Resonance®
Educating for better tomorrow

RBSE

RAJASTHAN BOARD SECONDARY EXAMINATION 2022

CLASS XII

Questions & Solutions

Date: 04 April, 2022 | TIME : (9.00 a.m. to 11.45 a.m)

Duration: 2hr, 45 min. | Max. Marks: 56

SUBJECT: PHYSICS

Resonance Eduventures Ltd.

Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005

Ph. No.: +91-744-2777777, 2777700 | **FAX No. :** +91-022-39167222

To Know more : sms **RESO** at **56677** | **Website :** www.resonance.ac.in | **E-mail :** contact@resonance.ac.in | **CIN :** U80302RJ2007PLC024029

Toll Free : 1800 258 5555 **7340010333** facebook.com/ResonanceEdu twitter.com/ResonanceEdu www.youtube.com/resowatch blog.resonance.ac.in

Phy.

Code No. **SS/40/1**

Roll No. | | | | | | | |

Candidates must write the Code on the title page of the answer-book

PHYSICS (Theory) & SOLUTION

Time allowed : 2 hr, 45 Min. **Maximum Marks : 56**

General Instructions :

परीक्षार्थियों के लिए सामान्य निर्देशः

1. Candidate must write first his/her Roll No. on the question paper compulsorily
परीक्षार्थी सर्वप्रथम अपने प्रश्न–पत्र पर नामांक अनिवार्यतः लिखें।
2. All the question are compulsory.
सभी प्रश्न करने अनिवार्य है।
3. Write the answer to all question in the given answer-book only.
सभी प्रश्नों का उत्तर–पुस्तिका में ही लिखें।
4. For questions having more than one part, the answers to those parts are to be written together in continuity.
जिन प्रश्नों में आन्तरिक खण्ड है उन सभी के उत्तर एक साथ ही लिखे।
5. If there is any error/ difference/ contradiction in Hindi & English versions of the questions paper, the questions of Hindi version should be treated valid.
प्रश्न–पत्र के हिन्दी व अंग्रेजी रूपान्तरण में किसी प्रकार की त्रुटि/अन्तर/विरोधाभास होने पर हिन्दी भाषा के प्रश्न को ही सही माने।
6. Write down the serial number of the question before attempting it.
प्रश्न का उत्तर लिखने से पूर्व प्रश्न का क्रमांक अवश्य लिखें।
7. There are internal choices in Questions Nos. 16 to 20.
प्रश्न क्रमांक 16 से 20 में आन्तरिक विकल्प है।

---

1. Choose the correct answer from multiple choice question 1 (i to ix) and write in given answer book.
बहुविकल्पी प्रश्न 1 (i से ix) : निम्न प्रश्नों के उत्तर का सही विकल्प चयन कर उत्तर पुस्तिका में लिखिए

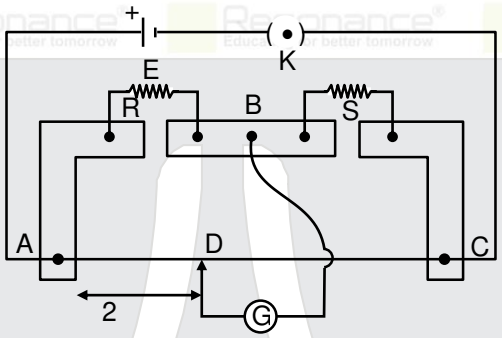
(i) The SI unit of electric flux is :
वैद्युत फ्लक्स का SI मात्रक है

(A*) $NC^{-1}m^2$ (B) $NC^{-1}m^{-2}$ (C) $N^{-1}C^{-1}m^{-2}$ (D) $N^{-1}C^{1}m^{2}$

(ii) The dependence of electric potential (V) on distance (r) inside a uniformly charged spherical shell is
एकसमान आवेशित एक गोलीय खोल (कोश) के भीतर वैद्युत विभव (V) की दूरी (r) पर निर्भरता होती है

(A) $V \propto r$ (B*) V = constant नियत (C) $V \propto 1/r$ (D) $V \propto 1/r^2$

(iii) In meter bridge experiment, the balance point is found to be at 20 cm distance from end A when R = 3Ω resistor applied between A and B, then the value of unknown resistance S will be
मीटर सेतु के एक प्रयोग में A व B के मध्य R = 3Ω प्रतिरोध प्रयुक्त करने पर A सिरे से 20 cm दूरी पर शून्य विक्षेप प्राप्त होता है, तो अज्ञात प्रतिरोध S का मान होगा



(A) 3Ω (B) 6Ω (C*) 12Ω (D) 10Ω

(iv) The correct relationship between the permittivity of free space ($\in_0$), the permeability of free space (μ_0) and the velocity of light in vacuum (c) is :
मुक्त दिक्स्थान की विद्युतशीलता ($\in_0$), मुक्त दिक्स्थान की चुम्बकशीलता (μ_0) तथा निर्वात् में प्रकाश का वेग (c) में सही सम्बन्ध है:

(A) $\mu_0 \in_0 = c^2$ (B*) $\frac{1}{\mu_0 \in_0} = c^2$ (C) $\sqrt{\mu_0 \in_0} = c^2$ (D) $\frac{1}{\sqrt{\mu_0 \in_0}} = c^2$

(v) A moving charge can produce –
(A) Only electric field (B) Only magnetic field
(C*) Both electric and magnetic field (D) None of these
गतिमान आवेश से उत्पन्न हो सकता है–
(A) केवल विद्युत क्षेत्र (B) केवल चुम्बकीय क्षेत्र
(C*) विद्युत एवं चुम्बकीय क्षेत्र दोनों (D) इनमें से कोई नहीं

(vi) Eddy currents are used in -
(A) Magnetic breaking in trains (B) Induction furnace
(C) Electromagnetic damping (D*) All of the above
भँवर धाराओं का उपयोग होता है–
(A) रेलगाडियों में चुम्बकीय ब्रेक में (B) प्रेरण भट्टी में
(C) विद्युत चुम्बकीय अवमंदन में (D*) उपरोक्त सभी

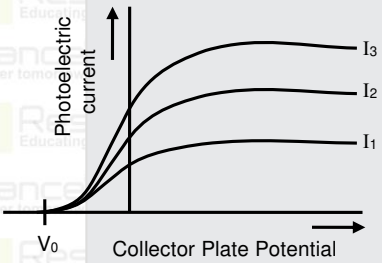
(vii) If refractive index of denser medium 1 with respect to rarer medium 2 in n_{12} critical angle for this pair of media is i_c, then correct relation between n_{12} and i_c is-

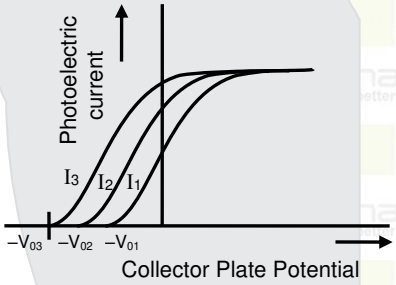
(A) $n_{12} = \sin i_c$ (B) $n_{12} = \tan i_c$ (C) $n_{12} = \frac{1}{\tan i_c}$ (D*) $n_{12} = \frac{1}{\sin i_c}$

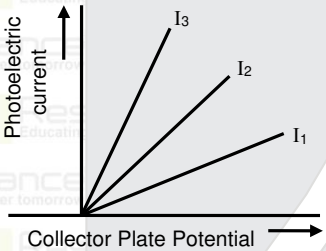
यदि सघन माध्यम 1 का विरल माध्यम 2 के सापेक्ष अपवर्तनांक n_{12} एवं इन माध्यमों के युगल के क्रांतिक कोण i_c है, तो n_{12} व i_c के मध्य सही सम्बंध है–

