MODEL PAPER – 2

Time : 3 Hours + 15 Minutes] **[Total Marks : 70**

INSTRUCTIONS TO THE CANDIDATES :

1. Candidates are required to give their answers in their own words as far as practicable.
2. Figure in the right hand margin indicate full marks.
3. While answering the questions, 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 **70 Objective Type Question**, out of which only 35 objective questions be answered. 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 **20 Short Answer Type Question** (each carrying 2 marks), out of which any 10 questions are be answered.

   Apart from this, there are **6 Long Answer Type Question** (Each Carrying 5 marks), out of which 3 questions are to be answered.
8. Use of any electronic device is prohibited.

SECTION – A : Objective Type Questions

Directions : *There are 70 Objective Type Questions, out of which only 35 objectives questions to be answered. For each question, mark the correct option on the* ***OMR*** *answer sheet.*

35 × 1 = 35

1. To increases the sensitivity of a potentiometre :
(A) the cross-section area of its wire will have to be increased
(E) current in its wire will have to be decreased
(C) current in its wire will have to be increased
(D) length of its wire have to be increased

2. The magnetic field produced at the centre of current carrying circular coil is :
(A) on the plane of coil
(B) perpendicular to the plane of coil
(C) at 45° to the plane of coil
(D) at 180° to the plane of coil

3. Convex lens is used in :
(A) short-sightedness (B) long-sightendness
(C) presbyopia (D) astigmatism

4. Unit of linear charge density is :
(A) Coulomb/metre (B) coulomb × metre
(C) metre/coulomb (D) none of these

5. The dimensional formula of intensity of electric field is :
(A) $[MLT^2A^{-1}]$ (B) $[MLT^{-3}A^{-1}]$
(C) $[MLT^{-3}A]$ (D) $[ML^2T^{-3}A-1]$

6. The value of magnetic potential at a distance r from a pole strength m is :
(A) $\frac{\mu_0}{4\pi}\frac{m}{r}$ (B) $\frac{\mu_0}{4\pi}\frac{m}{r^2}$ (C) $\frac{\mu_0}{4\pi}\frac{m}{r^3}$ (D) zero

7. Which of the following is blocked by a capacitor ?
(A) AC (B) DC
(C) Both AC and DC (D) Neither AC nor DC

8. Two bulbs of 40 W and 60 W are connected to 220 V source. The ratio of their resistances will be :
(A) 4 : 3 (B) 3 : 4
(C) 2 : 3 (D) 3 : 2

9. de-Broglie wavelength is :
(A) $\lambda = hmv$ (B) $\lambda = \frac{h}{mv}$ (C) $\lambda = \frac{mc^2}{v}$ (D) $h = hv$

10. Light year is equal to :
(A) 9.46×10^{15} m (B) 9.46×10^{12} m
(C) 9.46×10^{8} m (D) 9.46×10^{10} m

11. A spherical mirror is immersed in water. Its focal length will :
(A) decrease (B) increase
(C) remain same (D) none of these

12. For same wavelength of electron and photon, which physical quantity will be same ?
(A) Velocity (B) Energy
(C) Momentum (D) Angular momentum

13. The impurity element used for p-type semiconductor is :
(A) Boron (B) Bismuth
(C) Arsenic (D) Phosphorus

14. The phase difference between electric wave and magnetic wave in the electromagnetic wave is :
(A) π (B) $\frac{\pi}{2}$ (C) $\frac{\pi}{3}$ (D) zero

15. The formula for magnetic energy density for a solenoid is :
(A) $\frac{B^2}{2\mu_0}$ (B) $\frac{B}{2\mu_0}$ (C) $\frac{2\mu_0}{B^2}$ (D) $\frac{B}{4\pi\mu_0}$

16. What is mainly measured by potentiometer ?
(A) Current (B) Resistance
(C) Potential difference (D) All of these

17. Electric field lines provide information about :
(A) field strength (B) direction
(C) nature of charge (D) all of these

18. The force acting on per unit charge is called :
(A) Electric current (B) Electric potential
(C) Electric field (D) Electric space

19. Unit of ϵ_0 is :
(A) Nm^{-1} (B) Fm^{-1} (C) CV^{-1} (D) F.m

20. Sum of charges on collecting plate and condensing plate of a charged capacitor is :
(A) zero (B) 1 μC
(C) 1 C (D) Infinite

21. In the uniform electric field exists along X-axis, then equipotential is along :
(A) XY-plane (B) XZ-plane
(C) YZ-plane (D) anywhere

22. Which of the following values of n is not possible in relation $Q = ne$?
(A) 4 (B) 8
(C) 4.2 (D) 100

23. Electrical capacitance of earth of radius R is :
(A) $\frac{R}{4\pi\epsilon_0}$ (B) $4\pi\epsilon_0 R$ (C) $\frac{4\pi\epsilon_0}{R}$ (D) $4\pi\epsilon_0 \cdot R^2$

24. S.I. unit of self-inductance is :
(A) coulomb (C) (B) volt (V)
(C) ohm (Ω) (D) henry (H)

25. Kilowatt-hour (kWh) is the unit of :
(A) power (B) energy
(C) torque (D) none of these

26. How many different resistances are possible with two equal resistors ?
(A) 2 (B) 3
(C) 4 (D) 5

27. The length of a conductor is halved. Its resistance will be :
(A) halved (B) doubled
(C) unchanged (D) quadrupled

28. Power of an electric - circuit is :
(A) $V \cdot R$ (B) $V^2 \cdot R$
(C) $\frac{V^2}{R}$ (D) V^2Rt

29. Which elements is used in electic heater?
(A) Copper (B) Platinum
(C) Tungsten (D) Nichrome

30. The direction of propagation of electro-magnetic wave is :
(A) parallel to $\vec{B}$ (B) parallel to $\vec{E}$
(C) parallel to $\vec{B} \times \vec{E}$ (D) parallel to $\vec{E} \times \vec{B}$

