, n=2



$\Delta E = E_2 - E1 \Delta E = 10.2\ cV$

$= 10.2\ eV$ n=1

` $K = 2 \times 10.2$

$= 20.4\ eV$

2. In th Bohr atom model, the frequency of transitions is given by the following expression

$$\gamma = R_C \left(\frac{1}{n^2} - \frac{1}{m^2}\right), where\ n < m$$

Consider the following transitions

Transitions	m→ n
1	3→ 2
2	2→ 1
3	3→ 1

Show that the frequency of these transitions obey sum rule (Which is known as Ritz combination principle)

Solution

In the Bohr atom model the frequency of transition

$$\gamma = R_C \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

Transition 1:

$$m = 3, n = 2$$

$$\gamma_{3\rightarrow 2} = R_c \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= R_C \frac{5}{36}$$

Transition 2:

$$m = 2, n = 1$$

$$\gamma_{2\rightarrow 1} = R_c \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$= R_C \frac{3}{4}$$

Transition 3:

$$m = 3, n = 1$$

$$\gamma_{3\rightarrow 1} = R_c \left(\frac{1}{1^2} - \frac{1}{3^2}\right)$$

$$= R_C \frac{8}{9}$$

According to Ritz combination principle, the frequency transition of single step is the sum of frequency transition in two steps

$$R_c \frac{8}{9} = R_c \frac{5}{36} + R_c \frac{3}{4}$$

$$= R_C\left(\frac{8}{9}\right)$$

` $\gamma_{3\to1} = \gamma_{3\to2} + \gamma_{2\to1}$

3. (a) Hydrogen atom is excited by radiation of wavelength 97.5 nm, Find the Principal quantum number of the excited state.

(b) Show that the total number of lines in emission spectrum is $\frac{n(n-1)}{2}$ and compute the total number of possible lines in emission spectrum.

Solution

(a) Wavelength, $\lambda = 97.5\, nm$

$$= 97.5 \times 10^{-9} m$$

Principal quantum number $n =$?

According to Bohr atom model,

$$\frac{1}{\tau} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$n_1 = 1, n_2 = n$$

$$\frac{1}{\lambda R} = \left(1 - \frac{1}{n^2}\right)$$

$$n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$$

$$= \sqrt{\frac{97.5 \times 10^{-9} \times 1.09737 \times 10^7}{(97.5 \times 10^{-9} \times 1.09737 \times 10^7) - 1}}$$

$$= \sqrt{\frac{1.07}{0.07}} = 3.909 = 4$$

$$n = 4$$

(b) Total number of lines in emission

Spectrum $= \frac{n(n-1)}{2}$

$$= \frac{4(4-1)}{2} = \frac{4 \times 3}{2} = 6$$

4. Calculate the radius of earth if the density of the earth is equal to the density of the nucleus[$mass\ of\ the\ earth - 5.97 \times 10^{24} kg$]

The density of the nucleus of an atom $\rho_N = 2.3 \times 10^{17} kg\ m^{-3}$

$$\rho_N = \rho_E = 2.3 \times 10^{17}\ kgm^{-3}$$

$$mass\ of\ the\ earth, M_E = 5.97 \times 10^{24} kg$$

Density of the earth $\rho_E = \frac{M_E}{V}$

$$\rho_E = \frac{M_E}{\frac{4}{3}\pi R_E^3}$$

$$R_E^3 = \frac{M_E}{\frac{4}{3}\pi\rho_E} = \frac{5.97 \times 10^{24}}{1.33 \times 3.14 \times 2.3 \times 10^{17}}$$

$$R_E^3 = 0.6215\ \times 10^7\ m^3$$

$$R_E = 183.85m = 180m$$

5. Calculate the mass defect and the binding energy per nucleon of the ${}^{108}_{47}Ag$ nucleus ($atomic\ mass\ of\ Ag = 107.905949$)