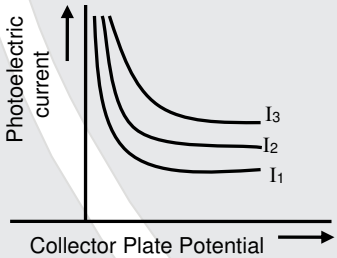
(A) $n_{12} = \sin i_c$ (B) $n_{12} = \tan i_c$ (C) $n_{12} = \frac{1}{\tan i_c}$ (D*) $n_{12} = \frac{1}{\sin i_c}$

(viii) In an experimental study of photoelectric effect, the correct graph between collector plate potential and photoelectric current for different intensities of incident radiation is :

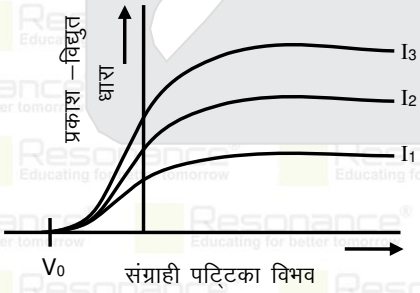
(A*)


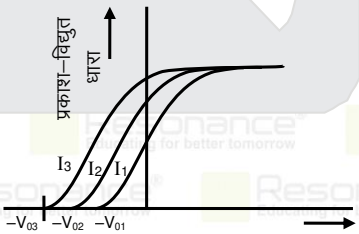
(B)


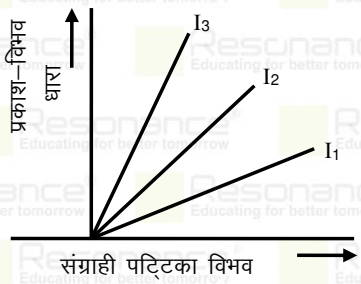
(C)


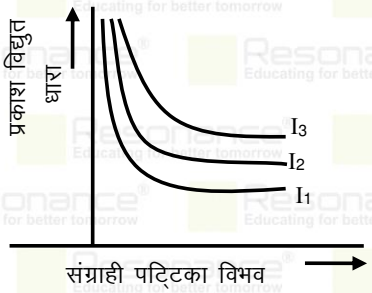
(D)


प्रकाश–विद्युत प्रभाव के प्रायोगिक अध्ययन में आपतित विकिरण की विभिनन तीव्रताओं के लिए संग्राही पट्टिका विभव तथा प्रकाश–विद्युत धारा के बीच सही आलेख है –

(A*)


(B)


(C)


(D)


(ix) Who first experimentally verified the wave nature of the electron ?

(A) Wilhelm Hallwachs and Philipp Lenard (B*) C.J. Davission and L.H. Germer

(C) Albert Einstein (D) A.H. Compton

इलेक्ट्रॉन की तरंग प्रकृति का प्रयोगिक तौर पर सर्वप्रथम सत्यापन किसने किया ?

(A) Wilhelm Hallwachs and Philipp Lenard (B) C.J. Davission and L.H. Germer

(C) Albert Einstein (D) A.H. Compton

2. Fill in the blanks (i) to (iv):

रिक्त स्थानों की पूर्ति कीजिए (i) से (iv) :

(i) The name of machine that accelerates charged particles or ions to high energies is _____.

आवेशित कणों अथवा आयनों को उच्च ऊर्जाओं तक त्वरित करने वाले यंत्र का नाम _____ है।

(ii) The ratio of flux linkage (Nϕ) associated with a coil having N turns to the current (I) flowing through it $\left(\frac{N\phi}{I}\right)$ is _____.

N फेरों वाली कुण्डली की फ्लक्स बंधता (Nϕ) तथा उसमें प्रवाहित धारा (I) का अनुपात $\left(\frac{N\phi}{I}\right)$ होता है।

(iii) If _____of two particles are equal, then their de Broglie wavelength will be equal.

यदि दो कणों का _____ समान है तो उनकी दे ब्रॉग्ली तरंग दैर्ध्य समान होगी।

(iv) The _____ are majority charge carriers and _____ are minority charge carriers in p-type semiconductor.

p-प्रकार के अर्द्धचालक में _____बहुसंख्यक आवेश वाहक तथा _____ अल्पसंख्यक आवेश वाहक होते हैं।

Ans. (i) Cyclotron (ii) Self Inductance (iii) Linear Momentum (iv) Holes and electrons

3. Give the answer of the following questions (i to viii) in one line.

निम्न प्रश्नों (I से viii) के उत्तर एक पंक्ति में दीजिए।

(i) In Milikan's experiment, the charge found on a charged droplet was -6.4×10^{-19} C then write the number of electrons in that charged droplet.

मिलिकन के प्रयोग में एक आवेशित बूँद पर -6.4×10^{-19} कूलॉम आवेश पाया गया तो उस आवेशित बूँद में इलेक्ट्रॉनों की संख्या लिखिए।

(ii) Write the value of electric potential at a distance r from the middle point of the dipole on the axis of the electric dipole of dipole moment p.

p द्विध्रुव आघूर्ण के वैद्युत द्विध्रुव की अक्ष पर द्विध्रुव के केन्द्र से r दूरी पर वैद्युत विभव का मान लिखिए।

(iii) Write dependence of resistivity with temperature for semiconductors.

अर्द्धचालकों की प्रतिरोधकता की ताप पर निर्भरता लिखिए।

(iv) If two cells of e.m.f. ε_1. ε_2 and internal resistance r_1, r_2 are connected in parallel combination, then write the equivalent e.m.f. of this combination.
दो सेलों के वि॰वा॰बल ε_1. ε_2 व आंतरिक प्रतिरोध क्रमशः r_1, r_2 है। दोनों सेलों को पार्श्व क्रम संयोजित किया गया है, तो इस संयोजन का तुल्य वि॰वा॰बल लिखिए।

(v) How can a galvanometer be converted into a voltmeter ?
एक गैल्वेनोमीटर को वोल्टमीटर में किस प्रकार रूपान्तरित किया जा सकता है ?

(vi) Draw a diagram of the magnetic field lines due to a current carrying circular loop.
किसी विद्युत धारावाही वृत्ताकार पाश के कारण चुम्बकीय क्षेत्र रेखाओं का चित्र बनाइए।

(vii) Write Faraday's law of electromagnetic induction.
फेराडे का वि.चु. प्रेरण का नियम लिखिए।

(viii) Draw a graph between angle of incidence (i) and angle of deviation (δ) for a triangular prism.
किसी त्रिभुजाकार प्रिज्म के लिए आपतन कोण (i) तथा विचलन कोण (δ) के बीच ग्राफ बनाइए।

Ans. (i) $q = \pm ne$

$$n = \frac{-6.4\times10^{-19}}{-1.6\times10^{-19}} = 4$$

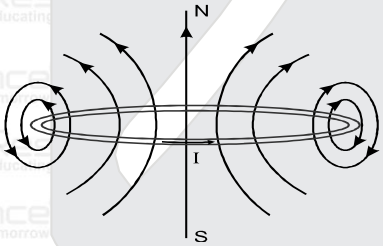
(ii) $V = \dfrac{Kp}{r^2}$

(iii) $T\uparrow\ \sigma\uparrow\ \rho\downarrow$

(iv) $\varepsilon_{net} = \dfrac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$

(v) A galvanometer can be converted into a voltmeter by connecting a high resistance in series with it.