31. Which of the following is not a unit of magnetic induction ?
(A) gauss (B) tesla
(C) oersted (D) weber/metre^2

32. The value of angle of dip at the earth's magnetic pole is :
(A) 0° (B) 45° (C) 90° (D) 180°

33. The moving coil galvanometer is based upon the principle of :
(A) interaction of charge and electric field
(B) interaction of current and magnetic field
(C) Faraday's law
(D) Maxwell's assumption

34. The SI unit for μ_0 is :
(A) T (B) TmA^{-1}
(C) TmA^{-2} (D) Tm^2A^{-1}

35. A straight conducting rod held horizontal along east-west is released to fall, Potential difference a across it will :
(A) be zero (B) increase
(C) decrease (D) change direction

36. The Drift velocity (V_d) and applied electric field (E) of a conductor are related as :
(A) $V_d \propto \sqrt{E}$ (B) $V_d \propto E$
(C) $V_d \propto E^2$ (D) V_d = Constant

37. The relation between r.m.s. value of alternating current ($I_{r.m.s.}$) and peak value of alternating current (I_0) is :
(A) $I_{r.m.s.} = 0.505\ I_0$ (B) $I_{r.m.s.} = 0.606\ I_0$
(C) $I_{r.m.s.} = 0.707\ I_0$ (D) $I_{r.m.s.} = 0.808\ I_0$

38. Power factor of an ac circuit is a measure of :
(A) virtual power (B) power lost in the circuit
(C) mean power (D) all the above

39. Inductive reactance offered by an inductor of inductance L in ac circuit of angular frequency ω is :
(A) $\frac{\omega}{L}$ (B) $\omega \cdot L$
(C) $\frac{1}{\omega \cdot L}$ (D) $\frac{L}{\omega}$

40. When an ammeter is shunted, its measuring range
(A) increases (B) decreases
(C) remains constant (D) none of these

41. S.I. unit of decay constant is :
(A) hertz (B) meter
(C) per meter (D) none of these

42. The direction of propagation of electromagentic wave is :
(A) Parrallel to $\vec{B}$ (B) Parrallel to $\vec{E}$
(C) Parrallel to $\vec{B} \times \vec{E}$ (D) Parrallel to $\vec{E} \times \vec{B}$

43. Light year is the unit of :
(A) distance (B) time
(C) energy (D) intensity of light

44. Brewster's law is :
(A) $\mu = \sin i_p$ (B) $\mu = \tan i_p$
(C) $\mu = \cos i_p$ (D) $\mu = \cot i_p$

45. The velocity of light is maximum in :
(A) air (B) glass
(C) water (D) vacuum

46. The radius of curvature of plane mirror is :
(A) Infinite (B) Zero
(C) +5 cm (D) – 5 cm

47. The transverse nature of light wave supports :
(A) interference (B) reflection
(C) polarisation (D) dispersion

48. Angular dispersion is equal to :
(A) $(\mu_v - \mu_r)A$ (B) $(\mu_v - \mu_r)$
(C) $(\mu_v - \mu_r)$ (D) $(\mu_v - \mu_r)A$

49. The final image in an astronomical telescope with respect to object is :
(A) virtual and erect (B) real and erect
(C) real and inverted (D) virtual and inverted

50. The magnifying power of an astronomical telescope for normal adjustment is :
(A) $-\frac{f_0}{f_e}$ (B) $-f_0 \times f_e$
(C) $-\frac{f_e}{f_0}$ (D) $-f_0 + f_e$

51. Which of the following series of hydrogen spectrum is in visible range ?
(A) Lyman series (B) Balmer series
(C) Paaschen series (D) Brackett series

52. Which of the following is not a fundamental particle?
(A) Neutron (B) Proton
(C) α-particle (D) Electron

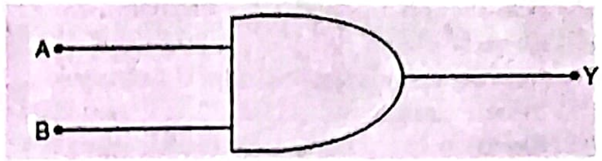
53. The source of solar energy is :
(A) nuclear fission
(B) chemical reaction
(C) annihilation of elementary particles
(D) nuclear fusion

54. Atomic number decreases with the emission of α–particles from the nucleus :
(A) 1 (B) 2
(C) 3 (D) 4

55. The quantities, which remain conserved in a nuclear reaction :
(A) Total Charge (B) Angular momentum
(C) Linear momentum (D) All the above

56. β-rays are deflected in :
(A) Gravitational field
(B) Only in magnetic field
(C) Only in electrical field
(D) In magnetic and electric field both

57. The logic gate shown in figure is :



(A) OR (B) NOR
(C) NAND (D) AND

58. Which of the following is not charged?
(A) Photon (B) α-particle
(C) β-particle (D) electron

59. The majority current-carrier in *p*-type semiconductor is :
(A) electron (B) hole
(C) photon (D) proton

60. The modulation index in amplitude modulation :
(A) is always zero (B) lies between 0 and 1
(C) lies between 1 and ∞ (D) can never exceed 0.5

61. The length of an astronomical telescope for normal adjustment is :
(A) $f_o - f_e$ (B) $f_o \times f_e$
(C) $\frac{f_o}{f_e}$ (D) $f_o + f_e$

62. The wave front due to a point source at a finite distance from the source is :
(A) Spherical (B) Cylindrical
(C) Plane (D) Circular

63. Diffraction was discovered by :
(A) Grimaldi (B) Thomas Young
(C) Malus (D) Huygens

64. Which of the following is used in optical fibres ?
(A) reflection (B) scattering
(C) total internal reflection (D) interference

65. A short sighted person uses for clear vision
(A) Convex Lense (B) Concave Lense
(C) Cylinderical Lense (D) Bi-focal Lense

66. The rest mass of photon is :
(A) zero (B) infinite
(C) 9.1×10^{-31} kg (D) 1.6×10^{-27} kg

67. De-Broglie equation states the :
(A) dual nature (B) particle nature
(C) wave nature (D) none of these

68. The charge of a photo electron is :
(A) 9.1×10^{-31} C (B) 9.1×10^{-27} C
(C) 9.1×10^{-24} C (D) none of these

69. The energy of emitted photo electron depends upon :
(A) Intensity of light (B) Wave length of light
(C) Work-function of metal (D) None of these