Solution

$$Mass\ of\ proton, \quad m_P = 1.007825\ u$$

$$Mass\ of\ neutrton, m_N = 1.008665\ u$$

$$Atomic\ mass\ of \quad A_g = 107.905949\ u$$

Mass defect, $\Delta m = \left(Zm_p + Nm_N\right) - M$

$$= (47 \times 1.007825 + 61 \times 1.008665)$$

$$-107.905949$$

$$= 108.89634 - 107.905949$$

$$= 0.990391\ u$$

$$\overline{BE} = \frac{\Delta m \times 931}{A} = \frac{0.990391 \times 931}{108}$$

Binding energy nucleon= 8.5 MeV/A

6. Half lives of two radioactive elements A and B are 20 minutes and 40 minutes respectively. Initially the samples have equal number of nuclei. Calculate the ratio of decayed numbers of A and B nuclei after 80 minutes

Given

Initial number of atoms present in A&B =N_0

$$\left(T_{1/2}\right)_A = 20\ minutes, \left(T_{1/2}\right)_B = 40\ minutes$$

t=80 minutes

Solution

Number of half lives, $n = \frac{t}{T_{1/2}}$

Number of nuclei undecayed, $N = N_0\left(\frac{1}{2}\right)^n$

$$n_A = \frac{80}{20} = 4, n_B = \frac{80}{40} = 2$$

$$N_A = N_0\left(\frac{1}{2}\right)^4$$

$$= \frac{N_0}{16}$$

` Number of atoms decayed in A

$$= N_0 - \frac{N_0}{16}$$

$$= N_0\left(1 - \frac{1}{16}\right) = \frac{15}{16}N_0$$

$$N_B = N_0\left(\frac{1}{2}\right)^2$$

$$= \frac{N_0}{4}$$

Number of atoms decayed in B

$= N_0 - \frac{N_0}{4}$

$= \frac{3}{4}N_0$

$$\frac{N_A}{N_B} = \frac{15}{16}N_0 \times \frac{4}{3N_0}$$

$$= \frac{5}{4}$$

$$N_A : N_B = 5 : 4$$

7. On your birthday, you measure the activity of the sample ^{210}Bi

Which has a half-life of 5.01 days. The initial activity that you measure is $1\mu ci$(a) what is the approximate activity of the sample on your next birthday? Calculate (b) the decay constant (c) the mean life (d) initial number of atoms.

Given data

$$T_{\frac{1}{2}} = 5.01\ days$$

Initial activity, $R_0 = 1\mu ci$

t=1 year = 365 days

Solution

(a) $n = \frac{t}{T_{1/2}} = \frac{365}{5.01}$=73 half lives

R = $\frac{1}{2}^n\ R_0$

$$= \frac{1}{2}^{73} \times 1\mu ci$$

$$= 10^{-22} 1\mu ci$$

(b) Deccay constant

$$\lambda = \frac{0.6931}{T_{1/2}} \qquad [24\ hours = 86400S]$$

$$= \frac{0.6931}{5.01 \times 86400}$$

$$= 1.6 \times 10^{-6} S^{-1}$$

(c) Mean life

$$\tau = \frac{1}{\lambda} = \frac{T_{1/2}}{0.6931}$$

$$= {}^{5.01}/_{0.6931} = 7.24\ days$$

(d) initial number of atom

$$R_0 = N_0 \lambda$$

$N_0 = \frac{R_0}{\lambda}$

$$= \frac{1 \times 10^{-6} \times 3.7 \times 10^{10}}{1.6 \times 10^{-6}}$$

$$[1ci = 3.7 \times 10^{10} B_N]$$

$$= 2.31 \times 10^{10}$$

8. Calculate the time required for 60% of a sample of radon undergo decay Given $T_{1/2}\ of\ radon =$ $3.8\ days$ Amount of sample to decay = 60%

∴ Remaining sample undeccayed= 40%

$$N = Noe^{\lambda t}$$

$$\frac{40}{100} \times N_0 = N_0 e^{-\lambda t}$$

$=\frac{40}{100} = e^{-\lambda t}$

$$e^{\lambda t} = \frac{100}{40}$$

$$e^{\lambda t} = 2.5$$

$$\lambda t = log_e\ 2.5$$

$$= log_{10}\ 2.5 \times 2.3026$$

$$t = \frac{log_{10}\ 2.5 \times 2.3026}{0.6931/_{3.8}}$$

$$= 5.022\ days$$

9. Assuming that energy released by the fission of a single ${}^{235}_{92}u$nucleus is 200Mev. calculate the number of fissions per secondsecond required to produce I watt power

Given

Energy released by fission

Of single ${}^{235}_{92}u$) $= 200\ Mev$

number of fissions/second =?