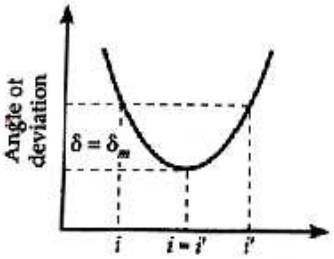
(vi)



(vii) Faraday's laws of electromagnetic induction:
First law: Whenever the magnetic flux linked with a closed circuit changes, an emf (and hence a current) is induced in it which lasts only so long as the changes in flux is taking place. This phenomenon is called electromagnetic induction.
Second law: The magnitude of the induced emf is equal to the rate of change of magnetic flux linked with the closed circuit. Mathematically,

$$|\varepsilon| = \frac{d\phi}{dt}$$

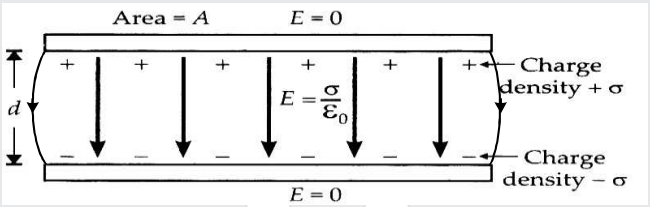
(viii)



SECTION B
खण्ड B

4. If the area of each conducting plate of parallel plate capacitor is A & d is the preparation between them, then derive its capacitance formula.
यदि एक समान्तर प्लेट संधारित्र की प्रत्येक चालक प्लेट का क्षेत्रफल A है तथा उनके बीच पृथक्कन d है, तो इसकी धारिता का सूत्र व्युत्पन्न कीजिए।

Ans. It consists of two large plane parallel conducting plates, separated by a small distance
Let A = area of each plate,
d = distance between the two plate
$\pm \sigma$ = uniform surface charge densities on the two plates
$\pm Q = \pm \sigma A$ = total charge on each plate.



Parallel plate capacitor.

The direction of the electric field is from the positive to the negative plate and the field is uniform throughout. For plates with finite area, the field lines bend at the edges. This effect is called fringing of the field. But for large plates separated by small distance ($A >> d^2$), the field is almost uniform in the regions far from the edges. For a uniform electric field,
P.D. between the plates
= Electric field × distance between the plates

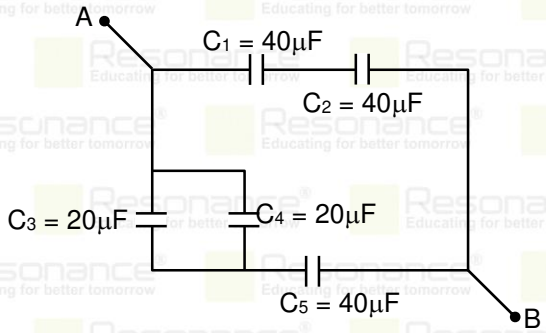
or $V = Ed = \frac{\sigma d}{\varepsilon_0}$ (Electric field between the plates)

$\left(\therefore E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}\right)$

Capacitance of the parallel plate capacitor is

$C = \frac{Q}{V} = \frac{\sigma A}{\sigma d/\varepsilon_0}$ or $C = \frac{\varepsilon_0 A}{d}$

5. If C_1, C_2, C_3, C_4, C_5 five capacitors are connected in an electrical circuit as shown in figure, then calculate the equivalent capacitance of this mesh (network) between point A & point B.
यदि C_1, C_2, C_3, C_4, C_5 पाँच संधारित्र चित्र में दर्शाये अनुसार विद्युत परिपथ में संयोजित हैं, तो बिन्दु A व B के मध्य इस जाल (नेटवर्क) की तुल्य धारिता की गणना कीजिए।



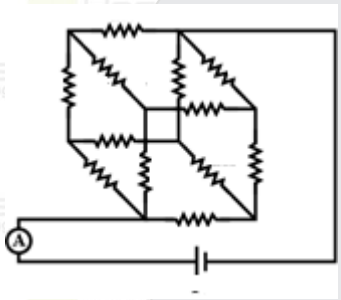
Ans. $C_{AB} = 40\ \mu f$

6. Carbon resistors are widely used in electronic circuits. Why ? Write any two reasons.
इलेक्ट्रॉनिक परिपथों में कार्बन प्रतिरोधक व्यापक रूप से उपयोग में लिए जाते है। क्यों ? कोई दो कारण लिखिए।

Ans. The big advantage of carbon composition resistors is their ability to withstand high energy pulses. When current flows through the resistor, the entire carbon composition body conducts the energy. The wire wound resistor, for example, has a much smaller volume of wire to conduct current.

7. If 12 resistors each of resistance 12Ω are connected in a cubical network, then determine the equivalent resistance of this network across the diagonally opposite corners of the cube.
यदि प्रत्येक 12Ω प्रतिरोध के 12 प्रतिरोधक एक घनीय परिपथ जाल (नेटवर्क) में जुडे हैं, तो घन के विकर्णतः सम्मुख कोनों के मध्य इस परिपथ जाल का समतुल्य प्रतिरोध ज्ञात कीजिए।

Ans.



Appling KVL

$$-IR-\frac{IR}{2}-IR+\varepsilon=0$$

$$\varepsilon=\frac{5}{2}IR$$

$$R_{eq}=\frac{\varepsilon}{3I}=\frac{5}{6}R$$

$$\therefore R=12\Omega$$

$$R_{eq}=\frac{5}{6}\times 12=10\Omega$$

8. If the focal length of a concave mirror is f and radius of curvature is R, then prove that radius of curvature is twice the focal length.
यदि एक अवतल दर्पण की फोकस दूरी f एवं वक्रता त्रिज्या R है, तो सिद्ध कीजिए कि वक्रता त्रिज्या फोकस दूरी की दुगुनी होती है।

Ans. Consider a ray AB parallel to the principal axis, incident at point B of a spherical mirror (concave or convex) of small aperture. After reflection from the mirror, this ray converges to point F (in case of a concave mirror) appears to diverge from point F (in case of a convex mirror),

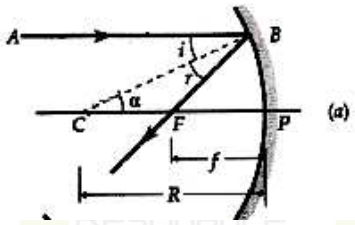


Fig. Relation between f and F of a concave mirror

According to the law of reflection,

$$\angle i = \angle r$$

As AB is parallel to PC,

$$\angle \alpha = \angle i$$

In Δ BFC, $\angle r = \angle \alpha$

Hence CF = FB

For a mirror of small aperture,

FB = FP $\quad \therefore \quad$ CF = FP

Hence CP = CF + FP = FP + FP = 2 FP

or R = 2f or $f = \frac{R}{2}$

or Focal length = $\frac{1}{2}$ × Radius of curvature

9. If a concave lens 25 cm focal length is placed in contact with a convex lens of 20 cm focal length, then calculate the power of the combined lens formed by this combination.