70. Kirchhoffe's second law of conservation of :
(A) charge (B) energy
(C) momentum (D) angular momentum

SECTION – B : Non-Objective Type Questions

SHORT ANSWER TYPE QUESTIONS

Directions : *Questions Nos. 1 to 20 are of short answer type. Each question carries 2 marks. Answer any ten question on your copy.* $10 \times 2 = 20$

1. **On what two factors does the capacity of a condenser depend?**
2. **Write snell's law and Huygens law for reflection at plane surface.**
3. **What is band width, Base band and fading?**
4. **Define ground waves, sky wave and space wave.**
5. **State some applications of radio waves and microwaves.**
6. **What is transformer ? What do you mean by its efficiency ?**
7. **Explain what do you understand by binding energy of a nucleus?**
8. **The Refractive index of glass is 1.5. What will be the speed of light in glass ?**
9. **Define magnetic potential.**
10. **What do you mean by apparent angle of dip at any place?**
11. **Define polar and non-polar molecules. Give one example each.**
12. **Draw a labelled diagram of van de Graff-generator.**
13. **Write down coulomb's law in vector form-due to group of charges.**
14. **Explain motional emf.**
15. **Write expression for force on unit of each of two long parallel wires having current.**
16. **What is Curie law in magnetism ?**
17. **State the principle of the working of a cyclotron. Write two uses of this machine.**
18. **Write Lenz's law of electromagnetic induction.**
19. **State Kirchhoff's two laws for electrical network.**
20. **What is total internal reflection? What are condition for it? Name any one of its practical application.**

LONG ANSWER TYPE QUESTIONS

Directions : *Questions Nos. 21 to 26 are Long Answer Type Questions. Answer any 3 out of them.* $3 \times 5 = 15$

21. **Define electric field intensity at a point and find its value at a point due to an electric dipole when point is axial or equitorial or any point.**
22. **State and explain Gauss's theorem, derive an expression for the electric field to the thin infinitely long straight line of charge.**
23. **Define drift velocity. Establish relation between drift velocity and electric field.**
24. **Explain with a neat diagram, the working of a compound microscope and astronomical telescope. Obtain expression for its magnifying power.**
25. **Explain the band theory of solid state how on this basis solids are classified into conductors, insulators and semiconductors ?**
26. **Derive an expression for the energy stored in a parallel plate capacitor C, charged to potential difference V.**

ANSWER WITH EXPLANATION

SECTION – A

OMR ANSWER-SHEET

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	36.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	37.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	38.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	39.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	40.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	41.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	42.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	43.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	44.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	45.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	46.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	47.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	48.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	49.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	50.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	51.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	52.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	53.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	54.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	55.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	56.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	57.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	58.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	59.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	60.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	61.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	62.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	63.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	64.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	65.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
31.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	66.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
32.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	67.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
33.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	68.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
34.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	69.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
35.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	70.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

ANSWER

1. (D)	2. (B)	3. (B)	4. (A)	5. (B)
6. (A)	7. (B)	8. (D)	9. (B)	10. (A)
11. (C)	12. (C)	13. (A)	14. (D)	15. (A)
16. (C)	17. (D)	18. (C)	19. (B)	20. (A)
21. (C)	22. (C)	23. (B)	24. (D)	25. (B)
26. (B)	27. (A)	28. (C)	28. (D)	30. (C)
31. (C)	32. (C)	33. (B)	34. (B)	35. (B)
36. (B)	37. (C)	38. (B)	39. (B)	40. (A)
41. (A)	42. (D)	43. (A)	44. (B)	45. (D)
46. (A)	47. (C)	48. (A)	49. (D)	50. (A)
51. (B)	52. (C)	53. (D)	54. (B)	55. (A)
56. (D)	57. (D)	58. (A)	59. (B)	60. (B)
61. (D)	62. (A)	63. (A)	64. (C)	65. (B)
66. (A)	67. (A)	68. (D)	69. (B)	70. (B)

SECTION – B

1. Capacitance of a capacitor depends on the following two terms.
   (a) Area of the plates
   (b) Seperation between the plates

2. **Snell's law of reflection :** The ratio of sine of angle of incident to the angle of reflection remains constant.

$$\text{i.e., } \frac{\sin i}{\sin r} = \mu$$

Huygen's law : In Huygen's law every wavefront behaves as the source for secondary wavelet.

3. **Band-width :** It refers to the frequency range over which an equipment operates or the **portion** of spectrum occupied by the signal.

   Fading : In wireless communication fading is deviation of attenuation affecting a signal over certain propagation medium.

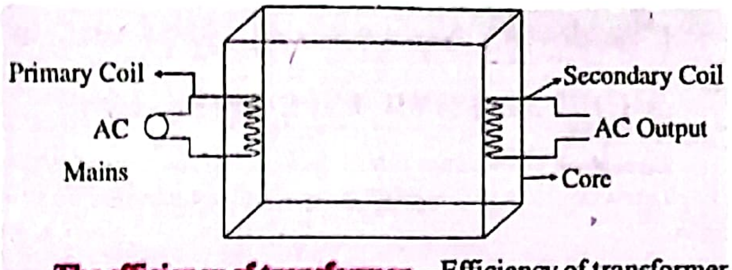
4. **Ground wave :** That wave which has frequencies below the *HF* range travel around the curvature of Earth, Some-times right around the globe.

   Space wave : That wave which has frequencies above the *HF* generally travel in straight lines. They propagate by means of so-called space waves.

   Sky wave : Waves in *HF* range, and sometimes frequencies just above or below it, are reflected by the ionised layers of the atmosphere and are called sky waves.

5. (i) Radio waves are used in radio astronomy.
   (ii) Radiowaves are used for wireless communication purposes.
   (iii) Microwaves are used in the study of atomic and molecular structure.
   (iv) Microwaves are used in radar systems and in long distance telephone communication systems.
   (v) Microwave ovens which are used for cooking also work by micro waves.