Solution

Energy released $= 200\ Mev$

$$= 200 \times 10^6 \times 1.6 \times 10^{-19}$$

$$= 320 \times 10^{-13}\ J$$

$$[1eV = 1.6 \times 10^{-19} J]$$

Let the number of fissions produced in one second to produce 1 watt power be N

∴ Energy released in one fission $\times N$

$$= Energy\ released\ in\ one\ second$$

$320 \times 10^{-13} \times N$ = 1 J/S

∴$N = \frac{1}{320 \times 10^{-13}} = 3.125 \times 10^{10}\ fissions$

10. Show that the mass of radium ${}^{226}_{88}R_a$ with an activity of 1 curie is almost a gram.

Given $T_{\frac{1}{2}} = 1600\ years$.

1 curie $= 3.7 \times 10^{10}\ disintegrations/second$

Solution:-

$$\lambda = \frac{0.6931}{T_{1/2}}$$

$$= \frac{0.6931}{1600\ \times 365 \times 24 \times 60 \times 60}$$

Rate of decay, $= \frac{dN}{dt} = 1\ ci = 3.7 \times 10^{10}$

$$\frac{dN}{dt} = \lambda N$$

$$N = \frac{1}{\lambda}\frac{dN}{dt}$$

$$N = \frac{3.7\ \times 10^{10} \times 365 \times 24 \times 60 \times 60}{\frac{0.6931}{1600}}$$

$$= 2.6936 \times 10^{21} atoms$$

As 226gm of radium contains 6.0236×10^{23} $atoms$, so the amount of radium required is

$$= \frac{226 \times 2.6936 \times 10^{21}}{6.023 \times 10^{23}}$$

$$= 1.0107g$$

11. Characol pieces of tree is found from an archeological site. The carbon -14 content of this characol is only 17.5% that of equivalent sample of carbon from a living tree. What is the age of the tree?

Given

$$R = 17.5\%, R_0 = 100\%, T_{1/2} = 5730\ years$$

According to radioactive law,

$$R = R_0 e^{-\lambda t}$$

$$e^{\lambda t} = \frac{R_0}{R}$$

$$\lambda t = log_e\left(\frac{R_0}{R}\right)$$

$$= log_{10}\left(\frac{R_0}{R}\right) \times 2.3026$$

$$t = \frac{1}{\lambda}\left(log_{10}\frac{R_0}{R} \times 2.3026\right)$$

$$= \frac{T_{1/2}}{0.6931}\left[log_{10}\left(\frac{1}{0.175}\right) \times 2.3026\right]$$

$$= \frac{5730}{0.6931} \times 0.757 \times 2.3026$$

$$= 1.44 \times 10^4\ years$$

LESSON-9.

SEMI-CONDUCTOR ELECTRONICS

POINTS TO PONDER

- Classification of materials

Material	Forbidden E.Gap	Resistivity
Insulatormetals Semiconductors	6 e v overlap $E_g < 3ev$	$10^{11} - 10^{19}\Omega m$ $10^{-2} - 10^{-8}\Omega m$ $10^{-5} - 10^{6}\Omega m$

- Passive components: cannot generate power in a circuit.
- Active components: generate power in a circuit
- forbidden Energy gap:$E_g = E_c - E_V$
- Semi-Conductors have negative temperature co-efficient of assistance
- Diffusion current is due to concentration difference of electrons.
- The diffusion current and drift current flow in opposite direction and at one instant they become equal. Thus PN Junction is formed
- The electric field for field ionization is $10^6 Vm^{-1}$
- Reverse voltage:

1. less than 4v-Zenerbreakdown
2. greater than 6v – Avalanche
3. between 4v&6v – both Zener& Avalanche

- PIV (Peak Inverse Voltage) The maximum
  Reverse bais that can be applied before entering in zenerregion
- Operating Point in a Point where transistor can be operated efficiently
- Amplification is the process of increasing the signal strength

VERY SHORT ANSWERS QUESTIONS:

1. Define Electron motion in a semi-conductor. 195
2. What do you mean by doping. 197
3. Draw the output waveform of a full wave rectifier 205 Fig 9.18 a & b
4. Distinguish the baising polarities in an NPN & PNP transistor 213
5. Explain the current flow in a NPN transistor 214
6. What is the phase relationship between the AC input and output voltages in a common emitter amplifier. What is the reason for phase reversal? 221
7. Explain the need for a feed back circuit in a transistor Oscillator. 222
8. State De Morgan's first and second theorem 228 &229

ADDITIONAL QUESTIONS:

1. Define efficiency of a rectifier. What is the efficiency of half and full wave rectifier. 205 206
2. Define energy band 194
3. Define hole 197
4. What is a Zener diode 207
5. What are sinusoidal and non sinusoidalOscillators. 221
6. What is rectification?
7. What are the Characteristic of an ideal diode 204
8. What is forward & Reverse Baising 201
9. What is Opto electronic device 209
10. what are the applications of

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(3) Photo diode 211 (4)Salar cell 212

(5) Oscillators 223

11. How are sinusoidal oscillators classified 222
12. What are the advantages of IC 229
13. Explain Baising&Baising voltage 201
14. Draw a block diagram of an Oscillator. 222

SHORT ANSWER QUESTIONS

1. Distinguish between Intrinsic & Extrinsic semi-conductors 195&196
2. How electron- hole pairs are created in a semi conductor material 196 & 197
3. A diode is called a unidirectional device Explain 199 & 200

4. What do you mean by leakage current in diode. 203
5. Distinguish between avalanche &zener break down 206&207
6. Discuss the transfer characteristic of a CE transistor 218
7. Give circuit Symbol, logical operations, truthtable and Boolean expressions of AND.OR,NAND, NOR and EX-OR gates

ADDITIONAL QUESTIONS:

1. Define Valence band. Conduction band and forbidden energy gap. 194
2. Define IC & its types 229
3. Explain Barkhausen conditions for Sustained oscillations. 223
4. Explain Different modes of transistor baising .213

LONG ANSWER QUESTIONS

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2. Explain the formation of PN Junction diode Discuss its V-I characteristic 202.
3. Draw the circuit diagram of a half wave rectifier and explain its working. 204
4. Explain the construction and working of a full wave rectifier.205
5. What is an LED? Give the principle and operation with a diagram.209
6. Write notes an Photodiode.211
7. Explain the working of a solar cell. Mention its application. 211 & 212.
8. Sketch the static characteristics of a common emitter transistor and bring out the essence of input and output charateristics.216 &217.
9. Describe the function of a transistor as an amplifier with circuit diagram. Sketch the input and output wave form. 220.
10. Explain transistor as a switch. 219
11. State Boolean laws. Elucidate how they are used to simplify Boolean expressions with suitable example.228 &229
12. State and prove Demorgan's first and second theorems. 228 & 229.

ADDITIONAL QUESTIONS:

1. Explain Energy band in Solis 194
2. Explain classification of materials 195
3. Explain the V-I caractertics of Zener diode with circuit diagram.207 & 208.
4. How does a transistor work as an Oscillator? Explain 222
5. Zener diode as voltage regulator 0- Explain. 208 & 209