यदि किसी 20 cm फोकस दूरी के उत्तल लैंस के सम्पर्क में 25 cm फोकस दूरी का अवतल लैंस रखा जाता है, तो इस संयोजन से बने संयुक्त लैंस की शक्ति की गणना कीजिए।

Ans. $f_1 = -25$ cm

$f_1 = 20$ cm

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \; ; \; f = 100 \text{ cm} \; ; \; P = \frac{100}{f} = \frac{100}{100} = 1 \text{ D}$$

10. By writing Einstein's photoelectric equation, explain any two observations related to photoelectric effect.

आइन्सटीन का प्रकाश–विद्युत समीकरण लिखकर, इससे प्रकाश–विद्युत प्रभाव से सम्बन्धित कोई दो प्रेक्षण की व्याख्या कीजिए।

Ans. Energy of the incident photon = maximum K.E. of photoelectron + work function

or $h\nu = \frac{1}{2}mv_{max}^2 + W_0$

or $\boxed{K_{max} = \frac{1}{2}mv_{max}^2 = h\nu - W_0}$ ..... (1)

Also, $h\nu_0 = W_0$

$\boxed{K_{max} = \frac{1}{2}mv_{max}^2 = h\nu - h\nu_0 = h(\nu - \nu_0)}$ ..... (2)

Equation (1) & (2) are called Einstein's photoelectric equations.

1. Explanation of effect of intensity :

The increase of intensity means the increase in the number of photons striking the metal surface per unit time.

So, the number of ejected photoelectrons increases with the increase in intensity of incident radiation.

2. Explanation of threshold frequency :

If $\nu < \nu_0$ i.e., the frequency of incident radiation is less than the threshold frequency, the kinetic energy of photoelectrons becomes negative. This has no physical meaning. So photoelectric emission does not occur below the threshold frequency.

11. Calculate the de-Broglie wavelength associated with an electron, accelerated through a potential difference of 100 V.

100 V के विभवान्तर द्वारा त्वरित किसी इलेक्ट्रॉन से सम्बद्ध दे ब्रोग्ली तरंगदैर्ध्य का परिकलन कीजिए।

Ans. $\lambda = \frac{12.3}{\sqrt{v}} = \frac{12.3}{\sqrt{100}} = 1.23\text{Å}$

12. What is meant by half-life of a radioactive nuclei ? Write the relation between half-life and mean life of a radioactive nuclei.

किसी रेडियोएक्टिव नाभिक की अर्द्धआयु से क्या तात्पर्य है ? रेडियोएक्टिव नाभिक की अर्द्धआयु एवं औसत आयु में सम्बन्ध लिखिए।

Ans. The time interval in which number of undecayed radioactive sample reduces to half of its initial value is called half-life of the radioactive substance.

The half-life of a particular radioactive isotope is a characteristic constant of that isotope. It is denoted by $T_{1/2}$.

Relation between half life and mean life :

We know that $\tau = \frac{1}{\lambda}$ ..... (1)

$T_{1/2} = \frac{0.693}{\lambda} \Rightarrow \frac{1}{\lambda} = \frac{T_{1/2}}{0.693}$ ..... (2)

Put (2) in (1)

$$\boxed{\tau = \frac{T_{1/2}}{0.693} = 1.44\,T_{1/2}}$$

13. Write any three features of the nuclear force.

नाभिकीय बल के कोई तीन अभिलक्षण लिखिए।

Ans. Features of nuclear force:

1. Strongest interaction:

Nuclear force is the strongest interaction known in nature that holds the nucleons together despite the strong electrostatic repulsion between the protons. The relative strength of gravitational, electrostatic and nuclear forces is

$$F_g : F_E : F_n = 1 : 10^{36} : 10^{38}$$

2. Short-range force:

Unlike gravitational and electrostatic forces, nuclear force is a short-range force. It operates only up to a very short distance of about 2-3 fm from a nucleon.

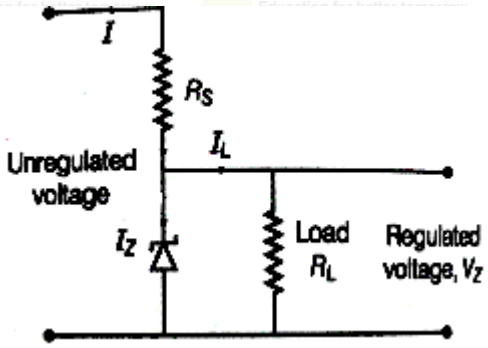
3. Charge independent character:

It is seen from experiments that the attractive force between two neutrons (nn-force) is nearly equal to that between two protons (pp-force) or between a proton and a neutron (pn-force). Thus the nuclear force does not depend on the charge of the particles.

14. Write the working of a voltage regulator made by using a Zener diode.
एक जेनर डायोड का उपयोग कर बनाए गए वोल्टता निचंत्रक की कार्यप्रणाली लिखिए।

Ans. Zener Diode as a Voltage Regulator

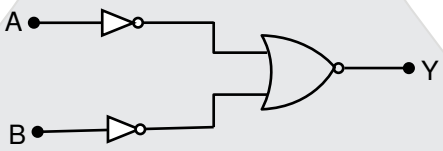
Principle From the above V - I characteristic of zener diode, we can say that, zener voltage remains over a wide range. If a Zener diode is joined in reverse bias to the fluctuating. DC input voltage through a resistance R then, the constant output voltage is taken across a load resistance connected on parallel with Zener diode.



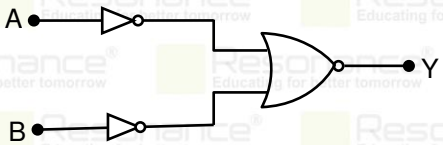
Circuit diagram of Zener diode as voltage regulator

Working Here, when input DC voltage increases beyond a certain limit, the current through the circuit rises sharply, causing a sufficient increase in the voltage drop across the resistor R_s . Thus, the voltage across the Zener diode remains constant and also the output voltage remains constant at V_Z. When the input DC voltage decreases, the current through the circuit goes down sharply causing sufficient decrease in the voltage drop across the residence. Thus, the voltage across the Zener diode remains constant and also the output voltage across R_L remains constant at V_Z. Hence, the output voltage remains constant in both conditions.

15. A circuit is shown in the figure by combining two NOT gates and one NOR gate. The truth table for this connected circuit.



दो NOT गेट एवं एक NOR गेट के संयोजन से चित्र में एक परिपथ दर्शाया गया है। इस संयोजित पर सत्यमान सारणी बनाइए।



Ans.

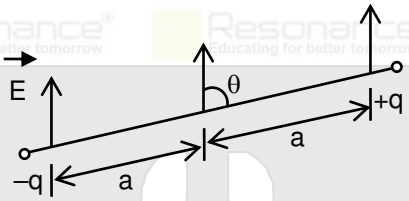
A	B	A'	B'	y
0	0	1	1	0
1	1	0	0	1
0	1	1	0	0
1	0	0	1	0

SECTION C
खण्ड C

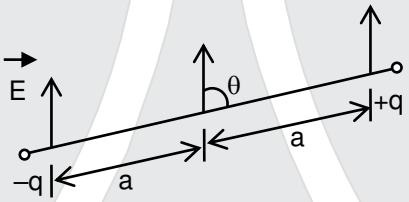
16. Write Gauss's law. Using this law, find the electric field due to a uniformly charged infinite plane sheet at a point near the sheet.
गाउस नियम लिखिए । इस नियम के अनुप्रयोग से एकसमान आवेशित अनंत समतल चादर के कारण चादर के समीप स्थित किसी बिन्दु पर विद्युत क्षेत्र का मान ज्ञात कीजिए।

OR / अथवा

Write the definition of electric dipole. An electric dipole is placed in a uniform external electric field $(\vec{E})$ as shown in the figure. Calculate the torque on this electric dipole.



