INTERMEDIATE EXAMINATION - 2018

(ANNUAL)

PHYSICS

I.Sc

Time- $3\frac{1}{4}$ **Hours** **Full Marks: 70**

Instruction for the candidates:

1) Candidates are required to give their answers in their own words as far as practicable.
2) Figures in the right hand margin indicate full marks.
3) While answering the question, candidate should adhere to the word limit as far as practicable
4) 15 Minutes of extra time has been allotted for the candidates to read the questions carefully
5) This question paper is divided into two sections- **Section-A** and **Section-B**
6) In **Section-A,** there **are 35 objective type questions** which are compulsory, each carrying **1 mark.** Darken the circle with blue/ black ball pen against the correct option on OMR Sheet provided to you.
Do not use Whitener/ Liquid/ Blade/Nail on OMR Paper, otherwise the result will be invalid.
7) **In Section- B, there are 15 short answer type questions (each carrying 2 marks), out of which any 10 questions are to be answered. Apart from this, there are 3 long Answer Type questions (Each Carrying 5 marks). Each question has alternate option.**
8) Use of any electronic device is prohibited.

Section –A (Objective Type Questions)

Question No. 1 to 35 have four options, out of which only one is correct. You have to mark, your selected option, on the OMR – Sheet. 35 x 1 = 35

1) The electric field at a point near an infinite thin sheet of charged conductor is :

(a) $\varepsilon_0\sigma$ (b) $\frac{\varepsilon_0}{\sigma}$

(c) $\frac{\sigma}{2\varepsilon_0}$ (d) $\frac{1}{2}\sigma\varepsilon_0$

2. Two capacitors $C_1 = 2\mu F$ and $C_2 = 4\mu F$ are connected in series and a potential difference (p.d) of 1200 V is applied across it. The Potential difference across $2\mu F$ will be:

(a)400V (b)600V

(c)800V (d)900V

3. In the figure, if net force on Q is zero then value of $\frac{Q}{q}$ is :

Figher

(a) $\sqrt{2}$ (b) $2\sqrt{2}$

(c) $\frac{1}{2\sqrt{2}}$ (d) $\frac{1}{\sqrt{2}}$

4.When a body is charged, its mass

(a)increases (b)decreases

(c)remains same (d) may increase or decrease

5. The electric potential due to a small electric dipole at a large distance r from the center of the dipole is proportional to:

(a) r (b) $\frac{1}{r}$

(c) $\frac{1}{r^2}$ (d) $\frac{1}{r^3}$

6. Minimum number of capacitors of $2\mu F$ each required to obtain a capacitance of $5\mu F$ will be

(a)4 (b)3

(c)5 (d)6

7.The specific resistance of a conductor increases with:

(a)increase of temperature (b)Increase of cross-sectional area

(c) decrease in length (d) decrease of cross-sectional area

8. The Drift velocity (v_d) and applied electric field (E) of a conductor are related as:

(a) $V_d \ \alpha \ \sqrt{E}$ (b) $V_d \ \alpha$ E

(c) $V_d \ \alpha$ E^2 (d) V_d = Constant

9. A charge 'q' moves in a region where electric field 'E' and magnetic field 'B' both exist, then force on it is:

(a) $q(\vec{v} \times \vec{B})$ (b) $q\vec{E}$

(c) $q\left\{\vec{E}+(\vec{v}\times\vec{B})\right\}$ (d) $q\left\{B+(\vec{v}\times\vec{E})\right\}$

10. A bar magnet of magnetic moment M is cut into two parts of equal length. The magnetic moment of either part:

(a)M (b)M/2

(c)2M (d)Zero

11. The dimensional formula for $\frac{1}{2}\varepsilon_0 E^2$ is identical to that of :

(a) $\frac{B^2}{2\mu_0}$ (b) $\frac{1}{2}B^2\mu_0$

(c) $\frac{\mu_0^2}{2B}$ (d) $\frac{1}{2}B\mu_0^2$

12. A circular coil of radius R carries a current I. The magnetic field at its center is B. At what distance from the center, on the axis of the coil, the magnetic field will be B/8?