LESSON-10

COMMUNICATION SYSTEMS

POINTS TO PONDER

- For long distance transmission, the low frequency baseband signal is superimposed onto ahigh frequency radio signal by a process called modulation.
- If the amplitude of the carrier wave is modified in proportion to the instantaneous amplitude of the baseband signal called amplitude modulation.
- Based on modified parameter, three types of modulation (1) Amplitude modulation (2) Frequency modulation (3) Phase modulation.
- In telecommunications and signal processing, Frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave.
- In radio transmission, carrier wave is modulated by changing its phase to transmit the amplitude and pitch of the signal is called phase modulation.
- A transducer is a device that converts variations in a physical quantity into an equivalent signal.
- The frequency range over which the baseband signal such as voice music etc is known as bandwith.
- The mode of propagation in which the electromagnetic waves radiated form an antenna, directed upward at large angles, get reflected by Ionosphere back to earth called sky wave propagation.
- The electromagnetic waves of very high frequencies above 30MHZ are called as space wave.
- The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called optic communication.
- RADAR basically stands for Radio Detection and Ranging System.
- Light has very high frequency (400 TH_{Z}- 790TH_{Z}) than microwave radio system
- Now-a-days Optical fibers are made up of chalcogenide glasses, fluoroaluminatecrystaline materials because they provide infrared wavelength and better transmission capability.
- Mobile communication allows the transmission over a wide range of area without the use of the physical link.
- GPS stands for Global positioning system.
- GPS software is able to recognize the Satellite, its location and the time taken by the signal to travel from each satellite.
- ICT stands for Information and Communication Technology.
- ICT is used in various Sectors like Fisheries, Mining and agriculture.

MULTIPLE CHOICE QUESTIONS

1. The output transducer of the communication system converts the radio signal into

(a) Sound | (b) Mechanical energy
(c) Kinetic energy | (d) None of the above

Ans: (a) Sound

2. The Signal is affected by noise in a Communication system

(a) At the transmitter | (b) At the modulator
(c) In the channel | (d) At the receiver

Ans: (c) In the Channel

3. The Variation of frequency of carrier wave with respect to the amplitude of the modulating signal is called

(a) amplitude modulation | (b) frequency modulation
(c) phase modulation | (d) pulse width modulation

Ans: (b) Frequency Modulation

4. The internationally accepted frequency deviation for the purpose of FM broadcasts

(a) 75 KHZ | (b) 68 KHZ
(c) 80 KHZ | (d) 70 KHZ

Ans: (a) 75 KHZ

5. The frequency range of 3 MHZ to 30 MHZ is used for

(a) Ground wave propagation | (b) space wave propagation
(c) sky wave propagation | (d) Satellite Communication

Ans: Sky wave propagation

SHORT ANSWERS

1. Give the Factors that are responsible for transmission impairments. P.No. 245
2. Distinguish between wire line and wireless Communication? Specify the range of electro-magnetic waves in which it is used. P.No:243 & 245
3. Explain Centre frequency or resting frequency in frequency modulation. P.No:240
4. What does RADAR stand for? P.No:249
5. What do you mean by internet of things? P.No:250

LONG ANSWERS

1. What is modulation? Explain the types of modulation with necessary diagrams. P.No239, 240 & 241
2. Elaborate on the basic elements of communication System with the necessary block diagram. P.No:241 &242
3. Explain the three modes of propagation of electromagnetic waves through space. P.No.245, 246 & 247
4. What do you know about GPS? Write a few applications of GPS. P.No 251
5. Give the applications of ICT in mining and agriculture sectors P.No:251 & 252
6. Modulation helps to reduce the antenna size in wireless communication - Explain - P.No:244
7. Fiber optic communication is gaining popularity among the various transmission media – Justify.
   P.No : 248 &249

ADDITIONAL QUESTIONS

1. Define Amplitude modulation. Pg.No :239
2. Give Some advantages and limitations of amplitude modulation. P.no: 239
3. What is Frequency modulation? P.No:240
4. Draw a diagram of amplitude modulation. P.No.:239
5. Draw a diagram of frequency modulation. P.No:240
6. Give Some advantages of frequency modulation. P.No:240
7. Write limitations of frequency modulation? P.No:240
8. Why FM radio has better quality compared to AM radio? P.No:240
9. What is phase modulation? P.No:240
10. What is the factors frequency shift depends on? P.No:241
11. Write advantages of PM? P.No:241
12. What are the basic elements of communication system? P.No 241& 242
13. Define input transducer (or) transducer. P.No:242
14. What is baseband signal? P.No.242

