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# CBSE

## CENTRAL BOARD SECONDARY EXAMINATION

## 2023

## CLASS XII

# Questions & Solutions

**Date: 06 March 2023 | TIME : (10:30 a.m. to 01:30 p.m)**

**Duration: 3 hr | Max. Marks: 70**

## SUBJECT: PHYSICS (Theory)


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प्रश्न पत्र कोड **SET-3**

Series HFG1E/2

Code No. **56/2/3**

Roll No. | | | | | | | |

परिक्षार्थी प्रश्न – पत्र कोड को उत्तर पुस्तिका के मुख – पृष्ठ पर अवश्य लिखे।
Candidates must write the Q.P. Code on the title page of the answer-book

# PHYSICS (Theory)

# भौतिक विज्ञान ( सैद्धान्तिक )

**निर्धारित समय : 3 घण्टे** **अधिकतम अंक : 70**

**Time allowed : 3 Hours** **Maximum Marks : 70**

**Note :**

(i) Please check that this question paper contains 23 printed pages.
कृपया जॉच कर ले कि इस प्रश्न –पत्र मे मुद्रित पृष्ठ 23 है।

(ii) Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
प्रश्न पत्र मे दाहिने हाथ की ओर दिए गए प्रश्न–पत्र कोड को परीक्षार्थी उत्तर पुस्तिका के मुख–पृष्ठ पर लिखे।

(iii) Please check that this question paper contains 35 questions.
कृपया जॉच कर ले कि इस प्रश्न– पत्र मे 35 प्रश्न है।

(iv) Please write down the serial number of the question in the answer book before attempting it.
कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर–पुस्तिका मे प्रश्न का क्रमांक अवश्य लिखे।

(v) 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.
इस प्रश्न–पत्र को पढने के लिए 15 मिनट का समय दिया गया है। प्रश्न–पत्र का वितरण पूर्वाह्न मे 10.15 बजे किया जाएगा। 10.15 बजे से 10.30 बजे तक परीक्षार्थी केवल प्रश्न–पत्र को पढ़ेगे और इस अवधि के दौरान वे उत्तर नही लिखेंगे।

**General Instructions :**

Read the following instructions very carefully and follow them :

(i) This question paper contains 35 questions. All questions are compulsory.

(ii) Question paper is divided into FIVE sections - Section A, B, C, D and E.

(iii) In Section A : Question number 1 to 18 are Multiple Choice (MCQ) type questions carrying 1mark each.

(iv) In Section B : Question number 19 to 25 are Short Answer-I (SA-I) type. questions carrying 2 marks each.

(v) In Section C : Question number 26 to 30 are Short Answer-2 (SA-2) type questions carrying 3 marks each.

(vi) In Section D : Question number 31 to 33 are Long Answer (LA) type questions carrying 5 marks each.

(vii) In Section E : Question number 34 and 35 are Case-Based questions carrying 4 marks each.

(viii) There is no overall choice. 'However, an internal choice has been provided in 2 questions in Section-B, 2 questions in Section-C, 3 questions in Section-D and 2 questions in Section-E.

(ix) Use of calculators is NOT allowed.

$C = 3 \times 10^8$ m/s

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

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

$\mu_0 = 4\pi \times 10^{-7}$ T m $A^{-1}$

$\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2$ $N^{-1}$ $m^{-2}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N $m^2$ $C^{-2}$

Mass of electron $= (m_e) = 9.31 \times 10^{-31}$ kg

Mass of neutron $= 1.675 \times 10^{-27}$ kg

Mass of proton $= 1.673 \times 10^{-27}$ kg

Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1.38 \times 10^{-23}$ $JK^{-1}$

**सामान्य निर्देश :**

निम्नलिखित निर्देशों को बहुत सावधानी से पढ़िए और उनका पालन कीजिए :

(i) इस प्रश्न पत्र में 35 प्रश्न हैं। सभी प्रश्न अनिवार्य हैं ।

(ii) प्रश्न पत्र पाँच खण्डों में विभाजित है – खण्ड– क, ख, ग, घ तथा ङ ।

(iii) खण्ड–क में प्रश्न संख्या 1 से 18 तक बहुविकल्पीय प्रकार के एक–एक अंक के प्रश्न हैं।

(iv) खण्ड – ख में प्रश्न संख्या 19 से 25 तक लघु उत्तरीय प्रकार–1 के दो–दो अंकों के प्रश्न हैं ।

(v) खण्ड – ग में प्रश्न संख्या 26 से 30 तक लघु उत्तरीय प्रकार–2 के तीन–तीन अंकों के प्रश्न हैं।

(vi) खण्ड – घ में प्रश्न संख्या 31 से 33 तक दीर्घ उत्तरीय प्रकार के पाँच–पाँच अंकों के प्रश्न हैं ।

(vii) खण्ड – ङ में प्रश्न संख्या 34 तथा 35 केस आधारित चार–चार अंकों के प्रश्न हैं।