6. **Transformer**—It is electrical device which is used to convert alternating current (AC) as high voltage into that at low voltage and vice-versa without changing frequency of A.C. current. It is bases on the principal of electromagnetic induction.



The efficiency of transformer—Efficiency of transformer is defined as, It is ratio of output power to the input power.

$$\text{i.e. } \eta = \frac{\text{output power}}{\text{input power}}$$

7. The minimum amount of energy required to seperate the nucleus is called Binding Energy.

   Binding energy of nucleous be equal to energy equivalence of mass defect of that nucleus.

8. $\mu_g = 1.5$

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

   V_g = velocity of light in glass

   By using

$$\mu = \frac{C}{V}$$

$$V_g = \frac{C}{\mu g} = \frac{3\times10^8}{1.5} = 2\times10^8 \text{ ms}^{-1}$$

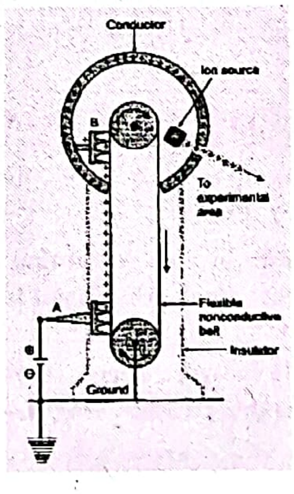
9. **Magnetic Potential**—Magnetic Potential is a physical quantity which governs the flow of charge between bodies. Magnetic potential at any point in the electric field is the work done per unit charge in bringing a unit positive charge from infinity to that point along any path.

10. **Apparent angle of dip**—The angle through which the needle showing north pole dips down with reference to horizontal is called the angle of dip. The angle made by the needle with the horizontal is called the apparent angle of dip.

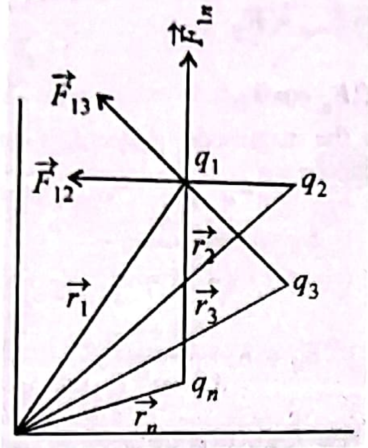
11. **Polar molecule :** That molecules which core made up of two atoms which has different electronegativities. In other words which molecule has positive and negative charges at two points are polar molecules. Ex.–HCl.

    Non-polar Molecule : Such molecules which are made up of same atoms and in which positive and negative charge coincides at a point is called non-polar molecule. **Ex.**–H_2.

12.



13. Consider n charges kept in coordinate system. Now force on q_1 due to charge q_2 is given as



$$F_{12} = K\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$$

By, $$F_{13} = K\frac{q_1 q_3}{r_{13}^2}\hat{r}_{13}$$

....

$$F_n = K\frac{q_1 q_3}{r_{1n}}\hat{r}_{1n}$$

Hence total force F, on charge q_1 will be–

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + ... + \vec{F}_{1n}$$

$$= K\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + K\frac{q_1 q_3}{r_{13}^2}\hat{r}_{13} + ... + \frac{q_1 q_3}{r_{1n}}\hat{r}_{1n}$$

$$\vec{F}_1 = Kq_1\sum_{i=2}^{n}\frac{q_i}{r_{1i}^2}\hat{r}_{1i}$$

14. Motional emf—When conducting loop or rod moves in uniform magnetic field then emf is induced due to

(i) Its dynamic interaction with magnetic field and

(ii) Charge in the magnetic flux enclosed by loop.

Such emf is known as motional emf.

15. $F = \dfrac{\mu_0 I_1 I_2}{2\pi d}$

16. Curie law. It states that the magnetic susceptibility of a paramagnetic material is inversely proportional to absolute temperature.

i.e., $\chi \propto \dfrac{1}{T} = \dfrac{C}{T}$ where c is Curie constant.

17. Cyclotron-Principle : A cyclotron is a device to accelerate charged particles/ions to high energies. In cyclotron charged particles are made to pass through accelerating electric field again and again by the help of a uniform magnetic field. For accelerating charged particles the resonance condition "The period of revolution of a charged particle in uniform magnetic field between metallic, chamber. T = $2\pi m/qB$ The period of revolution of ion is independent of speed and radius of its orbit.

Uses : (i) It is used to bombard nuclei with high energetic particles accelerated by cyclotron and study the resulting nuclear reaction.

(ii) It is used to implant ions into solids and modify their properties or even synthesize new materials.

18. It states that the induced current or induced e.m.f. Produced in a circuit always flows in such a direction that it opposes the every cause or charge which produces it.

19. Kirchoff's 1st Law : In his 1st law Kirchoff tells that the algebric sum of current at a junction of circuit be always equal to zero.

i.e., $$\sum_{i=1}^{n} I_i = 0$$

Kirchoff's 2nd Law : In his 2nd law Kirchoff states that the sum of potential drop and total emf of a close loop of a circuit always be zero i.e.

$$\sum_{i=1}^{n} I_i R_i + \sum_{i=1}^{n} \varepsilon_i = 0$$

20. When a ray of light travelling in denser medium incident at interface get reflected and goes to the same medium. This phenomenon is called total internal reflection.

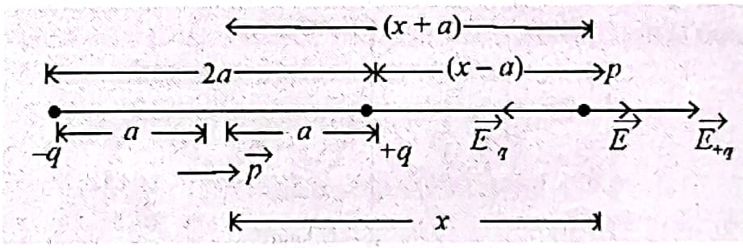
Condition : Incident angle must be greater than critical angle.