15. Give short notes on (i) Transmitter (ii) Amplifier (III) Oscillator (iv) Modulator.P.No :242
16. What is communication channel and write it types P.No:243
17. What is wire line communication? Give some examples. P.No:243
18. What is wireless communication? Give some examples. P.No:243
19. Write short note on receiver. P.No:243
20. What is repeators? Give example. P.No:243
21. Define output transducer. P.No:243
22. Differentiate between Input transducer and output transducer. P.No:243
23. Define bandwidth. P.No:244
24. If the Antenna height is reduced what changes expected in the long distance transmission. P.No:244
25. What are the three types of propagation of electromagnetic waves? mention its frequency range. P.No:245
26. What is Ground wave propagation. P.No :245
27. Give some uses of ground wave Propagation. P.No:246
28. What is sky wave propagation or ionosphere propagation. P.No:246
29. How sky wave propagation is used for short wave broadcast services. P.No:246
30. What is skip distance? P.No 246
31. What is skip zone or skip area? P.No 246
32. What is space wave propagation? P.No247
33. Give some applications of satellite communication. P.No 248
34. What is fibre optic communication? Pg.No:248
35. Give some applications of fibre optic communication? P.No:249
36. What are the merits and demerits of fibre optic communication? P.No:249
37. What are the uses of RADAR. P.No:249
38. Give some applications of mobile communication. P.No 250
39. Write a short note on Internet? P.No:250
40. Write some applications of Internet? P.No:251
41. Give the application of ICT in fisheries P.No:252

CONCEPTUAL QUESTION

1. Why are short wavebands used for long distance transmission of signals?

    Radio waves of short wavebands can be easily reflected by the ionosphere. So they are used in long distance transmission

2. It is necessary to use satellites for long distance TV transmission why?

    TV Signals being of high frequency are not reflected by the ionosphere. Also, ground wave transmission is possible only upto a limited range. That is why satellites are used for long distance TV transmission

3. Give the reason why transmission of TV Signals via Sky Waves is not possible.

    Television frequencies lie in the range 100-220 MHZ, Which cannot be reflected by the ionosphere. So Sky wave Propagation is not used in TV Transmission.

4. Why is the transmission of Signals Using sky waves restricted to frequencies upto 300 megahertz?

    This is because ionosphere cannot reflect electromagnetic radiations having frequency greater than 30 MHZ.

LESSON -11

RECENT DEVELOPMENTS IN PHYSICS

POINTS TO PONDER

- Physics is the basic building block for Science, Engineering, Technology and Medicine.
- Nano Science is the science of objects with typical Sizes of 1-100 nm.
- Nano technology is a technology involving the design, production, characterization and applications of Nano structural materials.
- If the particle of a solid is of size less the 100nm, it is said to be a ‘Nano solid’.
- When the Particle size exceeds 100 nm, it forms a ‘bulk solid’.
- Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering and science.
- Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task.
- The key components of a robot are power conversion unit, Actuators, Electric motors, pneumatic Air muscles, Muscle wires, Piezo motors and ultrasonic motors, Sensors and Robot locomotion.
- Five major fields of robotics: Human robot interface mobility, manipulation, Programming and Sensors.
- Materials used to make robots: aluminium and steel are the most common metals.
- Aluminium is a softer metal and is therefore easier to work with
- Steel is several times stronger.
- The development in medical field has been proportional to the evolution of physics.
- The recent medical technology includes Virtual reality, Precision medicine, health wearables, artificial organs, 3D Printing, wireless brain sensors, robotic surgery, smart inhalers.
- Particle Physics deals with fundamental Particles of nature protons and neutrons are made of quarels
- Accelerated mass emits gravitational waves which are very weak.
- Black holes are end stage of stars which are highly dense massive object.

MULTIPLE CHOICE QUESTIONS

1. The particle size of Zno material is 30nm. Based on the dimension it is classified as

   (a) Bulk material (b) Nanomaterial

   (c) Soft material (d) magnetic material

   Ans: (b) Nanomaterial

   (Less than 100 nm Nano solid)

2. Which one of the following is the natural nanomaterial

   (a) Peacock feather (b) Peacock beak

   (c) Grain of sand (d) Skin of the Whale.