(viii) प्रश्न–पत्र में समग्र विकल्प नहीं दिया गया है। यद्यपि, खण्ड–ख के 2 प्रश्नों में, खण्ड–ग के 2 प्रश्नों में, खण्ड – घ के 3 प्रश्नों में तथा खण्ड–ङ के 2 प्रश्नों में आंतरिक विकल्प का प्रावधान दिया गया है।

(ix) कैल्कुलेटर का उपयोग वर्जित है ।

$C = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ T m $A^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2$ $N^{-1}$ $m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N $m^2$ $N^{-1}$ $m^{-2}$ $C^{-2}$
इलेक्ट्रन का द्रव्यमान = $(m_e) = 3.41 \times 10^{-31}$ kg
न्यूट्रन का द्रव्यमान = $1.675 \times 10^{-27}$ kg
प्रोटॉन का द्रव्यमान = $1.673 \times 10^{-27}$ kg
आवोगाद्रो संख्या = $6.023 \times 10^{23}$ प्रति ग्राम मोल
बोल्ट्जमान नियतांक = $1.38 \times 10^{-23}$ $JK^{-1}$

## SECTION - A / खण्ड –क

**1.** A long straight wire of radius 'a' carries a steady current 'I'. The current is uniformly distributed across its area of cross-section. The ratio of magnitude of magnetic field $\vec{B}_1$ at $\frac{a}{2}$ and $\vec{B}_2$ at distance 2a is **1**
त्रिज्या 'a' के किसी सीधे लम्बे तार से कोई स्थायी धारा 'I' प्रवाहित हो रही है। इसकी अनुप्रस्थ– काट के क्षेत्रफल पर धारा एकसमान वितरित है । दूरी $\frac{a}{2}$ पर चुम्बकीय क्षेत्र $\vec{B}_1$ और दूरी 2a पर चुम्बकीय क्षेत्र $\vec{B}_2$ का अनुपात है

(a) $\frac{1}{2}$ (b) 1 (c) 2 (d) (4)

**Ans.** (b)

**Sol.** $B_{inside} = \frac{\mu_0 Ir}{2\pi R^2}$

$B_1 = \frac{\mu_0 Ia/2}{2\pi a^2} = \frac{\mu_0 Ia}{4\pi a^2} = \frac{\mu_0 I}{4\pi a}$

$B_{inside} = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi(2a)}$

$B_2 = \frac{\mu_0 I}{4\pi a}$

$\frac{B_1}{B_2} = 1$

**2.** The energy of a photon of wavelength 663 nm is **1**
किसी फोटॉन, जिसकी तरंगदैर्ध्य 663 nm है, की ऊर्जा होती है

(a) $6.64 \times 10^{-20}$ J (b) $5.18 \times 10^{-19}$ J (c) $3.0 \times 10^{-19}$ J (d) $2.0 \times 10^{-20}$ J

**Ans.** (c)

**Sol.** $E = \frac{hc}{\lambda} = \frac{1240 \text{ ev} - \text{nm}}{663\text{nm}}$

$= \frac{1240 \times 1.6 \times 10^{-19}}{663}$ J

$= 2.99 \times 10^{-19}$ J
$\simeq 3 \times 10^{-19}$ J

**3.** An electromagnetic wave is produced by a charge **1**
(a) moving with a constant velocity
(b) moving with a constant speed parallel to a magnetic field
(c) moving with an acceleration
(d) at rest
विद्युतचुम्बकीय तरंग किसके द्वारा उत्पन्न की जा सकती है ?
(a) नियत वेग से गतिमान किसी आवेश द्वारा
(b) चुम्बकीय क्षेत्र के समान्तर नियत चाल से गतिमान किसी आवेश द्वारा
(c) त्वरण से गतिमान किसी आवेश द्वारा
(d) विरामावस्था पर आवेश द्वारा
**Ans.** (c) moving with an acceleration

**4.** A semiconductor device is connected in series with a battery, an ammeter and a resistor. A current flow in the circuit. If the polarity of the battery is reversed, the current in the circuit almost becomes zero. The device is a/an **1**
(a) intrinsic semiconductor (b) p-type semiconductor
(c) n-type semiconductor (d) p-n junction diode
कोई अर्धचालक युक्ति श्रेणी में किसी बैटरी, अमीटर और प्रतिरोधक से संयोजित है । इस परिपथ में कोई धारा प्रवाहित हो रही है । यदि बैटरी की ध्रुवता उत्क्रमित कर दी जाए तो परिपथ में धारा लगभग शून्य हो जाती है यह अर्धचालक युक्ति है
(a) नैज अर्धचालक (b) p – प्रकार का अर्धचालक
(c) n – प्रकार का अर्धचालक (d) p–n संधि डायोड
**Ans.** (d) p-n junction diode

**5.** The formation of depletion region in a p-n junction diode is due to **1**
(a) movement of dopant atoms (b) diffusion of both electrons and holes
(c) drift of electrons only (d) drift of holes only
किसी p-n संधि डायोड में ह्रासी क्षेत्र निर्मित होने का कारण है.
(a) मादक परमाणुओं की गति (b) इलेक्ट्रनों और विवरों दोनों का विसरण
(c) केवल इलेक्ट्रनों का अपवाह (d) केवल विवरों का अपवाह
**Ans.** (b) diffusion of both electrons and holes