(a) $\sqrt{2}R$ (b)2R

(c) $\sqrt{3}R$ (d)3R

13. Magnetic dipole moment is a vector quantity directed from:

(a) South to North Pole (b)North to South Pole

(c) East to West direction (d)West to East direction

14. A wire of magnetic dipole moment M and L is bent into shape of semi-circle of radius r. What will be its new dipole moment?

(a)M (b) $\frac{M}{2\pi}$

(c) $\frac{M}{\pi}$ (d) $\frac{2M}{\pi}$

15.In a closed circuit of resistance 10Ω, the linked flux varies with time according to relation $\phi = 6t^2 - 5t + 1$. At $t = 0.25$ second, the current (in Ampere) flowing through the circuit is:

(a)0.4 (b)0.2

(c)2.0 (d)4.0

16.In A.C circuit, the current and voltage are given by I = 5 cos wt and V = 200 sin wt respectively. Power loss in the circuit is:

(a)20W (b)40W

(c)1000W (d)Zero

17. The energy of an electromagnetic radiation is 13.2keV. This radiation is related to which region of spectrum ?

(a)Visible (b)X-rays

(c)Ultra violet (d)Infra-red

18.The image formed by objective lens of a Compound Microscope is:
(a)Virtual and diminished (b)Real and diminished

(c) Real and large (d) Virtual and large

19. A convex lens is dipped in a liquid, whose refractive index is equal to refractive index of material of lens. Then its focal length will:

(a)become zero (b) become infinite

(c)decrease (d) increase

20. Critical angle for light moving from medium I to medium II is θ. The speed of light in medium I is v. Then speed in medium II is :

(a) $v(1-\cos\theta)$ (b) $\frac{v}{\sin\theta}$

(c) $\frac{v}{\cos\theta}$ (d) $v(1-\sin\theta)$

21. A magnifying glass is to be used at the fixed object distance of 1 inch. If it is to produce an erect image 5 times magnified, its focal length should be:

(a)0.2’’ (b)0.8’’

(c)1.25’’ (d)5’’

22. To remove hyper metropia lens used is:

(a) Convex (b) Concave

(c) Cylindrical (d) Plano-convex

23. Which of the following phenomenon takes place when a monochromatic light is incident on a prism ?

(a) Dispersion (b)Deviation

(c)Interference | (d) All of the above

24. Optical fiber communication is based on which of the following phenomenon:

(a) Total Internal reflection | (b)Scattering

(c)Reflection | (d) Interference

25. The value of maximum amplitude produced due ito interference of two wave is given by-

$y_1 = 4\sin$ wt and $y_2 = 3$ cos wt

(a)7 | (b)5

(c)1 | (d)25

26. The phase difference ϕ is related to Path difference Δx by:

(a) $\frac{\lambda}{\pi}\phi$ | (b) $\frac{\pi}{\lambda}\phi$

(c) $\frac{\lambda}{2\pi}\phi$ | (d) $\frac{2\pi}{\lambda}\phi$

27. The resolving power of human eye (in minute) is :

(a) $\frac{1}{60}$ | (b)1

(c)10 | (d) $\frac{1}{2}$

28. A particle of mass m and charge q is accelerated through a potential V. The De-Broglie wave length of the particle will be :

(a) $\frac{Vh}{\sqrt{2qm}}$ | (b) $\frac{q}{\sqrt{2mV}}$

(c) $\frac{h}{\sqrt{2qmV}}$ | (d) $\frac{mh}{\sqrt{2qV}}$

29.The number of Photons of frequency 10^{14}Hz in radiation of 6.62 will be:

(a) 10^{10} | (b) 10^{15}

(c) 10^{20} | (d) 10^{25}

30. The minimum angular momentum of electron in Hydrogen atom will be:

(a) $\frac{h}{\pi} Js$ (b) $\frac{h}{2\pi} Js$

(c) $h\pi Js$ (d) $2\pi h Js$

31. The atomic number and mass number for a specimen are Z and A respectively. The number of neutrons in the atom will be:

(a) A (b)Z

(c) A+Z (d) A-Z

32. The quantities, which remain conserved in nuclear reaction:

(a) Total Charge (b) Access Transmission

(c) Factual Auto Access (d) First decrease then increase

33. Meaning of "FAX" is:

(a) Full Access Transmission (b) Fascimile Telegraphy

(c) Factual Auto Access (d) Feed Auto Exchange

34. A semi-conductor is cooled from $T_1 K$ to $T_2 K$,then its resistance will

(a)increase (b)decrease

(c)remain constant (d)First decrease then increase

35.If the current constant for a transistor are α and β then:

(a) $\alpha\beta = 1$ (b) $\beta > 1, \alpha < 1$

(c) $\alpha = \beta$ (d) $\beta < 1, \alpha > 1$

Section-B (Non- Objective Type Questions)

(Short Answer Type Question)

Question no. 1 to 15 are short answer type questions. Each question of this category carries 2 marks. Answer any ten (10) questions on your copy. 10 x 2 = 20

1. (i) Write down unit and dimension of permittivity of free space.

Sol:

Unit of permittivity : $Coulomb^2/Nm^2$

Dimension : $[M^{-1}L^{-3}T^{4}I^{2}]$

(ii) A Gaussian surface contains three charges (-q), (+2q) and (-q). Evaluate net electric flux through the surface.

Sol;

Total charge $= -q + 2q - q = 0$

Electric flux

$$\phi = \frac{q}{\varepsilon_0} = 0$$

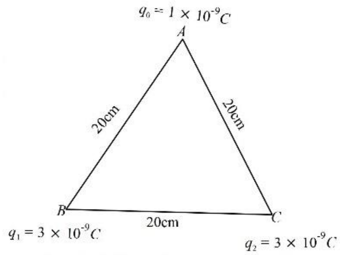
$$\phi = 0$$

2. The side of an equilateral triangle is 20cm. Two equal point chargers (+) 3nC are placed at its two corners. What will be the amount of work done in bringing a (+)1 nC test charge from infinity to third corner of the triangle.?(1 mark for formula, 1 mark for calculation)

Sol:

Given,

$$q_1 = 3\times10^{-9}C; q_2 = 3\times10^{-9}C$$
$$q_0 = 1.0\times10^{-9}C; r = 20cm = 0.2m$$



Work done in taking charge q_0 from infinity to point C

$$W = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_0}{r} + \frac{q_2q_0}{r}\right]$$

$$W = q\times10^9\left[\frac{3\times10^{-9}\times10^{-9}}{0.2} + \frac{3\times10^{-9}\times1\times10^{-9}}{0.2}\right]$$

$$W = \frac{9\times10^9\times2\times3\times10^{-18}}{0.2}$$

$$W = 2.7\times10^{-7}\ Joule$$

3. Atmosphere is not electrically neutral. Explain why?

Sol:

The atmosphere is not electrically neutral because atmosphere is continuously being charged by thunderstorms and lightning bolts all over the globe. This maintains an equilibrium with the discharge of the atmosphere in ordinary weather condition.

4. Evaluate the capacitance of a parallel plate capacitor, having parallel plates of area 6 cm^2 placed at a separation of 2mm. Consider air between plates as a dielectric medium. If the capacitor is connected to 200V power supply, what will be the charge on each plate?

Sol:

Given,

$$A = 6cm^2 = 6\times10^{-4} m^2$$
$$d = 2mm = 2\times10^{-3} m$$

Capacity of parallel plate capacitor

$$C = \frac{A\varepsilon_0}{d} = \frac{8.85\times10^{-12}\times6\times10^{-4}}{2\times10^{-3}}$$
$$C = 2.655\times10^{-12}\ f$$

Now,

$$C = \frac{Q}{V}; Q = CV = 2.655\times200$$
$$Q = 5.31\times10^{-10} C$$

5. Four 12Ω resistances are connected in parallel. Three such combinations are connected in series. What will be the total resistance?