Application : It is applicable in production of rainbow.

21. Electric field intensity—Electric field intensity at a point inside the electric field of a charge be defined as force acting per unit test charge placed at that point.

Electric field intensity at a point due to an electric pole when point is axial.

First : Consider a dipole having charge $-q$ and $+q$ and length $2a$ we had to calculate electric field intensity at a point 'A' on its axis at a distance x from center of dipole.



Electric field intensity at point A will be equal to the vector sum of electric field the both charge due to dipole

$$\vec{E} = \vec{E}_{+q} + \vec{E}_{-q} \quad ...(1)$$

Since angle b/w $\vec{E}_{-q}$ and $\vec{E}_{+q}$ is 180° magnitude of electric field intensity due the $+q$ charge.

$$|\vec{E}_{+q}| = K\frac{q}{(x-a)^2} \quad ...(2)$$

and due the $-q$ charge

$$\vec{E}_{-q} = K\frac{q}{(x+a)^2} \quad ...(3)$$

From eqn. (1), (2) and (3)

$$\vec{E} = K\frac{q}{(x-a)^2} - K\frac{q}{(x+a)^2}$$

$$|\vec{E}| = Kq\left[\frac{4ax}{(x^2-a^2)^2}\right]$$

$$|\vec{E}| = \frac{1}{4\pi \in_0}\frac{q\times 2a\times 2x}{(x^2-a^2)^2}$$

$$|\vec{E}| = \frac{1}{4\pi \in_0}\frac{2px}{(x^2-a^2)^2} \quad \text{where, } (p = q \times 2a)$$

As we know $a << x$ hence, a^2 can be neglacted

$$|\vec{E}| = \frac{1}{4\pi \in_0}.\frac{2px}{x^4}$$

$$|\vec{E}| = \frac{1}{4\pi \in_0}\frac{p}{x^3}$$

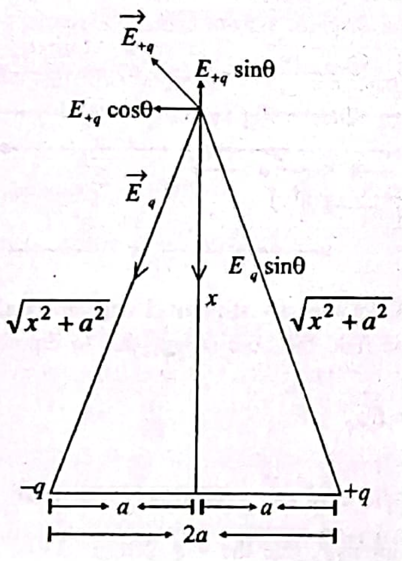
$$\vec{E} = \frac{1}{4\pi \in_0}\frac{p}{x^3}$$

This is the expression for electric field intensity due to a dipole at its axial position.

Second : Electric field intensity due to dipole on its equitorial point.

Similarly consider a dipole having charge $-q$ and $+q$ and length $2a$ we have to calculate electric field intensity due to this dipole at a distance x from center of dipole on its equitorial line.

The net electric field will in horizontal direction i.e.,



$$|\vec{E}| = E_{+q}\cos\theta + E_{-q}\cos\theta$$

$$\because \quad E_{+q} = E_{-q} = E_q$$

$$|\vec{E}| = 2E_q\cos\theta \quad ...(1)$$

Here, E_q is the magnitude of electric field intensity due to any charge of dipole.

Hence, $$E_q = \frac{Kq}{(\sqrt{x^2+a^2})^2}$$

$$E_q = K\frac{q}{x^2+a^2}$$

$$\cos\theta = \frac{a}{(x^2+a^2)^{\frac{1}{2}}}$$

From eqn. (1)

$$|\vec{E}| = 2K\frac{q}{(x^2+a^2)} \times \frac{a}{(x^2+a^2)^{1/2}}$$

$$|\vec{E}| = \frac{Kq\times 2a}{(x^2+a^2)^{3/2}}$$

$$|\vec{E}| = \frac{1}{4\pi \in_0}\frac{P}{(x^2+a^2)^{3/2}}$$

As $a << x$

Hence, a^2 can be neglected

$$|\vec{E}| = \frac{1}{4\pi \in_0}\frac{p}{x^3}$$

in vector form

$$\boxed{\vec{E} = \frac{1}{4\pi \in_0}\frac{-\vec{p}}{x^3}}$$

This is the expression for electric field intensity due a dipole on its equitorial position.

Electricl field intensity due to a dipole at any other point:

Consider a dipole having dipole moment $\vec{p}$. A point is x distance from mid point of dipole on a line passing through mid-point and making an angle θ with axis of dipole.

We can split the dipole having dipole moment p into two components such that point A becomes axial for dipole of moment $p\cos\theta$ and equitorial for dipole of moment $p\sin\theta$.

Hence, for axial point

$$E_{axi} = \frac{1}{4\pi\varepsilon_0}.\frac{2p\cos\theta}{x^3}$$

and for equitorial point

$$E_{eq} = \frac{1}{4\pi\varepsilon_0}.\frac{p\sin\theta}{x^3}$$

Hence the net electric field

$$\vec{E} = \vec{E}_{axi} + \vec{E}_{eq}$$

$$\Rightarrow |\vec{E}| = \sqrt{(E_{axi})^2 + (E_{eq})^2}$$

Since E_{axi} is perpendicular to E_{eq},

$$E = \sqrt{\left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{2p\cos\theta}{x^3}\right)^2 + \left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{p\sin\theta}{x^3}\right)^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{x^3}\sqrt{4\cos^2\theta + \sin^2\theta}$$

$$\therefore \quad E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{x^3}\sqrt{3\cos^2\theta + 1}$$

22. Total electrical flux through close surface be equal to $\frac{1}{\epsilon_0}$ times the total charge enclosed by that closed surface.

$$\oint_S \vec{E}.\vec{dS} = \frac{q}{\epsilon_0}$$

$$\phi_e = \oint_S \vec{E}.\vec{dS} = \frac{q}{\epsilon_0}$$

$$\boxed{\phi_e = \frac{q}{\epsilon_0}}$$

Proof of Gauss's law :
For a spherical surface :

$$|\vec{E}| = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2} \quad \text{... (1)}$$

Consider an elementary area $\vec{dS}$ in the direction of electric field at point A on the surface sphere.