**6.** The radius of $^{27}_{13}X$ nucleus is R. the radius of $^{125}_{53}Y$ nucleus will be **1**

नाभिक $^{27}_{13}X$ की त्रिज्या R है । नाभिक $^{125}_{53}Y$ की त्रिज्या होगी

(a) $\frac{5}{3}R$ (b) $\left(\frac{13}{53}\right)^{1/3}R$ (c) $\left(\frac{5}{3}R\right)1^{/3}$ (d) $\left(\frac{13}{53}R\right)^{1/3}$

**Ans.** (a)
**Sol.** $R = R_0 A^{1/3}$

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

$$\frac{R}{R_2} = \left(\frac{27}{125}\right)^{1/3}$$

$$\frac{R}{R_2} = \frac{3}{5}$$

$$R_2 = \frac{5}{3}R \text{ (a)}$$

**7.** An electric dipole of dipole moment 2 x $10^{-8}$ C-m in a uniform electric field experiences a maximum torque of 6 x $10^{-4}$ N-m. The magnitude of electric field is **1**

कोई विद्युत द्विध्रुव जिसका द्विध्रुव आघूर्ण 2 ×$10^{-8}$ C-m है किसी एकसमान विद्युत क्षेत्र में 6×$10^{-4}$ N-m के अधिकतम बल–आघूर्ण का अनुभव करता है। इस विद्युत क्षेत्र का परिमाण है–

(a) 2.2 x $10^{3}$Vm$^{-1}$ (b) 1.2 x $10^{4}$Vm$^{-1}$ (c) 3.0 x $10^{4}$ Vm$^{-1}$ (d) 4-2 x $10^{3}$Vm$^{-1}$

**Ans.** (c)

**Sol.** We know that

$\tau = P\,E \sin\theta$ (for maximum torque, sin 90 = 1)

$6 \times 10^{-4} = 2 \times 10^{-8} \times E$

$$E = \frac{6\times10^{-4}}{2\times10^{-8}}$$

$E = 3 \times 10^{4}$ V/m

**8.** In an extrinsic semiconductor, the number density of holes is 4 x $10^{20}$ m$^{-3}$.If the number density of intrinsic carriers is 1.2 x $10^{15}$ m$^{-3}$, the number density of electrons in it is **1**

किसी अपद्रव्यी अर्धचालक में विवरों का संख्या घनत्व 4 ×$10^{20}$ m$^{-3}$ है। यदि नैज वाहकों का संख्या घनत्व 1.2×$10^{15}$ m$^{-3}$ है, तो इसमें इलेक्ट्रनों का संख्या घनत्व है

(a) 1.8 x $10^{9}$ m$^{-3}$ (b) 2.4 X $10^{10}$ m$^{-3}$ (c) 3.6 x I0$^{9}$ m$^{-3}$ (d) 3.2 x $10^{10}$ m$^{-3}$

**Ans.** (c)

**Sol.** For mass action law

$n_i^2 = n_e \times n_h$

$$n_e = \frac{n_i^2}{n_h} = \frac{(1.2\times10^{15})^2}{4\times10^{20}}$$

$$= \frac{1.44}{4}\times10^{30-20}$$

$= 0.36 \times 10^{10}$

$= 3.6 \times 10^{9}$ m$^{-3}$

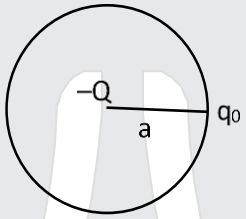
**9.** A point charge $q_0$ is moving along a circular path of radius a, with a point charge – Q at the centre of the circle. The kinetic energy of $q_0$ is **1**

कोई बिन्दु आवेश $q_0$ त्रिज्या a के वृत्ताकार पथ के अनुदिश गतिमान है । इस वृत्त के केन्द्र पर कोई बिन्दु आवेश –Q स्थित है। आवेश $q_0$ की गतिज ऊर्जा है।

(a) $\frac{q_0 Q}{4\pi\varepsilon_0 a}$ (b) $\frac{q_0 Q}{8\pi\varepsilon_0 a}$ (c) $\frac{q_0 Q}{4\pi\varepsilon_0 a^2}$ (d) $\frac{q_0 Q}{8\pi\varepsilon_0 a^2}$

**Ans.** (b)

**Sol.**




$$K.E. = \frac{1}{2}mv^2$$

$$\because Fc = Fe$$

$$\frac{mv^2}{a} = \frac{KQq_0}{a^2}$$

$$\therefore K.E. = \frac{KQq_0}{2a}$$

$$K.E. = \frac{Qq_0}{8\pi\varepsilon_0 a}$$

**10.** The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium nucleus is **1**

(a) radioactive (b) unstable

(c) easily fissionable (d) more stable nucleus than its neighbours

बंधन ऊर्जा प्रति न्यूक्लिअन को द्रव्यमान संख्या का फलन मानकर खींचे गए वक्र पर हीलियम नाभिक के लिए तीक्ष्ण शिखर है। इससे यह ध्वनित होता है कि हीलियम नाभिक