Sol:

In parallel grouping $\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + ... + n = \frac{n}{R}; Rp = \frac{R}{n} = \frac{12}{4} = 3\Omega$

In series $R_s = 3+3+3 = 9\Omega$

6. Using theory of dirft velocity, express Ohm’s law.

Sol:

Let l is length, A is cross-sectional area of conductor. The relation between drift velocity and current

$I = nAeV_d$ --------------(i)

Where n = number of electron per unit volume

Now, magnitude of drift velocity $V_d = \frac{eE}{m}\tau = \frac{eV\tau}{ml}$

Putting the value of V_d in eqn. (1)

$$I = neA\left[\frac{eV\tau}{ml}\right]; \frac{V}{I} = ne^2\frac{A\tau}{ml}.V$$
$$\frac{V}{I} = \frac{ml}{ne^2 A\tau} = cons\tan t = R; \frac{V}{I} = R;$$
$$V = IR$$
$$V \infty I$$

This is Ohm's law.

7. An electron moving through a field remains undeflected. It is possible that there is no magnetic field. Explain.

Sol:

The force acts on electron in magnetic field B moves with velocity $\vec{V}$

$$\vec{F} = -e(\vec{V} \times \vec{B}); F = -eVB\sin\theta$$

F will be zero when $\theta = 0^0$ or 180^0

So, electron does not deflect in magnetic field when it moves Parallel or Antiparallel. Thus, we can not say that magnetic field is absent.

8. At a place Horizontal Component of Earth's magnetic field is $\sqrt{3}$ times its Vertical Component value. What is the value of 'Angle of Dip' at that place?
(1 mark for formula, 1 mark for calculation)

Sol:

Angle of dip, $\tan\theta = \frac{B_v}{B_H}$

Given,

$$B_v = \sqrt{3}B_H; \tan\theta = \frac{\sqrt{3}B_H}{B_H} = \sqrt{3}; \tan 60^0$$
$$\theta = 60^0$$

9. What are Eddy currents? Give its two uses.

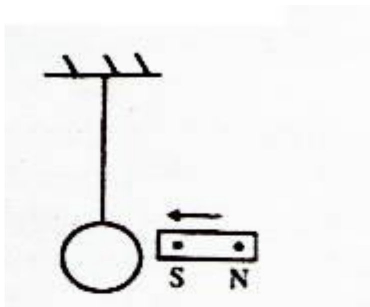
Sol:

Eddy current: The current induced in the body of a conductor to changing magnetic flux passing through it, are called eddy current.

Application: (i) Eddy currents are used for magnetic braking in trains.

(ii) Eddy currents are used in induction furnace.

10. When a magnet is moved towards a suspended wire loop as shown in figure then evaluate the direction of induced current in loop. State the law used by you for this evaluation.



Sol:

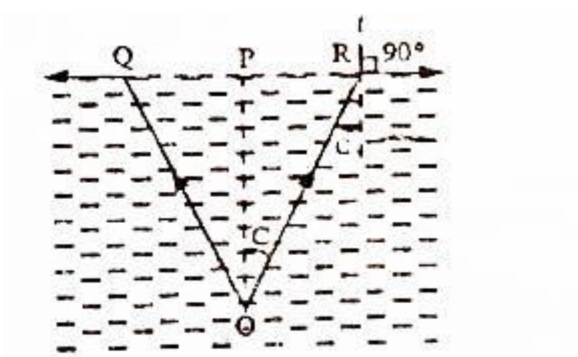
Using Lenz's Law, we conclude that the face of the loop towards the magnet should acquire polarity. So, the direction of induced current in the loop is clockwise when seen from the side of magnet.

11. A fish is at a depth of $\sqrt{7}$ cm and it can see only through a circular section of water surface. What will be the radii of this circular surface ?The refractive index of water with respect to air is $\frac{4}{3}$. Sketch the diagram also.