Now, the electric flux through the elementary area

$$d\phi = \vec{E}.\vec{dS}$$

$$= \vec{E}.\vec{dS}\cos 0°$$

$$\boxed{d\phi = EdS} \quad \text{... (1)}$$

Now, the total flux through the whole sphere.

$$\phi = \int d\phi = \oint_S EdS$$

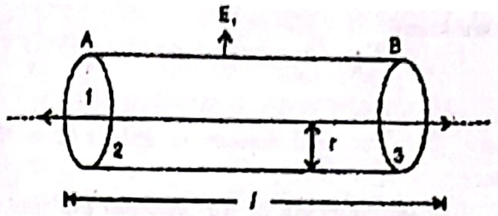
From eqn.

$$\phi = \oint_S \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}dS$$

$$\phi = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2} \times 4\pi r^2$$

$$\phi_e = \frac{q}{\epsilon_0}$$

The figure shows an infinitely long straight line of charge, having linear charge density λ. We have to derive an expression for the electric field due to it at a distance r from it.



Consider a cylindrical Gaussian surface of radius r and length l. The charge enclosed by the Gaussian surface is $q = l\lambda$.

From symmetry, the electric field E at every point on the surface is same and is directed radially. If q is positive then the direction of E is radially outwards. Applying Gauss's theorem

$$n\vec{E}.\vec{ds} = \frac{q}{\varepsilon_0} = \frac{l\lambda}{\varepsilon_0}$$

or, $$n_1\vec{E}.\vec{ds} + n_2\vec{E}.\vec{ds} + n_3\vec{E}.\vec{ds} = \frac{l\lambda}{\varepsilon_0}$$

$n_1\vec{E}.\vec{ds}$ and $n_3\vec{E}.\vec{ds}$ are contributions to the electric flux by side caps of the Gaussian surface which vanish as E and $\vec{ds}$ are perpendicular to each other on these faces. $n\vec{E}.\vec{ds}$ is the contribution of the curved surface of the cylinder towards the electric flux.

So, $$n_2\vec{E}.\vec{ds} = 0 + n\vec{E}.\vec{ds} + 0 = \frac{l\lambda}{\varepsilon_0}$$

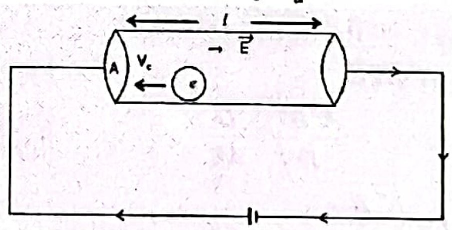
or, $$n_2\vec{E}.\vec{ds} = \frac{l\lambda}{\varepsilon_0}$$ or, $$E(2\pi rl) = \frac{l\lambda}{\varepsilon_0}$$

or, $$E = \frac{l\lambda}{2\pi l\varepsilon_0} = \frac{\lambda}{2\pi r\varepsilon_0}$$

23. Drift velocity—The average accelerated velocity of free electrons in a conductor with which it moves from one end to other of that conductor.

Direction of drift velocity be always opposite to the direction of electric field.

Relation between current and drift velocity : Consider a conductor having length l and cross sectional area t. It is connected through a supply. Therefore, electrons will drifted from it's one end to other with a velocity V_d



Let, t be the time taken by the electron in moving from one end to other then,

$$t = \frac{S}{V}$$

$$t = \frac{l}{V_d} \quad \text{... (1)}$$

As we know,

$$I = \frac{Q}{t} \quad \text{... (2)}$$

where, Q is the total amount of charge flow through the conductor.

Let, n be the numbers of free electron per unit volume of conductor. Then, total no. of electron in that conductor i.e.,

$N = n \times l \times A$

Hence, total charge of that conductor

$Q = Ne$

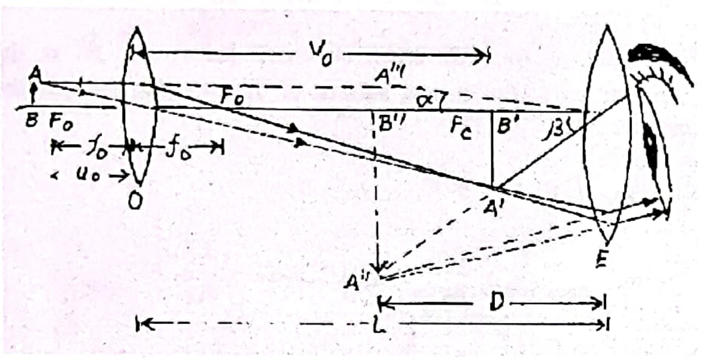
$Q = nlAe \quad \text{... (3)}$

from eqn. (1), (2) & (3)

$$I = \frac{neAl}{l / V_d}$$

$\Rightarrow \boxed{I = neAV_d}$

24. Ray diagram of compound microscope to show image formation :



Expression for magnifying power : Angular magnifica-tion or magnifying power of compound microscope is defined as the ratio of the angle β substended by the final image at the eye to the angle α subtended by the object seen directly when both are placed at the least distance of distinct vision.