(a) रेडियोएक्टिव है । (b) अस्थायी है।

(c) सरलता से विखण्डनीय है । (d) अपने निकट के नाभिक से अधिक स्थायी है।

**Ans.** (d) more stable nucleus than its neighbours

**11.** The current in a device varies with time t as I = 6t . where I is in mA and t is in s. The amount of charge that passes through the device during t = 0s to t = 3s is **1**
किसी युक्ति में प्रवाहित धारा का विचरण समय t के साथ I = 6t के रूप में हो रहा है, यहाँ धारा I को mA तथा समय t को सेकण्ड (s) में व्यक्त किया गया है। t = 0s से t = 3s की अवधि में इस युक्ति से प्रवाहित आवेश की मात्रा है–
(a) 10 mC (b) 18mC (c) 27 mC (d) 54mC

**Ans.** (c)

**Sol.** $I = \frac{dq}{dt}$

$\int dq = \int I dt \quad \because I = 6t$

$q = \int_0^3 6t dt \Rightarrow 6\left[\frac{t^2}{2}\right]_0^3 = \frac{6}{2}\left[(3)^2 - (0)^2\right]$

$= 3[9] = 27$ mC

**12.** A ray of light travels a distance of 12.0 m in a transparent sheet in 60 ns. The refractive index of the sheet is **1**
कोई प्रकाश किरण किसी पारदर्शी शीट में 12.0m दूरी को 60 ns में तय करती है । इस शीट का अपवर्तनांक है–
(a) 1.33 (b) 1.50 (c) 1.65 (d) 1.75

**Ans.** (b) 1.50

**Sol.** $\mu = \frac{c}{v} \quad \because v = \frac{\text{district}}{\text{time}} = \frac{12}{60\times10^{-9}} = 2 \times 10^8$ m/s

$= \frac{3\times10^8}{2\times10^8}$

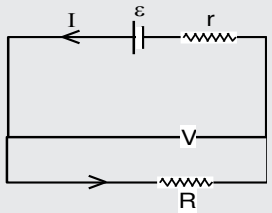
$= 1.5$

**13.** A cell of emf E is connected across an external resistance R. When current I is drawn from the cell, the potential difference across the electrodes of the cell drops to V. The internal resistance 'r' of the cell is
किसी बाह्य प्रतिरोध R के सिरों से emf E का कोई सेल संयोजित है। जब सेल से धारा I ली जाती है तो सेल के इलेक्ट्रोडों के बीच विभवान्तर घटकर V हो जाता है। सेल का आन्तरिक प्रतिरोध 'r' है **1**

(a) $\left(\frac{E-V}{E}\right)R$ (b) $\left(\frac{E-V}{R}\right)$ (c) $\frac{(E-V)R}{I}$ (d) $\left(\frac{E-V}{V}\right)R$

**Ans.** (c)

**Sol.**




$I = \frac{E}{R+r}$

$IR + Ir = E$

$V + Ir = E \quad \because V = IR$

$r = \frac{E-V}{I} \quad \because I = \frac{V}{R}$

$r = \frac{(E-V)}{V}R$

**14.** A ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the, same for the reflected and refracted rays ? **1**

(a) Energy carried (b) Speed (c) Frequency (d) Wavelength

वायु में संचरण करती एकवर्णी प्रकाश की कोई किरण जल के पृष्ठ पर आपतन कर रही है। निम्नलिखित में से कौन परावर्तित और अपवर्तित किरणों के लिए समान होगा ?

(a) वहन की गयी ऊर्जा (b) चाल (c) आवृत्ति (d) तरंगदैर्ध्य

**Ans.** (c) Frequency

**15.** Beams of electrons and protons move parallel to each other in the same direction. They **1**

(a) attract each other.

(b) repel each other.

(c) neither attract nor repel.

(d) force of attraction or repulsion depends upon speed of beams.

इलेक्ट्रनों और प्रोटनों के पुंज समान दिशा में एक दूसरे के समान्तर गतिमान हैं। इन दोनों के बीच

(a) आकर्षण बल होगा ।

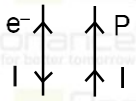
(b) प्रतिकर्षण बल होगा ।

(c) न तो आकर्षण बल होगा और न ही प्रतिकर्षण बल होगा ।

(d) आकर्षण अथवा प्रतिकर्षण बल पुंजों की चाल पर निर्भर करता है ।

**Ans.** (b)

**Sol.**




Here , current in opposite direction so Repel each other.

**Note**: In question number 16 to 18 two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R).** Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

**नोट :** प्रश्न संख्या 16 से 18 में दो कथन दिए गए हैं – एक को अभिकथन (A) तथा दूसरे को कारण (R) लेबल किया गया है इन प्रश्नों के सही उत्तरों का नीचे दिए कोड (a), (b) ,(c) और (d) में से चयन कीजिए

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(b) Both Assertion (A) and Reason (R) are true and Reason (R) is NOT the correct explanation of Assertion (A).