वैद्युत द्विध्रुव की परिभाषा लिखिए। एकसमान बाह्य विद्युत क्षेत्र में चित्रानुसार एक विद्युत द्विध्रुव रखा है। इस विद्युत द्विध्रुव पर बल–आघूर्ण की गणना कीजिए।



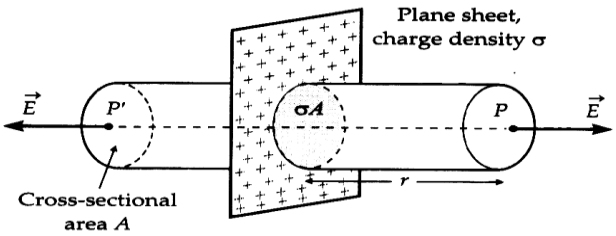
Ans. Gauss theorem states that the total flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the closed surface.
Mathematically, it can be expressed as

$$\phi_E = \oint \vec{E}.d\vec{S} = \frac{q}{\varepsilon_0}$$

This theorem gives a relationship between the total flux passing through any closed surface and the net charge enclosed within the surface.

Electric field due to a uniformly charged infinite plane sheet :

Consider a thin, infinite plane sheet of charge with uniform surface charge density σ. We wish to calculate its electric field at a point P at distance r from it.



Gaussian surface for a uniformly charged infinite plane sheet.

By symmetry, electric field E points outwards normal to the sheet. Also, it must have same magnitude and opposite direction at two points P and P′ equidistant from the sheet and on opposite sides. We choose cylindrical Gaussian surface of cross-sectional area A and length 2r with its axis perpendicular to the sheet.

As the lines of force are parallel to the curved surface of the cylinder, the flux through the curved surface is zero. The flux through the plane-end faces of the cylinder is

ϕ_E = EA + EA = 2 EA (A = cross sectional area of plane-end faces)

Charge enclosed by the Gaussian surface,

q = σA

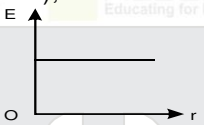
According to Gauss's theorem,

$$\phi_E = \frac{q}{\varepsilon_0} \quad \therefore \quad 2\,EA = \frac{\sigma A}{\varepsilon_0} \text{ or } E = \frac{\sigma}{2\varepsilon_0}$$

Clearly, E is independent of r, the distance from the plane sheet.

(i) If the sheet is positively charged (σ > 0), the field is directed away from it.

(ii) If the sheet is negatively charged (σ > 0), the field is directed towards it.

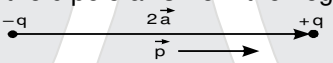


Variation of electric field (E) due to a uniformly charged infinite plane sheet with distance (r)

OR

Dipole moment :

It measures the strength of an electric dipole. The dipole moment of an electric dipole is a vector whose magnitude is the product of magnitude of either charge and the separation between the two opposite charges and the direction is along the dipole axis from the negative to the positive charge.



Dipole moment = Magnitude of either charge × separation distance between charges.

$$\vec{p} = q(2\vec{a})$$

Thus the dipole moment $\vec{p}$ is a vector quantity. Its direction is along the dipole axis from –q to +q

The SI unit of dipole moment is coulomb-metre (Cm)

Force and torque on a dipole in a uniform electric field :

As shown in fig. consider an electric dipole consisting of charges +q and –q and of length 2a placed in a uniform electric field $\vec{E}$ making an angle θ with it. has dipole moment of magnitude,

p = q × 2a

Force exerted on charge +q by field $\vec{F} = q\vec{E}$ (along $\vec{E}$)

Force exerted on charge –q by field $\vec{F} = -q\vec{E}$ (opposite to $\vec{E}$)

$$\vec{F}_{Total} = +q\vec{E} - q\vec{E} = 0$$

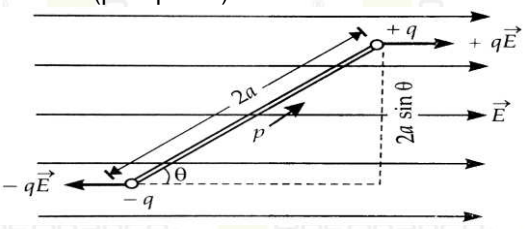
Hence the net translating force on a dipole in a uniform electric field is zero.

But the two equal and opposite forces act at different points of the dipole. They form a couple which exerts torque.

Torque = Either force × Perpendicular distance between the two forces

$\tau = qE \times 2a \sin\theta = (q \times 2a)\, E \sin\theta$

$\tau = pE \sin\theta$ $\quad \therefore \quad$ (p = q × 2a)



Torque on a dipole in a uniform electric field

17. If a metal rod of length ℓ is placed normal to a uniform magnetic field (B) and move with a velocity (v) perpendicular to the magnetic field, the find the induced (motional emf) between its ends. Draw the necessary diagram.

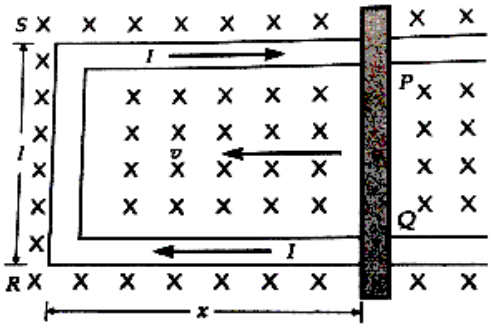
यदि ℓ लंबाई की धात्विक छड़ को एकसमान चुम्बकीय क्षेत्र (B) के लम्बवत् रखकर इसे चुम्बकीय क्षेत्र लम्बवत् (v) वेग से चलाएँ तो इसके सिरों के बीच प्रेरित विद्युत वाहब बल (गतिज विद्युत वाहक बल) ज्ञात कीजिए। आवश्यक चित्र बनाइए।

OR (अथवा)

In an ac generator, a rectangular coil of N turns and cross-section A is rotated in uniform magnetic field (B) with a uniform angular speed w, then find the instantaneous value the induced emf in it. Draw the necessary diagram.

प्रत्यावर्ती धारा जनित्र में N फेरों तथा A अनुप्रस्थ–काट वाली आयताकार कुण्डली को एकसमान चुम्बकीय (B) में एकसमान कोणीय चाल w से घूर्णन कराया जाता है, तो इसमें प्रेरित विद्युत वाहक बल का तात्क्षणिक मान ज्ञात कीजिए। आवश्यक चित्र बनाइए।

Ans. The emf induced across the ends of a conductor due to its motion in a magnetic field is called motional emf consider a conductor PQ of length l free to move on U-shaped conducting rails situated in a uniform and time independent magnetic field B, directed normally into the plane of paper. The conductor PQ is moved inwards with a speed v. As the conductor slides towards left , the area of the rectangular loop PQRS decreases. This decreases the magentic flux linked with the closed loop. Hence an emf is set up across the ends of conductor PQ because of which an induced current flows in the circuit along the path PQRS.