Sol:

Let O is position of fish $\frac{1}{R}$

Let PR = r radius of circular part



Step-I

$$\sin C = \frac{1}{\mu}; \sin C = \frac{3}{4}$$

But,

$$\sin C = \frac{PR}{OR}$$

$$\therefore \frac{PR}{OR} = \frac{3}{4}$$

$$OR = \frac{4}{3} PR = \frac{4}{5} r$$

Step-II

$$(OR)^2 = (OP)^2 + (PR)^2$$

$$(OP)^2 = (OR)^2 - (PR)^2$$

$$(OP)^2 = \left(\frac{4}{3} r\right)^2 - r^2$$

$$(OP)^2 = \frac{16r^2}{9} - r^2 = \frac{7r^2}{9}$$

$$OP = \frac{\sqrt{7r}}{3}; r = \frac{3}{\sqrt{7}} OP$$

$$r = \frac{3}{\sqrt{7}} \times \sqrt{7} = 3$$

$$r = 3cm$$

12. Why Red Signals are used as danger sign ? Explain.

Sol:

The scattering of light is inversely proportional to the fourth power of wavelength of light. So, the scattering of red light is must less than all colour. So, red light signal can be seen up to longer distance without must loss in its intensity. For this reason, the danger signals are red in colour.

13. A small pin is fixed on a table and it is viewed from a distance of 50 cm from above. A glass slab of thickness 15 cm is placed just above the pin, parallel to surface to table, then image of this pin will be viewed at what height ? Draw the sketch also. $\left(\text{Refractive index of Glassis} = \frac{3}{2}\right)$

Sol:

Lateral displacement

$$t = d\left[1 - \frac{1}{\mu}\right]$$

$$t = 15\left[1 - \frac{1}{15}\right]$$

$$= 15 \times \frac{05}{15} = 5$$

$$t = 5cm$$

The location of the slab will not affect the answer.

14. A radio active nucleus undergoes a series of decays as per following scheme :

$$A \xrightarrow{(\alpha)} A_1 \xrightarrow{(\beta)} A_2 \xrightarrow{(\gamma)} A_3$$

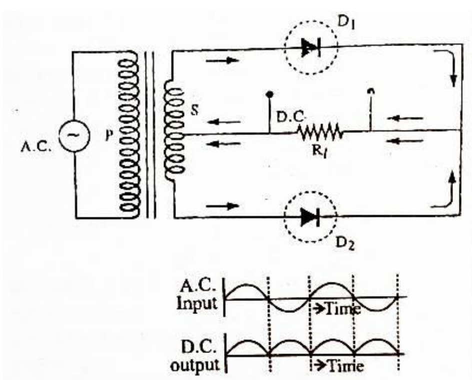
The Atomic number and Mass number of Nuclei 'A' are 92 and 238 respectively then what are these numbers for A_3

Sol:

$${}_{92}A^{238} \xrightarrow{\alpha} {}_{90}A_1^{234} \xrightarrow{\beta} {}_{91}A_2^{234} \xrightarrow{\gamma} {}_{91}A_3^{234}$$

15. Draw the circuit diagram to explain the working of a full wave p-n junction rectifier.

Sol:



Long Type Questions

Question No. 16 to 18 are long answer type questions. All questions are compulsory. In each question there are internal options. (3 x 5 = 15)

16. Define capacitance of a capacitor. Derive expression for stored energy between plates of parallel plate capacitor. Show that energy-density between plates of the capacitor can be expressed as $\frac{1}{2}\varepsilon_0 E^2$,when E = Electric field between plates.

Sol:

Capacity of capacitor : It is defined as the ratio of charge given to plate of capacitor and potential difference between two plates of capacitor

$$C = \frac{Q}{V} = \frac{Q}{(V_1 - V_2)}$$

Expression for energy stored in capacitor : If q is charge on the plate of capacitor then q = CV

Suppose battery supplies an infinitesimally small amount of charge dq to capacitor at constant Potential V. Then work done

$$dW = V.dq = \frac{q}{C}.dq$$

Now, energy stored in charging from $q = 0$ to $q = Q$

$$W = \frac{1}{C}\int_O^Q q.dq = \frac{1}{C}\left[\frac{q^2}{2}\right]_O^Q ; W = \frac{1}{2C}[Q^2 - O^2]; W = \frac{1}{2}\frac{Q^2}{C}$$