(c) Assertion (A) is true and Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false

**16.** **Assertion (A) :** In Young's double slit experiment all fringes are of equal width. **1**
**Reason (R) :** The fringe width depends upon wavelength of light ($\lambda$) used, distance of screen from plane of slits (D) and slits separation (d).
**अभिकथन (A)** : यंग के द्विझिरी प्रयोग में सभी फ्रिन्जों की चौड़ाई समान होती है।
**कारण (R) :** फ्रिंज चौड़ाई उपयोग किए गए प्रकाश की तरंगदैर्ध्य ($\lambda$) पर्दे की झिरियों के तल से दूरी (D) और झिरियों के पृथकन (d) पर निर्भर करती है।

**Ans.** (A)

**Sol.**

$$\beta = \frac{\lambda D}{d}$$

$\lambda \rightarrow$ wavelength
$D \rightarrow$ Distance b /w screen and slit
$d \rightarrow$ Distance b /w slits
So correct option is A.

**17.** **Assertion (A) :** Diamagnetic substances exhibit magnetism. **1**
**Reason (R) :** Diamagnetic materials do not have permanent magnetic dipole moment
**अभिकथन (A) :** प्रतिचुम्बकीय पदार्थ चुम्बकत्व दर्शाते हैं ।
**कारण (R):** प्रतिचुम्बकीय पदार्थों में स्थायी चुम्बकीय द्विध्रुव आघूर्ण नहीं होता है ।

**Ans.** (D)

**18.** **Assertion (A) :** Work done in moving a charge around a closed path, in an electric field is always zero.
**Reason (R) :** Electrostatic force is a conservative force **1**
**अभिकथन (A) :** किसी विद्युत क्षेत्र में किसी बन्द पथ के चारों ओर किसी आवेश को गमन कराने में किया गया कार्य शून्य होता है।
**कारण (R) :** स्थिरविद्युत बल संरक्षी बल होता है।

**Ans.** (A)

## SECTION - B/ खण्ड – ख

**19.** What happens to the interference pattern when two coherent sources are **2**
(a) infinitely close, and
(b) far apart from each other
व्यतिकरण पैटर्न का क्या होता है जब दो कलासंबद्ध स्त्रोत
(a) अनन्ततः निकट, और
(b) एक दूसरे से काफी दूरी पर हैं ?

**Sol.** $\because \beta = \frac{\lambda D}{d}$,

(a) When d is small, $\beta$ will be larger. Even a single fringe may occupy the whole screen. Hence the pattern cannot be Detected.

(b) If the sources are far apart, d is large so frindge width ($\beta$) will be small that the fringes are not resolved and they do not appear separate. that is why interterence pattern is not Detected for large separation of coherent sources.

**20.** (a) What is meant by ionisation energy ? Write its value for hydrogen atom ? **2**

**OR**

(b) Define the term, mass defect. How is it related to stability of the nucleus?

(a) आयनन ऊर्जा से क्या तात्पर्य है ? हाइड्रोजन परमाणु के लिए इसका मान लिखें।

**अथवा**

(b) द्रव्यमान क्षति की परिभाषा लिखिए। नाभिक के स्थायित्व से यह किस प्रकार संबंधित है ?

**Sol.** **(a) Ionisation Energy :** The amount of energy required to knock out an electron from outer most orbit of an atom is known is ionisation energy

The ionisation energy is equal to energy required to take an electron form ground state to infinite state.

The ionisation energy for H-atom is

$E = E_\infty - E_1$

$E = 0 - (-13.6) = 13.6$ eV

**OR**

**(b) Mass defect :-** 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 ($\Delta m$) will be:

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

Here $m_p$ = mass of each proton

$m_N$ = mass of nucleus

$m_n$ = mass of each neutron

**Cause of mass defect:**

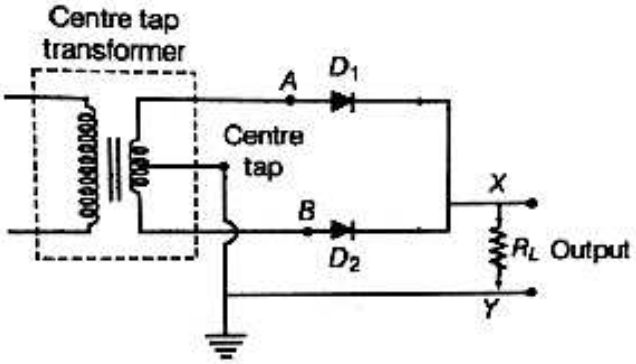
To overcome electrostatic forces of repulsion between protons, energy is required (called binding energy) which is provided by mass defect.