Induced current by changing area of the rectangular loop

Suppose a length x of the loop lies inside the magnetic field at any instant of time t. Then the magnetic flux linked with the rectangular loop PQRS is

$$\phi = BA = B\ell x$$

According to Faraday's law of electromagnetic induction, the induced emf is

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}(B/x) = -B\ell\frac{dx}{dt}$$

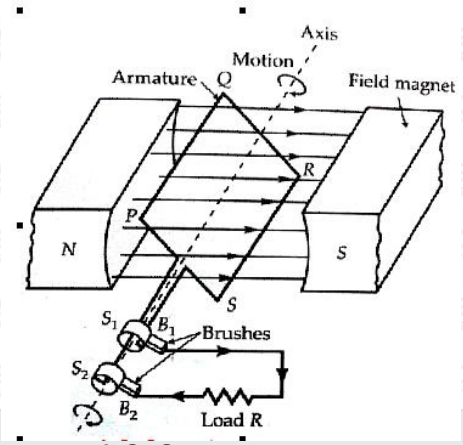
or $\varepsilon = B\ell v$

where dx/dt = - v, because the velocity v is in the decreasing direction of x. The induced emf B/v is called motional emf because this emf is induced due to the motion of a conductor in a magnetic field.

OR

A generator or dynamo is a device which converts mechanical energy into electrical energy.

Principle: The working of an a.c. generator is based on the principle of electromagnetic induction. When a closed coil is rotated in a uniform magnetic field with its axis perpendicular to the magnetic, field, the magnetic flux linked with the coil changes and an induced emf and hence a current is set up in it.



A.C. Generator.

Working: Suppose initially the coil PQRS be in the vertical position and it is rotated in the clockwise direction. The side PQ moves downward and SR moves upward. According to Fleming's right hard rule, the induced current flows from Q to P and from S to R. So during the first half rotation of the coil, the induced current flows in the direction SRQP, with brush B_1 acting as positive terminal and brush B_2 as negative terminal. During the second half - rotation, the side PQ moves upward and SR moves downward. The direction of induced current is reversed, i.e., it flows along PQRS, so that the brush B_2 now functions as the positive terminal and brush B_1 as the negative terminal. Thus the direction of current in the external circuit is reversed after every half cycle.

Expression for induced emf:

Let

N = number of turns in the coil

A = face area of each turn

B = magnitude of the magnetic field

θ = angle which normal to the coil makes with field $\vec{B}$ at any instant t

ω = the angular velocity with which coil rotates. Then the magnetic flux linked with the coil at any instant t will be

$$\phi = NBA\cos\theta = NBA\cos\omega t$$

By Faraday's flux rule, the induced emf is given by

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}(NBA\cos\omega t) = NBA\,\omega\sin\omega t \quad \text{or} \quad \varepsilon = \varepsilon_0\sin\omega t$$

where $\varepsilon_0 = NBA\,\omega$. When a load of resistance R is connected across the terminals, a current I flows in the external circuit.

$$I = \frac{\varepsilon}{R} = \frac{\varepsilon_0\sin\omega t}{R} = I_0\sin\omega t$$

where $I_0 = \frac{\varepsilon_0}{R}$. Both current and voltage vary sinusoidally with time. The power dissipated in the load is supplied by the agent in rotating the coil in the magnetic field.

18. What is meant by mass defect and nuclear binding energy ? Draw a graph between mass number and binding energy per nucleon.

द्रव्यमान क्षति एवं नाभिकीय बंधन ऊर्जा से क्या तात्पर्य है? द्रव्यमान संख्या एवं प्रति न्यूक्लिऑन बंधन ऊर्जा मध्य आरेख बनाइए।

OR (अथवा)

Explain the following in a nuclear reactor based on thermal neutron fission :

(i) The moderator

(ii) The coolant

Draw a block diagram of this reactor.
तापीय न्यूट्रॉन विखण्डन पर आधारित किसी नाभिकीय रिएक्टर में निम्नांकित की व्याख्या कीजिए।
(i) मंदक
(ii) शीतलक
इस रिएक्टर का ब्लॉक आरेख बनाइए।

Ans. Mass defect (Δm):

It is found that the mass of a stable nucleus is always less than the sum of the masses of its constituent protons and neutrons (nucleons) in their free state.

The difference between the sum of the rest masses of its constituent nucleons and the rest mass of a nucleus is called its mass defect.

Consider the nucleus ${}^{A}_{Z}X$. It has Z protons and (A – Z) neutrons. Therefore, its mass defect (Δm) will be

$$\Delta m = Zm_p + (A-Z)\ m_n - m_N$$

Here m_p = mass of each proton

m_N = mass of nucleus

m_n = mass of each neutron

Cause of mass defect :

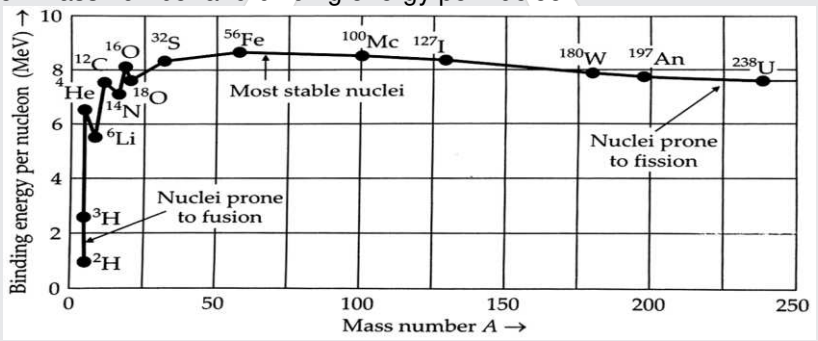
To overcome electrostatic forces of repulsion between protons, energy is required (called binding energy) which is provided by mass defect.

Binding energy :

The binding energy (E_b) of a nucleus may be defined as the energy required to break up a nucleus into its constituent protons and neutrons and to separate them to such a large distance that they may not interact with each other.

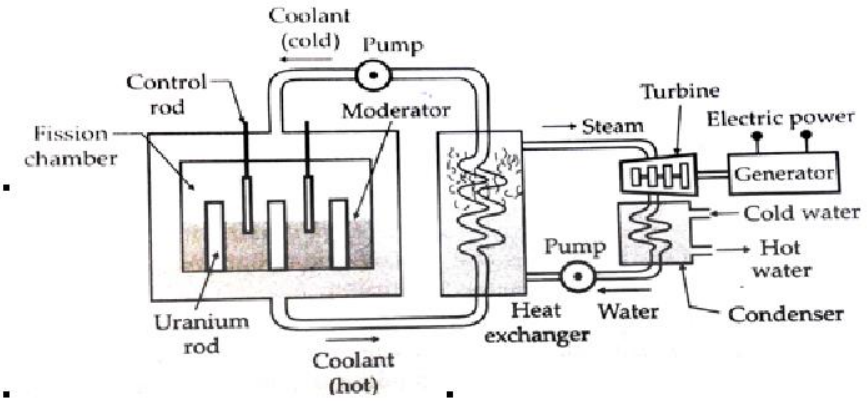
$$E_b = \Delta m \times c^2 = \left[Zm_p + (A-Z)m_n - m_N\right]c^2$$

Graph between mass number and binding energy per nucleon.



OR

Nuclear reactor:



(i) Moderator:
By the use of a moderator, the fast neutrons are slowed to thermal velocities (2200 m/s).
Usually, heavy water (D_2O), graphite, beryllium and beryllium oxide are used as moderators.
(ii) Coolant:
It is the material used to cool the fuel rods and the moderator and is capable of carrying away large amount of heat produced in the fission process.
The coolant must have high boiling point and high specific heat.

SECTION D

खण्ड D

19. What is meant by compound microscope? Draw a ray diagram of the formation of an image by a compound microscope. Briefly describe its working and derive the formula for its total magnification.