This work done is stored in the form of potential energy

$$U = \frac{1}{2}\frac{Q^2}{C}; U == \frac{1}{2}\frac{C^2V^2}{C} = \frac{1}{2}CV^2$$

Substituting

$$C = \frac{Q}{V}; U = \frac{1}{2}\frac{Q}{V}.V^2 = \frac{1}{2}QV$$

$$U = \frac{1}{2}QV$$

Energy density: The energy stored in capacitor $U = \frac{1}{2}CV^2 --------(i)$

Capacity of Capacitor $C = \frac{A\varepsilon_0}{d}$

Potential $V = E.d$

Putting the value of C and V in eqn. (i)

$$U = \frac{1}{2}\frac{A\varepsilon_0}{d}.E^2d^2; U - \frac{1}{2}A\varepsilon_0E^2d$$

Energy stored in unit volume $\frac{U}{Ad} = \frac{1}{2}\frac{A\varepsilon_0 E^2 d}{Ad}$

$U_E = \frac{1}{2}\varepsilon_0 E^2$

The energy stored in unit volume is called Energy density.

Or, In the given figure, find the equivalent resistance between P and Q. If: $C_1 = C_3 = C_4$ and C_5 are each of $4\mu F$ and $C_2 = 10\mu F$

Sol:

The equivalent circuit of question

The point a and b are at same potential. So, charge does not flow from C_2. The capacitor C_1 and C_5 are in series.

Equivalent capacity $\frac{1}{C'} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}; C" = 2\mu f$

Similarly, C_4 and C_3 are in series $\frac{1}{C"} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}; C" = 2\mu f$

Now, C' and $C"$ are in parallel .So,

Equivalent capacity:

$C = C' + C", C = 2 + 2 = 4\mu f$

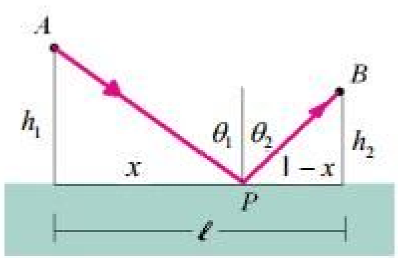
$C = 4\mu f$

17. Explain Huygen's principle of secondary wavelets and on the basis of this principle establish the law of Refraction of Refraction 'OR' reflection.

Sol:

Consider the light ray shown in the figure. A ray of light starting at point A reflects off the surface at point P before arriving at point B, a horizontal distance from point A. we calculate the length of each path and divide the length by the speed of light to determine the time required for the light to travel between the two points.

$$t = \frac{\sqrt{x^2 + h_1^2}}{c} + \frac{\sqrt{(1-x)^2 + h_2^2}}{c}$$

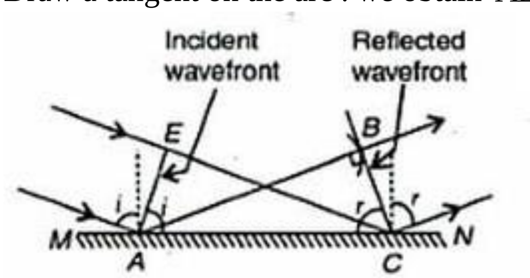


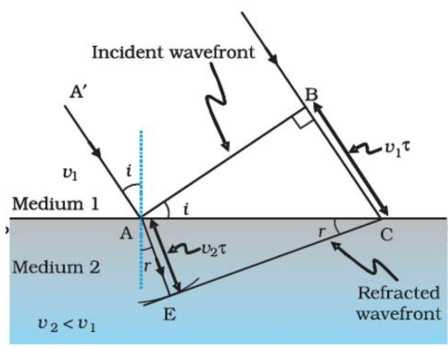
To minimize the time we set the derivative of the time with respect to x equal to zero. We also use the definition of the sine as opposite side over hypotenous to relate the lengths to the angles of incident and reflection.