**21.** With the help of a circuit diagrams, explain how a full wave rectifier gives output rectified voltage corresponding to both halves of the input ac voltage. **2**

परिपथ आरेख की सहायता से व्याख्या कीजिए कि कोई पूर्ण तरंग दिष्टकारी किस प्रकार किसी निवेशी ac वोल्टता के दोनों अर्धो के तदनुरूप निर्गत दिष्टकारी वोल्टता देता है ।

**Sol.** **Diode as a Full Wave Rectifier**

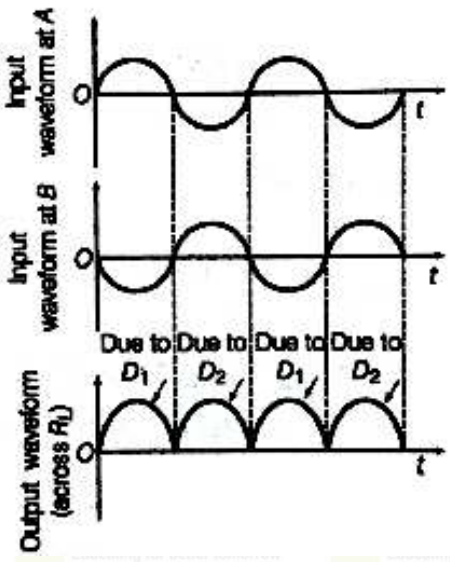
In the full wave rectifier, two p - n junction diodes, $D_1$ and $D_2$ are used. This arrangement is shown in the diagram below.




Circuit diagram of full wave rectifier

**Working**

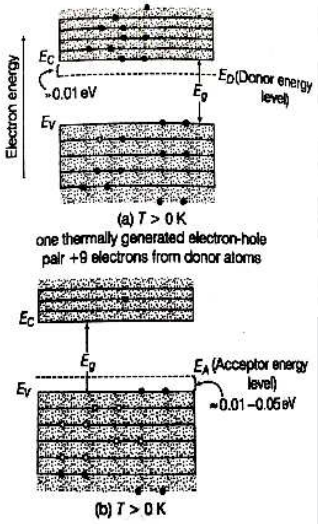
During the positive half cycle of the input AC, the diode $D_1$ is forward biased and the diode $D_2$ is reverse biased. The forward current flows through diode $D_1$. During the negative half cycle of the input AC, the diode $D_1$ is reverse biased and diode $D_2$ is forward biased. Hence, current flows through diode $D_2$. Hence, we find that during both the halves, current flows in the same direction.




Input and output waveforms

**22.** Draw energy band diagram for an n-type and p-type semiconductor at T> 0K **2**
T> 0K के लिए किसी n प्रकार और p–प्रकार के अर्धचालकों के लिए ऊर्जा बैण्ड आरेख खींचिए ।

**Sol.** Energy band diagram for an n-type and p-type semiconductor at T> 0K




Energy band of (a) n - type semiconductor at T > 0 K, (b) p - type semiconductor at T > 0 K

**23.** The power of a thin lens is +5 D. When it is immersed in a liquid, it behaves like a concave lens of focal length 100 cm. Calculate the refractive index of the liquid. 'Given refractive index of glass = 1.5.
किसी पतले लेंस की क्षमता + 5 D है। जब इस लेंस को किसी द्रव में डुबोया जाता है तो यह 100 cm फोकस दूरी के अवतल लेंस की भाँति व्यवहार करता है । इस द्रव का अपवर्तनांक परिकलित कीजिए । दिया है – काँच का अपवर्तनांक 1.5 है।

**Sol.** P = +5D

$$\frac{100}{f} = 5 \text{ or } f = 20\text{cm}$$

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

$$\frac{1}{20} = (1.5\text{-}1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{R_1} - \frac{1}{R_2} = \frac{1}{10}$$

when immersed in liquid f = –100cm

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

$$-\frac{1}{100} = \left(\frac{1.5}{\mu} - 1\right) \times \frac{1}{10}$$

$$-\frac{1}{10} = \frac{1.5}{\mu} - 1$$

$$\frac{1.5}{\mu} = 1 - \frac{1}{10}$$

$$\frac{1.5}{\mu} = \frac{9}{10} \quad \Rightarrow \quad \mu = \frac{15}{9} = 1.666$$

$\mu = 1.67$

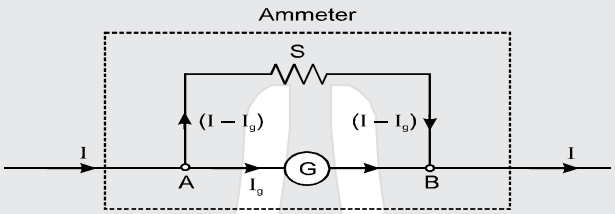
**24.** Briefly explain why and how a galvanometer is converted into an ammeter. **2**

संक्षेप में व्याख्या कीजिए कि किसी गैल्वैनोमीटर को अमीटर में क्यों और किस प्रकार परिवर्तित किया जाता है।

**Sol.** **Conversion of a galvanometer into an ammeter :**

An ordinary galvanometer gives full scale deflection with a small current of few microamperes. To measure large currents with it, a small resistance is connected in parallel with the galvanometer coil. The resistance connected in this way is called a **shunt.**

When a small resistance shunt is connected in parallel, only a small part of the total current passes through the galvanometer and remaining current passes through the shunt.




Let

G = resistance of the galvanometer

$I_g$ = the current with which galvanometer gives full scale deflection.