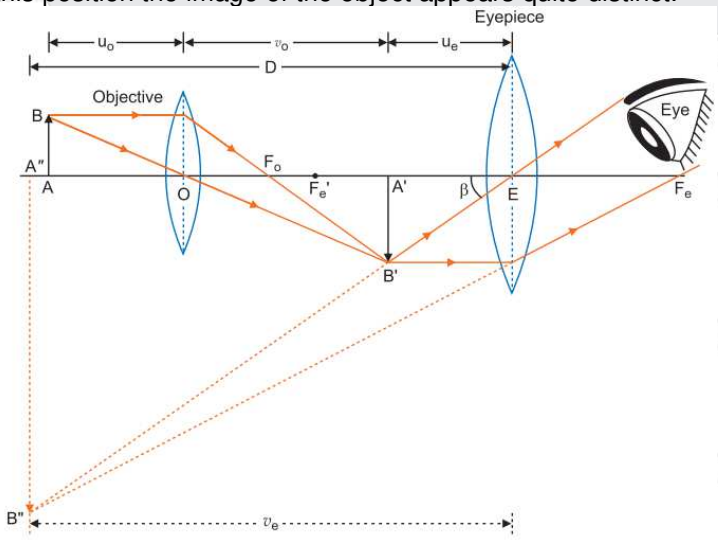
संयुक्त सूक्ष्मदर्शी से क्या तात्पर्य है? संयुक्त सूक्ष्मदर्शी द्वारा प्रतिबिम्ब बनने का किरण आरेख बनाइए। इसकी कार्यप्रणाली का संक्षिप्त में वर्णन कर इसके कुल आवर्धन का सूत्र व्युत्पन्न कीजिए।

OR/अथवा

What is meant by Telescope? Draw a ray diagram of image formation by a refracting telescope. Briefly describe its working and derive the formula for a its magnifying power.

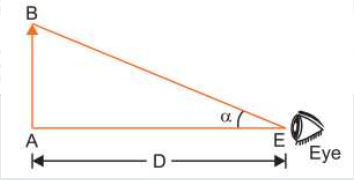
दूरदर्शक से क्या तात्पर्य है? अपवर्ती दूरदर्शक द्वारा प्रतिबिम्ब बनने का किरण आरेख अनाइए। इसकी कार्य प्रणाली का संक्षिप्त में वर्णन कर इसकी आवर्धन क्षमता का सूत्र व्युत्पन्न कीजिए।

Ans. **Compound Microscope:** It consists of a long cylindrical tube, containing at one end a convex lens of small aperture and small focal length. This is called the objective lens *(O)*. At the other end of the tube another co-axial smaller and wide tube is fitted, which carries a convex lens *(E)* at its outer end. This lens is towards the eye and is called the eye-piece. The focal length and aperture of eyepiece are somewhat larger than those of objective lens. Cross-wires are mounted at a definite distance before the eyepiece. The entire tube can be moved forward and backward by the rack and pinion arrangement.
Adjustment: First of all the eyepiece is displaced backward and forward to focus it on cross wires. Now the object is placed just in front of the objective lens and the entire tube is moved by rack and pinion arrangement until there is no parallax between image of object and cross wire. In this position the image of the object appears quite distinct.



Working: Suppose a small object *AB* is placed slightly away from the first focus F_0' of the objective lens. The objective lens forms the real, inverted and magnified image *A′ B′* which acts as an object for eyepiece. The eyepiece is so adjusted that the image *A′ B′* lies between the first focus F_e' and the eyepiece *E*. The eyepiece forms its image *A″ B″* which is virtual, erect and magnified. Thus the final image *A″ B″* formed by the microscope is inverted and magnified and its position is outside the objective and eyepiece towards objective lens.

Magnifying power of a microscope is defined as the ratio of angle (β) subtended by final image on the eye to the angle *(a)* subtended by the object on eye, when the object is placed at the least distance of distinct vision, *i.e.*,



Magnifying power $M = \frac{\beta}{\alpha}$ …(i)

As object is very small, angles a and β are very small and so tan a = a and tan β = β. By definition the object *AB* is placed at the least distance of distinct vision.

$$\alpha = \tan\alpha = \frac{AB}{EA}$$

By sign convention EA = –D, $\therefore\ \alpha = \frac{AB}{-D}$

and from figure $\beta = \tan\beta = \frac{A'B'}{EA'}$

If u_e is distance of image *A′ B′* from eye-piece *E*, then by sign convention, $EA' = -u_e$

and so, $\beta = \frac{A'B'}{(-u_e)}$

Hence magnifying power $M = \frac{\beta}{\alpha} = \frac{A'B'/(-u_e)}{AB/(-D)} = \frac{A'B'}{AB}.\frac{D}{u_e}$

By sign conventions, magnification of objective lens

$$\frac{A'B'}{AB} = \frac{\upsilon_0}{(-u_0)}$$

$$M = -\frac{\upsilon_0}{u_0}.\frac{D}{u_e}$$

Using lens formula $\frac{1}{f} = \frac{1}{\upsilon} - \frac{1}{u}$ for eye-lens, *(i.e.,* using $f = f_e$, v_e , $u = -u_e$*),* we get

$$\frac{1}{f_e} = \frac{1}{-\upsilon_e} - \frac{1}{(-u_e)} \text{ or } \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{u_e}$$

Magnifying power $M = \frac{\upsilon_0}{u_0} D\left(\frac{1}{f_e} + \frac{1}{\upsilon_e}\right)$

or $M = -\frac{\upsilon_0}{u_0}\left(\frac{D}{f_e} + \frac{D}{\upsilon_e}\right)$

When final image is formed at the distance of distinct vision, $v_e = D$

Magnification, $M = -\frac{\upsilon_0}{u_0}\left(1 + \frac{D}{f_e}\right)$

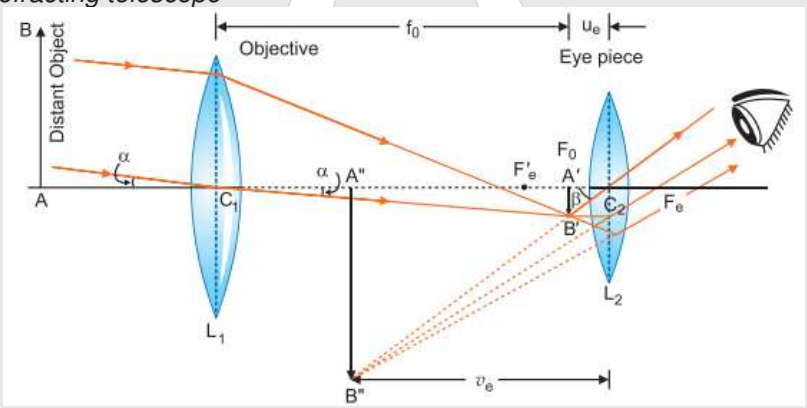
For greater magnification of a compound microscope, f_e should be small. As $f_0 < f_e$, so f_0 is small. Hence, for greater magnification both f_0 and f_e should be small with f_0 to be smaller of the two.

OR

Astronomical (Refracting) Telescope:

Construction: It consists of two co-axial cylindrical tubes, out of which one tube is long and wide, while the other tube is small and narrow. The narrow tube may be moved in and out of the wide tube by rack and pinion arrangement. At one end of wide tube an achromatic convex lens L_1 is placed, which faces the object and is so called ***objective (lens).*** The focal length and aperture of this lens are kept large. The large aperture of objective is taken that it may collect sufficient light to form a bright image of a distant object. The narrow tube is towards eye and carries an achromatic convex lens L_2 of small focal length and small aperture on its outer end. This is called **eye-lens or eyepiece.** The small aperture of eye-lens is taken so that the whole light refracted by it may reach the eye. Cross-wires are fitted at a definite distance from the eye-lens. Due to large focal length of objective lens and small focal length of eye lens, the final image subtends a large angle at the eye and hence the object appears large. The distance between the two lenses may be arranged by displacing narrow tube in or out of wide tube by means of rack and pinion arrangement.