$$0=\frac{dt}{dx}=\frac{x}{\sqrt{x^2+h_1^{\;2}c}}+\frac{(1-x)}{\sqrt{(1-x)^2+h_2^{\;2}c}}$$

$$\frac{x}{\sqrt{x^2+h_1^{\;2}c}}=\frac{(1-x)}{\sqrt{(1-x)^2+h_2^{\;2}c}}\rightarrow \sin\theta_1=\sin\theta_2\rightarrow\theta_1=\theta_2$$

Consider a plane wave AB incident at an angle i on a reflecting surface MN. If v is the speed of the wave in the medium and t is the time taken by the wavefront to cover the distance BC, then BC = vt
To construct the reflected wavefront we draw an arc (represent reflected wavefront) of radius vt from the point A.
Draw a tangent on the arc . we obtain AE = BC = vt





We can see a ray of light is incident on this surface and another ray which is parallel to this ray is also incident on this surface. As these rays are incident from the surface, so we call it incident ray.
Let PP' represent the medium 1 and medium 2. The speed of the light in this medium is represented by v_1 and v_2. If we draw a perpendicular from point 'A' to this ray of light, Point A, and point B will have a line joining them and this is called as wavefront and this wavefront is incident on the surface.
If ' r ' represents the time taken by the wavefront from the point B to C then the distance,

$$BC=v_1r$$

So to determine the shape of the refracted wavefront, we draw a sphere of radius v_2r from the point A in the second medium. Let CE represent a tangent plane drawn from the point C on to the sphere. Then, AE = v_2r, and CE would represent the refracted wavefront. If we now consider the triangles ABC and AEC, we get that,

$$\sin i = BCAC = v_1 rAC$$
$$\sin r = AEAC = v_2 rAC$$

Where, I and r are the angles of incidence and refraction

$$n_1 \sin i = n_2 \sin r$$

OR,

(i) Two thin convex lenses of focal length 15 cm and 30cm are placed in contact. What will be the power of the combination?

Sol:

Equivalent focal length $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{15} + \frac{1}{30} = \frac{3}{30}$

$$\frac{1}{F} = \frac{1}{10}, F = 10cms = 0.1m$$

Power of equivalent lens $P = \frac{1}{F} = \frac{1}{0.1} = 10D$

$$P = 10D$$

(ii) A Glass prism $\left(\mu_g = 1.66\right)$ of Angle of Prism 72^0, is placed in Water $\left(\mu_w = 1.33\right)$ .Calculate the value of minimum deviation produced by Prism for parallel incident ray.

Sol:

According to question ${}_a\mu_g = 1.66, {}_a\mu_l = 1.33, A = 72^0$

When prism is immersed in liquid then refractive index of glass with respect liquid.

$${}_l\mu_g = \frac{{}_a\mu_g}{{}_a\mu_l} = \frac{1.66}{1.33} = 1.248$$

Now,

$$ {}_l\mu_g = \mu = \frac{\sin \frac{A+\delta m}{2}}{\sin \frac{A}{2}} $$

$$ \sin \frac{A+\delta m}{2} = {}_l\mu_g \times \sin \frac{A}{2} = 1.248 \times \sin \frac{72^0}{2} $$

$$ = 1.248 \times \sin 36^0 = 1.248 \times 0.5878 = 0.7336 $$

According to 'sine' table $\frac{A+\delta m}{2} = 47^0 12'$

$$ A + \delta m = 94^0 24' $$

$$ \delta m = 94^0 24' - 72^0 $$

$$ \delta m = 22^0 24' $$

18. What are 'Energy Bands'? How are these formed? Distinguish between Conductors, Semi-conductors and Insulators on the basis of Formation of these bands.

Sol:

Energy band- A range of energies that electron can have in solid. In a single atom electrons exist in discrete energy level. In a crystal in which large numbers of atoms are held closely together in a lattice, electrons are influenced by a number of adjacent nuclie and sharply defined levels of the atom become bands of allowed energy. This approach to energy level in solid is known as energy band.

There are some terms related to bond theory are following.