0 to $I$ = the required current range of the ammeter

S = shunt resistance

$I - I_g$ = current through the shunt

As galvanometer and shunt are connected in parallel, so

P.D. across the galvanometer = P.D. across the shunt

$$I_g G = (I - I_g)S$$

or $$\boxed{S = \frac{I_g}{I - I} \times G}$$

So by connecting a shunt of resistance S across the given galvanometer, we get an ammeter of desired range. Moreover,

$$\boxed{I_g = \frac{S}{G + S} \times I}$$

The deflection in the galvanometer is proportional to $I_g$ and hence to $I$. So the scale can be graduated to read the value of current $I$ directly.

Hence an ammeter is a shunted (or low resistance) galvanometer. Its effective resistance is :

$$\boxed{R_A = \frac{GS}{G + S}} \qquad (R_A > S)$$

**25.** (a) How are infrared waves produced? Why are these waves referred to as heat waves? Give any two uses of infrared waves. **2**

**OR**

(b) How are X-rays produced? Give any two uses of these.

(a) अवरक्त तरंगें किस प्रकार उत्पन्न होती हैं ? इन तरंगों को ऊष्मीय तरंगें क्यों कहा जाता है ? अवरक्त तरंगों के कोई दो उपयोग लिखिए ।

**अथवा**

(b) X–किरणें किस प्रकार उत्पन्न होती हैं ? इन किरणों के कोई दो उपयोग लिखिए ।

**Sol.** (a) Infrared waves produced by vibration of atoms and molecules,
they are readily absorbed by water molecules iin most materials which increase their thermal motion so they heat up the material.
Uses : (i) For therapeutic purpose.
(ii) For long distance photography

**OR**

(b) X- ray produced by bombarding a target of high atomic number with a beam of fast moving electrons.
Uses : - (i) They are used as diagnostic tool in medicine.
(ii) they are used in radio therapy.

## SECTION - C/ खण्ड –ग

**26.** A ray of light is refracted by a glass prism. Obtain an expression for the refractive index of the glass in terms of the angle of prism A and the angle of minimum deviation $\delta_m$. **3**

किसी काँच के प्रिज्म द्वारा किसी प्रकाश किरण को अपवर्तित किया गया है। प्रिज्म कोण A तथा न्यूनतम विचलन कोण $\delta_m$ के पदों में काँच के अपवर्तनांक के लिए व्यंजक प्राप्त कीजिए ।

**Sol.**

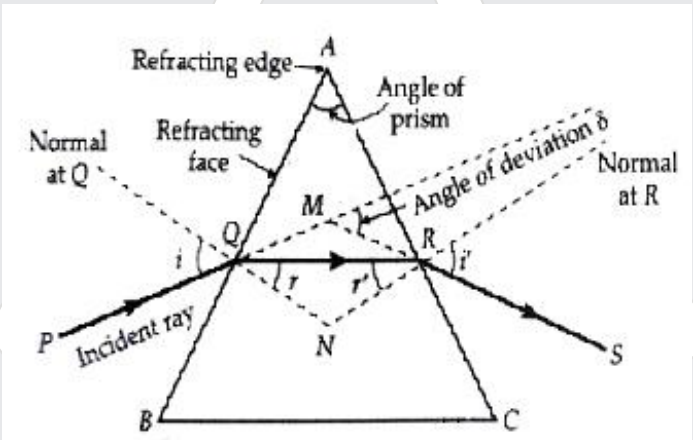



Fig. Refraction through a prism.

From the quadrilateral AQNR,

$A + \angle QNR = 180^\circ \Rightarrow A = 180^\circ - \angle QNR$

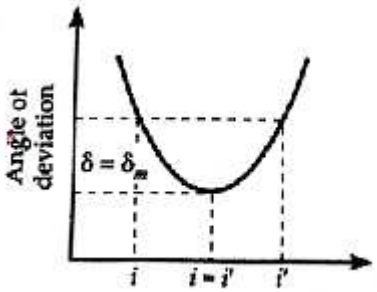
$\therefore$ From the triangle QNR,

$r + r' + \angle QNR = 180^\circ \Rightarrow r + r' = 180^\circ - \angle QNR$

$\therefore A = r + r'$

$\therefore \delta = (i - r) + (i' - r') \Rightarrow \delta = (i + i') - (r + r') \Rightarrow \delta = (i + i') - A \Rightarrow \delta + A = i - i'$

**Variation of angle of deviation with angle of incidence.**




A ray of light passing through a prism.

(b) Plot of variation of angle of deviation $\delta$ versus angle of incidence i for a prism.

The minimum value of the angle of deviation suffered by a ray on passing through a prism is called the angle of minimum deviation and is denoted by $\delta_m$

**Relation between refractive index and angle of minimum deviation**

$i = i', r = r', \delta = \delta_m$

As $A + \delta = i + i'$

$\therefore \quad A_m + \delta = i + i \quad$ or $i = \dfrac{A + \delta_m}{2}$

Also $A + r + r' = r + r = 2r$

$\therefore \quad r = \dfrac{A}{2}$

From Snell's law, the refractive index of the material of the prism will be

$$\mu = \frac{\sin i}{\sin r} \quad \text{or} \quad \mu = \frac{\sin\dfrac{A + \delta_m}{2}}{\sin\dfrac{A}{2}}$$

**27.** **(a)** (i) Distinguish between nuclear fission and fusion giving an example of each.

(ii) Explain the release of energy in nuclear fission and fusion on the basis of binding energy per nucleon curve.