   Ans: (a) Peacock Feather

   (Peacock feathers get their iridescent coloration from light interacting with 2 dimensional photonic crystal Structures just tens of nanometres thick)

3. The blue print for making ultra-durable synthetic material is mimicked form

   (a) Lotus leaf (b) Morpho butterfly

   (c) Parrot fish (d) Peacock feather

   Ans:(c) Parrot fish

   The natural structure of parrot fish teeth are incredible durability so it is provides a blueprint for creating ultra-durable synthetic materials. (P.No:260)

4. The method of making nanomaterial by assembling the atoms is called

   (a)Top down approach (b) Bottom up approach

   (c) Cross down approach (d) diagonal approach

   Ans:(b) Bottom up approach

   (Nanomaterial's are synthesised by assembling the atoms/ molecules together selectively atoms are added to create structures)

5. "Sky wax" is an application of nano product in the field of

   (a) Medicine (b) Textile

   (b) Sports (d)Automotive industry

   Ans: (c) Sports

6. The materials used in Robotics are

   (a) Aluminium and silver (b) silver and gold

   (c) Copper and gold (d) Steel and aluminium

Ans: Steel and aluminium

(Aluminium and steel are the most common metals. Aluminium is a softer metal and is therefore easier to work with, but steel is several times stronger.

7. The alloys used for muscle wires in Robots are

(a) shape memory alloys (b) Gold copper alloys

(c) Gold silver allays (d) Two dimensional alloys

Ans: (a) shape memory alloys

(They are thin strands of wire made of shape memory alloys. They can contract by 5 % when electric current is passed through them).

8. The technology used for stopping the brain from processing pain is

(a) Precision medicine (b) wireless brain sensor

(c) virtual reality (d) Radiology

Ans: (c) Virtual reality

(Medical Virtual reality is effectively used to strop the brain from processing pain and cure soreness in the hospitalized patients)

9. The particle which gives mass to protons and neutrons are

(a) Higgs particle (b) Einstein Particle

(c) Nanoparticle (d) Bulk particle

Ans: (a) Higgs particle

10. The gravitational waves were theoretically proposed by

(a) Conrad Rontgen (b) Marie curie

(c) Albert Einstein (d) Edward Purcell

Ans: (c) Albert Einstein

SHORT ANSWERS

1. Distinguish between Nano science and Nano technology Pg.No:258
2. What is the difference between Nano materials and Bulk materials? Pg.:258 &262
3. Give any two examples for Nano in nature. Pg.No:259
4. Mention any two advantages and disadvantages of Robotics. Pg.No:270
5. Why Steel is preferred in making Robots? Pg.No:270
6. What are black holes? Pg. No :279
7. What are Sub atomic particles? P. No:278

LONG ANSWERS

1. Discuss the applications of Nanomaterials in Various fields. P.No:263
2. What are the possible lawful effects of usage of Nanoparticles? Why? P.No:264
3. Discuss the functions of key components in Robots? P.No:267
4. Elaborate any two types of Robots with relevant examples.
   P.No:267 &268
5. Comment on the recent advancement in medical diagnosis and therapy. P.No:274 to 277

ADDITIONAL QUESTIONS

VERY SHORT ANSWER QUESTIONS

1. What is Nano Science? (Pg.No:258)
   Nano science is the Science of Objects with typical size 1 to 100 nm.
2. Name the two important Phenomena given by Nano properties? (Pg. No: 258)
   (a) QUANTUM Confinement effects (b) Surface effects
3. How Peacock Feathers get their iridescent Coloration? (Pg.No:259)
   Peacock Feathers get their iridescent coloration from light interacting with 2 – dimensional photonic crystal structures just tens of nanometres thick.
4. How do you synthesis Nano particles? (Pg.No:262)
   There are two ways of preparing the nanomaterials, top down approach and bottom up approach
5. Name the different roles of robot play in our scientific world? (Pg.No:266)
   a. Medical Surgery
   b. Security
   c. Intelligent Transportation
   d. Monitoring Insoection
   e. Logistics

f. Unmanned Vehicles

6. Mention three main parts are composed of robots (Pg.No:267)

   1. CONTROLLER 2.MECHANICAL PARTS 3.SENSORS

7. Write a note on Virtual Reality (Pg.No:274)

   Medical Virtual reality is effectively used to stop the brain from processing pain and cure Soreness in the hospitalized patients.