$\therefore$ Angular magnification $(M) = \frac{\beta}{\alpha}$

Since the angle are small $\therefore \alpha \cong \tan\alpha$ and $\beta \cong \tan\beta$

$$\therefore \quad M = \frac{\tan\beta}{\tan\alpha}$$

$$\text{Now, } \tan B = \frac{A''B''}{D} \times \frac{D}{AB}$$

$$\therefore \quad M = \frac{A''B''}{AB}$$

$$\text{or, } M = \frac{A''B''}{A'B'} \times \frac{A'B'}{AB}$$

$\therefore M = M_e \times M_o$

Where M_e and M_o are the magnifying powers of the eye piece and objective respectively.

$$\therefore \quad M = M_o \times M_e = \left(\frac{v_0}{u_0}\right) \times \frac{D}{u_e} \quad \text{... (i)}$$

$$\left(\text{since } M_o = \frac{v_o}{u_0}, M_e = \frac{D}{u_e}\right)$$

Now, for the eye lens $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f_e}$;

Here $u = -u_e$, $v = -D$

$$\therefore \quad \frac{1}{u_e} - \frac{1}{D} = \frac{1}{f_e} \quad \text{or} \quad \frac{1}{u_e} = \frac{1}{D} + \frac{1}{f_e} \quad \text{or} \quad \frac{D}{u_e} = 1 + \frac{D}{f_e}$$

$$\text{Since } Me = \frac{D}{u_e}$$

$$\therefore \quad Me = 1 + \frac{D}{f_e} \quad \text{... (ii)}$$

From (i) and (ii) $\boxed{M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)}$

For object tenses

$$\text{Again} \quad \frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\text{or} \quad \frac{v_0}{v_0} - \frac{v_0}{u_0} = \frac{v_0}{f_0} \quad \text{or} \quad -\frac{v_0}{u_0} = -1 + \frac{v_0}{f_0}$$

$$\text{or} \quad \frac{v_0}{u_0} = 1 - \frac{v_0}{f_0} \qquad \therefore \; M = \left(1 - \frac{v_0}{f_0}\right)\left(1 + \frac{D}{f_e}\right)$$

Application—This optical device is used to observe highly magnified image of a tiny particle.

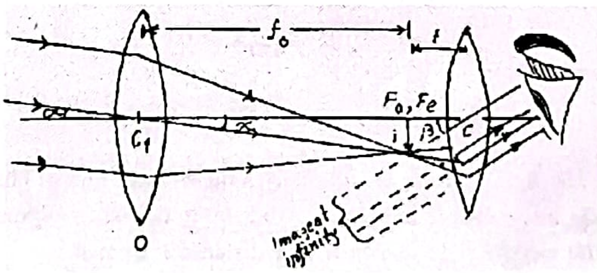
Astronomical Telescope—This telescope is used to observe heavenly objects like moon, stars and planets etc.The image formed by this telescope is virtual and inverted. Since the heavenly bodies are almost round therefore the inverted image doesn't affect the observation.

There are two type of astronomical telescope, which are following.

(a) Normal adjustment telescope (when final image is formed)

(b) Near point adjustment (when final image is formed at the least distance of distinct vision)

(a) Normal adjustment telescope—Ray diagramn of this telescope is following—



Magnifying power of telescople in normal adjustment is the ratio of the angle subtended by the image at the eye as seen through the telescope to the angle subtended by the object as seen directly, when both the object and the image are at inifnity.

Let α = Angle substanded by object at the eye

β = Angle substended by the image at the eye.

Magnification power or Angular magnification, $M = \dfrac{\beta}{\alpha}$

But β and α are so small that $\beta \cong \tan\beta$ and $\alpha \cong \tan\alpha$

$\therefore \quad M = \dfrac{\tan\beta}{\tan\alpha}$

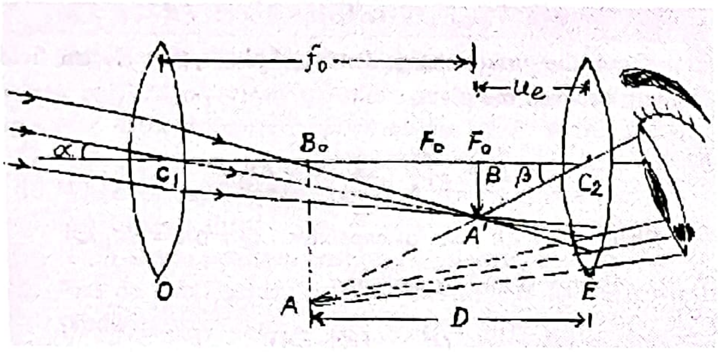
Let I is the image formed by the object, f_0 and f_e are the focal length of objective and eyepiece respectively.

$$\tan\alpha = \frac{I}{f_0} \quad \text{and} \quad \tan\beta = \frac{I}{-f_e}$$

(Distance of image from eyepiece is takes as negative)

$$\therefore \quad m = \frac{-1/f_e}{1/f_0} \quad \text{or} \quad \boxed{M = \frac{f_0}{f_e}}$$

(b) Near point adjustment ray diagram :



Magnifying Power—It is the ratio the angle subtended at the eye by the angle subtended at the eye by the image formed at the least distance of distinct vision to the angle substended at the eye by the object lying at infinity when seen directly.

Let α = Angle substended at the eye by the object lying at infinity when seen directly.

β = Angle substended at eye by the final image.

Magnifying power, $M = \dfrac{\beta}{\alpha}$; Since α and β are small

So, $\tan\alpha \cong \alpha, \tan\beta \cong \beta$; $M = \dfrac{\tan\beta}{\tan\alpha}$ ... (i)

In $\Delta A'B'C_2$, $\tan\beta = \dfrac{A'B'}{C_2B'}$ In $\Delta A'B'C_1$, $\tan\alpha = \dfrac{A'B'}{C_1B'}$

from equation (i) $M = \dfrac{A'B'}{C_2B'} \times \dfrac{C_1B'}{A'B'}$ or, $M = \dfrac{C_1B'}{C_2B'}$

Here $C_1B' = +f_0$ and $C_2B' = -u_e$, $M = \dfrac{f_0}{-u_e}$ ... (ii)

using lens equation $\left(\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}\right)$ for the eyepiece.

$$\frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{f_e} \quad \text{or} \quad -\frac{1}{D} + \frac{1}{u_e} = \frac{1}{f_e}$$

$$\text{or} \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} \quad \text{or} \quad \frac{f_0}{u_e} = \frac{f_0}{f_e} + \frac{f_o}{D}$$

$$\text{or} \quad \frac{f_0}{u_e} = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right) \quad \text{or} \quad \boxed{M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)}$$

25. Band theory of solids state that all materials consist valance band and conduction band separated by forbidden energy gap.