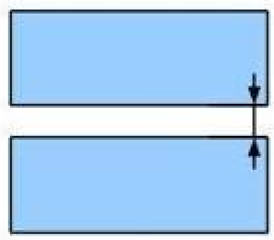
Conduction band – The band corresponding to the conduction electrons is called conduction band. In this band, electrons are free to conduct c(move).

Valence hand- The band corresponding to the valence electrons is called valence band. In this band, electrons are bounded and can't conduct. In figure, lower band is valence band.

Forbidden gap- This is also called forbidden gap, or energy gap or band gap. Energy gap between valence band and conduction band is shown in figher is called forbidden gap.

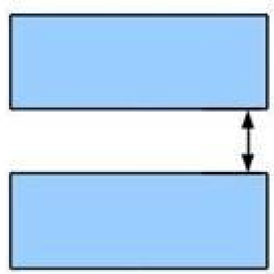
Band Theory for conductor, Semiconductor and insulator-

(a) Conductor-



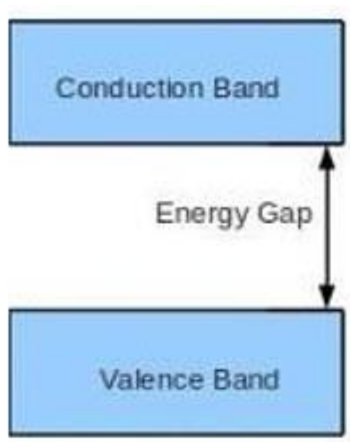
In above figure. There is overlapping of valence and conduction bands. This is because the lowest levels in the conduction band need less energy than the highest levels in the valence band and electrons in the valence field, contribute to electrical conduction.

(b) Semiconductors-



In this class of crystals the two energy bands are distinctly separate with no overlapping. The forbidden gap and reach the conduction band. Therefore, the substance is an insulator. But at room temperature, some valence electrons acquire thermal energy greater then the gap and move to the conduction band where they are free to move influence of even a weak electric field.

(c) Insulator-



In this case, there is large forbidden gap approx. 5ev upon the nature of the crystal. Electrons, however heated, find it practically impossible to jump this gap and thus never reach the conduction band. Thus, electrical conduction is not possible through an insulator, normally carbon is a conductor but the same carbon as diamond, with the energy gap of 7ev is perfect insulator.

Or

For a nuclear reaction $A+b \to c+d$,the Q-value is defined as $Q=[m_A+m_b-m_c-m_d]c^2$ .A radio – active nuclei ${}^{11}_{6}C$ decays in following way ${}^{11}_{6}C \to {}^{11}_{6}B+e^{+}+v; T_{1/2}=20.3$ minutes. The maximum energy emitted by positron is 0.960 MeV. Following values are given:

$m\left({}^{11}_{6}C\right)=11.011434u, m\left({}^{11}_{6}B\right)=11.009305u, m_e=0.000548u$

Evaluate Q-value of this reaction and compare it with maximum Energy Emitted by Positron.

Sol:

Mass difference $\Delta m = m_N\left({}^{11}_{6}C\right)-\left[m_N\left({}^{11}_{6}B+m_e\right)\right]$

Where m_N denotes that masses are of atomic nuclei

If we take the masses of atom, then we have to add $6m_e$ for 11_c and for $5m_c$ for 11_B ,then

Mass difference $m\left({}^{11}_{6}C+6m_e\right)-\left(m{}^{11}_{5}B-5m_e+m_e\right)$

$$\left[m\begin{pmatrix}11\\C\end{pmatrix}-m\left({}^{11}_{6}B\right)-2m_e\right]=11.011434-11.009305-2\times 0.000548$$

$$= 0.001033 \text{ u}$$

$$Q = 0.001033 \times 931.5 \text{ MeV} = 0.962 \text{ MeV}$$

This energy is nearly the same as energy carries by positron (0.960MeV). The reason is that the daughter nucleus is too heavy as compared to e^{+} and v.

So, it carries negligible kinetic energy. Total kinetic energy is shared by positron and neutrino. Here energy carried by neutrino (E_v) in minimum. So that energy carried by positron E_e is maximum (Practically $E_e \approx Q$)