Adjustment: First of all the eyepiece is moved backward and forward in the narrow tube and focused on the cross-wires. Then the objective lens is directed towards the object and narrow tube is displaced in or out of wide tube until the image of object is formed on cross-wires and there is no parallax between the image and cross-wires. In this position a clear image of the object is seen. As the image is formed by refraction of light through both the lenses, this telescope is called the *refracting telescope*



Working: Suppose AB is an object whose end *A* is on the axis of telescope. The objective lens (L_1) forms the image *A′ B′* of the object *AB* at its second principal focus F_0 This image is real, inverted and diminished. This image *A′ B′* acts as an object for the eye-piece L_2 and lies between first focus *F*

e and optical centre C_2 of lens L_2. Therefore eye-piece forms its image *A′ ′ B′ ′* which is virtual, erect and magnified.

Thus the final image *A″ B″* of object *AB* formed by the telescope is magnified, inverted and lies between objective and eyepiece.

Magnifying Power: The magnifying power of a telescope is measured by the ratio of angle (β) subtended by final image on the eye to the angle (a) subtended by object on the eye, *i.e.*,

$$\text{Magnifying power } M = \frac{\beta}{\alpha}$$

As a and β are very small angles, therefore, from figure.

The angle subtended by final image *A″ B″* on eye

β = angle subtended by image *A′ B′* on eye

$$\tan\beta = \frac{A'B'}{C_2A'}$$

As the object is very far (at infinity) from the telescope, the angle subtended by object at eye is same as the angle subtended by object on objective lens.

$$\alpha = \tan\alpha = \frac{A'B'}{C_1A'}$$

$$M = \frac{\beta}{\alpha} = \frac{A'B'/C_2A'}{A'B'/C_1A'} = \frac{C_1A'}{C_2A'}$$

If the focal lengths of objective and eye-piece be f_o, and f_e , distance of image A' B' from eye-piece be u_e, then by sign convention

$$C_1A' = +f_0,\ C_2A' = -u_e \ ;\ M = -\frac{f_0}{u_e}$$

20. What is meant by forward bias and reverse bias of p-n junction diode? Draw an experimental electric circuit diagram to study the V-I characteristics in the forward bias and reverse bias of a p-n junction diode. Draw forward & reverse bias V-I characteristics curves for p-n junction diode and explain the following in brief :

(i) Threshold or cut in voltage (ii) Breakdown voltage

p-n संधि डायोड के अग्रदिशिक बायस एवं पश्चदिशिक बायस से क्या तात्पर्य है? p-n संधि डायोड के अग्रदिशिक बायस एवं पश्चदिशिक बायस में V-I अभिलाक्षणिक के अध्ययन क लिए प्रायोगिक विद्युत परिपथ आरेख बनाइए। p-n संधि डायोड के अग्रदिशिक बायस एवं पश्चदिशिक बायस V-I अभिलाक्षणिक वक्र बनाइए और निम्न की संक्षिप्त कीजिए :

(i) देहली या कट इन वोल्टता (ii) भंजन वोल्टता

OR / अथवा

What is meant by rectification? Draw an electric circuit diagram of a half wave rectifier. Write a brief description of its working. Draw input and output voltage waveforms for this rectifier circuit.

दिष्टकरण से क्या तात्पर्य है? अर्द्धतरंग दिष्टकारी विद्युत परिपथ का चित्र बनाइए। इसकी कार्यप्रणली का संक्षिप्त विवरण लिखिए। इस दिष्टकारी परिपथ के लिए निवेशी वोल्टता तथा निर्गता वोल्टता के तरंगरूप का चित्र बनाइए।

Ans. Forward Biasing

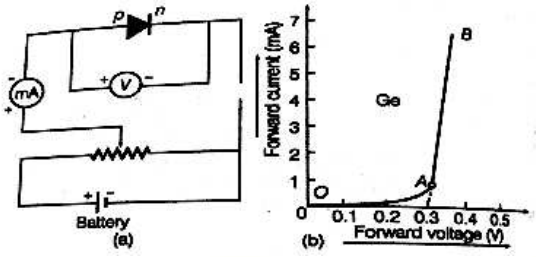
A junction diode is said to be forward biased when the positive terminal of the external battery is connected to the p - side and negative terminal to the n - side of the diode.

Flow if Current in Forward Biasing

Reverse Biasing

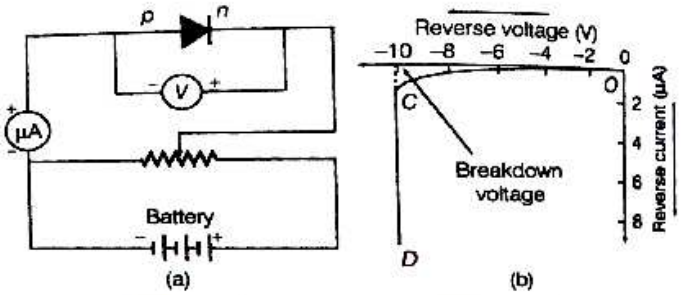
A junction diode is said to be reverse biased when the positive terminal of the external battery is connected to the n - side and negative terminal to the p - side of the diode.

Forward Biased Characteristics



Forward biased characteristic of a diode

Reverse Biased Characteristics



Reverse biased characteristic of a diode

(i) Threshold voltage is the voltage above which current increases very rapidly with applied voltage. Beyond threshold voltage, the resistance offered by the potential barrier is overcome by forward bias voltage, therefore, it is easy for charge carriers to cross the barrier.

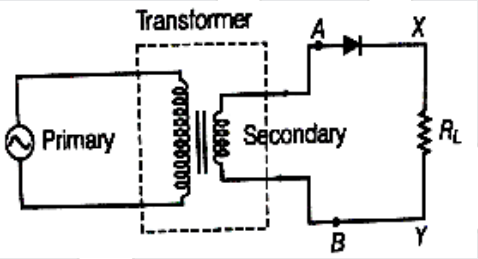
(ii) Breakdown voltage of a zener-diode is the reverse-bias voltage across the diode at which current (from n-side to p-side) suddenly increases across it. This phenomenon results in a practically constant voltage equal to the breakdown voltage across zener-diode.

OR

The process of converting alternating voltage / current into direct voltage / current is called rectification.

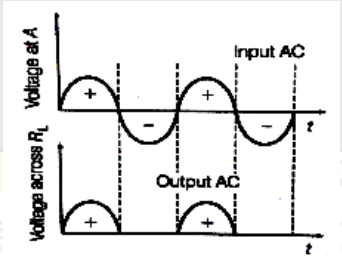
Diode as a Half - Wave Rectifier

In this, the AC voltage to be rectified is connected to the primary coil of a step - down transformer and secondary coil is connected to the diode through resistor R_L across which , output is obtained.



Circuit diagram of half - wave rectifier

Working



During positive half cycle of the input AC, the p - n junction is forward biased. Thus, the resistance in p - n junction becomes low and current flows. hence, we get output in the load. During negative half cycle of the input AC, the p - n junction is reverse biased. Thus, the resistance of p - n junction is high and current does not flow. Hence, no output is in the load.