8. What is the meaning of particle physics?

   Particle Physics deals with the theory of fundamental particles of nature and it is one the active research areas in physics.

9. What is Cosmology?

   Cosmology is the branch that involves the origin and evolution of the universe.

   It deals with formation of star, Galaxy etc.

10. What are Black holes? (Pg.No:279)

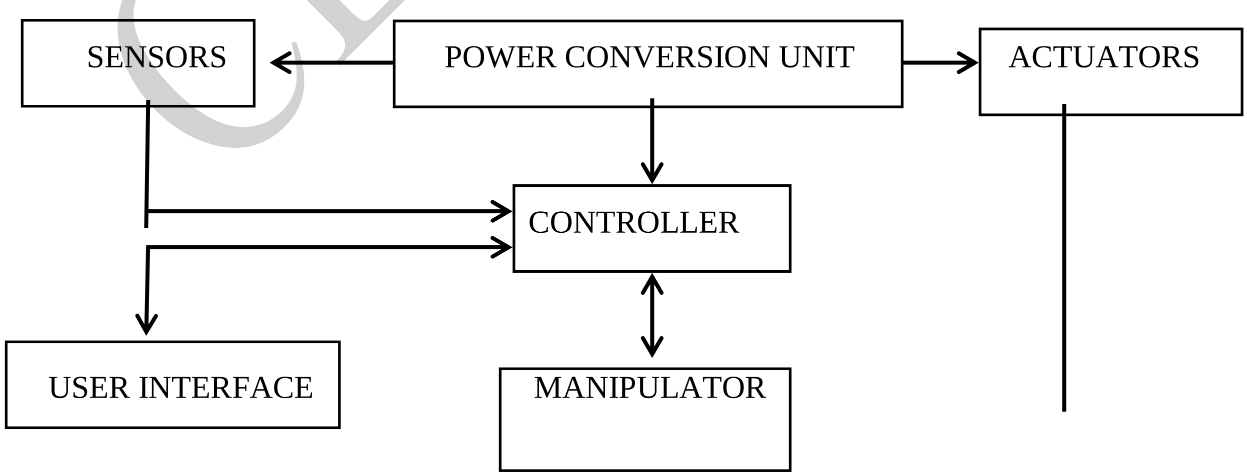
    Black holes are end stage of stars which are highly dense massive objects. Its mass ranges from 20 times mass of the sun to 1 million times mass of the sun.

SHORT ANSWERS

1. Name the application of Nano materials in Automotive Industry? (Pg.No:263)
   a. Lightweight construction
   b. Painting
   c. Catalyst
   d. Tires
   e. Sensors
   f. Coating for wind Screen and car bodies

2. Design the key components of Robotic System? Pg.No:267

KEY COMPONENTS



LINKAGE BASE

3. What is gravitational waves? Name the Source of gravitational waves? (Pg.No:279)

   Gravitational waves are the disturbances in the curvature of space-time and it travel with speed of light. Black holes are the strangest source of gravitational waves .

4. How artificial Intelligence works on various field? (Pg.No:268)
   a. Face Recognition
   b. Providing response to player's action in computer games
   c. Analysing the density of traffic on roads
   d. Translate words from one language to another.

5. Which material used to make robots? Why? (Pg.No:270)

   Aluminium and steel are the most common metals. Because Aluminium is softer and steel is several times stronger.

6. Which device help the patients may return to normal life? (Pg. No:275)

   An artificial organ is a engineering device or tissue that is implanted or integrated in to a human. It is possible to interface it with living tissue or to replace a natural organ.