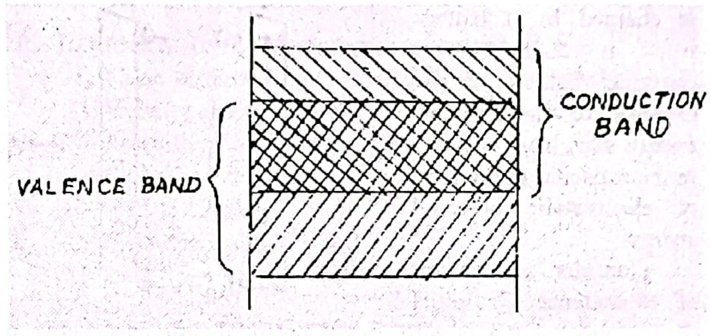
Conduction band—The band correspondings to the conduction electrons is called conduction band. In this band, electrons are free to conduct c (move). In figure upper band is conduction band.

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 figure is called forbidden gap.

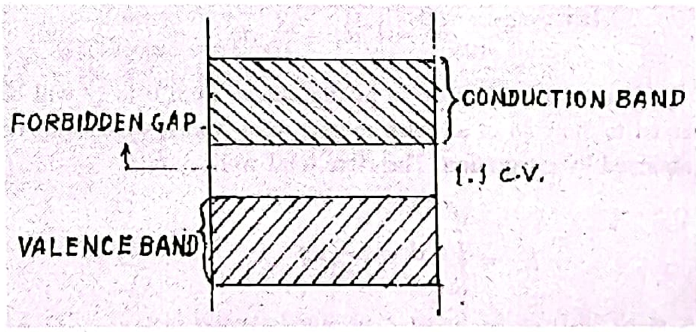
Band theory for conductor, Semiconductor and insulator—

(a) Conductor :



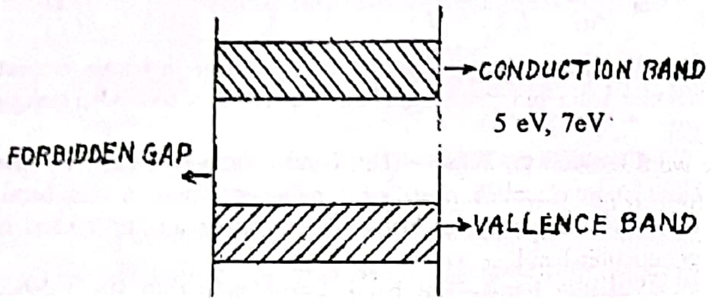
In above figure. There is overlapping of valence and conduction bands. This is because the lowest levels in the conduction band need less energy than the highest levels in the valence band. This tends the electrons in one band to overflow, as it were, into another band and electrons in the valence bands are free to move about inside the crystal lattice and with an applied field, contribute to electrical conduction.

(b) Semiconductors :



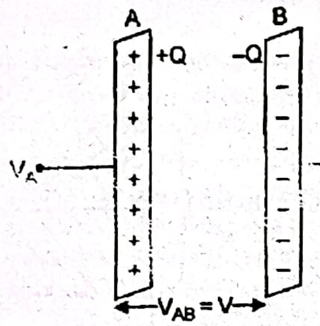
In this class of crystals the two energy bands are distinctly separate with no overlaping. The forbidden gap is nearly 1.1ev as shown in above figure. At absolute zero of temperature, no electron has energy even to Jump the forbidden gap and reach the conduction band. Therefore, the substance is an insulator. But at room temperature, some valence electrons acquire thermal energy greater than 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.

26. When a capacitor is charged by a battery, work is done by the charging battery at the expense of its chemical energy. This work is stored in the capacitor in the form of electrostatic potential energy.



Consider a capacitor of capacitance C. Initial charge on capacitor is zero. Initial potential difference between capacitor plates = zero. Let a charge Q be given to it in small steps. When charge is given to capacitor, the potential difference between the plates increases. Let at any instant when charge on capacitor be q, the potential difference between its plates $V = \frac{q}{C}$.

Now work done in giving an additional infinitesimal small charge dq to capacitor

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

The total work done in giving charge from 0 to Q will be equal to the sum of all such infinitesimal works, which may be obtained by integration. Therefore total work

$$W = \int_0^Q V\,dq = \int_0^Q \frac{q}{C}\,dq$$

$$= \frac{1}{C}\left|\frac{q^2}{2}\right|_0^Q = \frac{1}{c}\left(\frac{Q^2-0}{2}\right) = \frac{Q^2}{2C}$$

If V is the final potential difference between capacitor plates, then $Q = CV$

$$\therefore \quad W = \frac{(CV)^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

This work is stored as electrostatic potential energy of capacitor i.e.

$$\text{Electrostatic potential energy, } U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

Energy Density : Consider a parallel plate capacitor consisting of plates, each of area A, separated by a distance d. If space between the plates is filled with a medium of dielectric constant K, then

$$\text{Capacitance of capacitor, } C = \frac{K\varepsilon_0 A}{d}$$

If σ is the surface charge density of plates, then electric field strength between the plates

$$E = \frac{\sigma}{K\varepsilon_0} \Rightarrow \sigma = K\varepsilon_0 E$$

Charge on each plate of capacitor, $Q = \sigma A = K\varepsilon_0 EA$

$\therefore$ Energy stored by capacitor,

$$U = \frac{Q^2}{2C} = \frac{(K\varepsilon_0 EA)^2}{2\,(K\varepsilon_0 A/d)} = \frac{1}{2}K\varepsilon_0 E^2 Ad$$

But $Ad = \tau$, volume of space between capacitor plates

$\therefore$ Energy stored, $U = \frac{1}{2}K\varepsilon_0 E^2\tau$

Electrostatic Energy stored per unit volume,

$$u_e = \frac{U}{\tau} = \frac{1}{2}K\varepsilon_0 E^2$$

This is expression for electrostatic energy density in medium of dielectric constant K.

In air of free space ($K = 1$), therefore energy density,

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

□□□