**OR**

**(b)** (i) How is the size of a nucleus found experimentally? Write the relation between the radius and mass number of a nucleus.

(ii) Prove that the density of a nucleus is independent of its mass number. **3**

(a)(i) प्रत्येक का एक–एक उदाहरण देकर नाभिकीय विखण्डन और नाभिकीय संलयन के बीच विभेदन कीजिए ।

(ii) बंधन ऊर्जा प्रति न्यूक्लियन वक्र के आधार पर नाभिकीय विखण्डन और नाभिकीय संलयन में ऊर्जा मुक्त होने की व्याख्या कीजिए ।

**अथवा**

(b) (i) प्रयोग द्वारा नाभिक का साइज किस प्रकार ज्ञात किया जाता है ? किसी नाभिक की त्रिज्या और उसकी द्रव्यमान संख्या के बीच संबंध लिखिए ।

(ii) सिद्ध कीजिए कि किसी नाभिक का घनत्व उसकी द्रव्यमान संख्या पर निर्भर नहीं करता है ।

**Sol.** **(a)**

(i) Difference between nuclear fission and nuclear fusion :

| | Nuclear fission | Nuclear fusion |
|---|---|---|
| 1. | Here a heavy nucleus when excited gets split up into two smaller nuclei of nearly comparable masses. | Here two lighter nuclei fuse together to form a heavier nucleus. |
| 2. | The conditions of high temperature and pressure are not necessary for it. It can be carried on the earth. | The conditions of extremely high pressure and temperature are necessary for it. So it cannot be easily carried in a laboratory. |
| 3. | Neutrons are the link particles of this process. | Protons are the like particles of this process. |
| 4. | It is a quick process. | It occurs in serveral steps. There is sufficient time gap between initial and final steps. |
| 5. | Here the energy available per nucleon is small. | Here the energy available per nucleon is large. |
| 6. | It produces very harmful radioactive wastes. | The products of fusion are harmless. |
| 7. | The fissionable material is limited (Non-renewable) | The fusionable material is unlimited. (renewable) |

**Example** for Nuclear fission

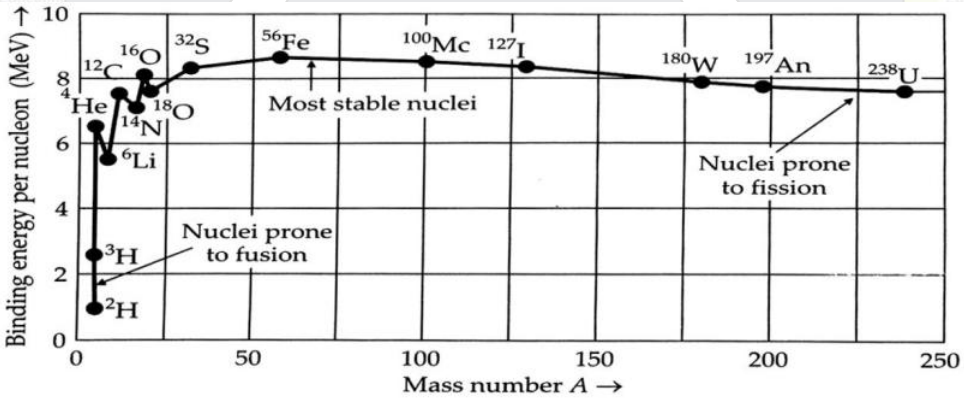
$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3^{1}_{0}n + Q$$

**Example** for Nuclear fusion

$$4^{1}_{1}H + 2e^{-} \longrightarrow ^{4}_{2}He + 2\nu + 6\gamma + 26.7\,MeV$$

**(ii) Binding energy curve:**

It is the curve showing the variation of binding energy per nucleon with the mass number of different nuclei.




Binding energy per nucleon as a function of mass number A

The binding energy per nucleon is small for light nuclei (A < 30) i.e., they are less stable. So when two light nuclei combine to form a heavier nucleus, the binding energy per nucleon increases result in the release of energy and stability increases. So, to gain stability they undergo **nuclear fusion.**

Binding energy per nucleon is smaller for heavier nuclei (A > 170) than the middle ones, i.e., heavier nuclei are less stable. This decrease is due to coulomb repulsion between the protons so the heavier nuclei become less stable and they undergo **nuclear fission** to attain stability.

**OR**

**(b)**

**(i)** Experimental observations show that the volume of a nucleus is directly proportional to its mass number.

If R is the radius of a nucleus having mass number A, then

$$\frac{4}{3}\pi R^3 \propto A$$

or $R \propto A^{1/3}$

Thus, the radius R of a nucleus is proportional to cube root of its mass number. We can write

$$\boxed{R = R_0 A^{1/3}} \quad \text{..... (1)}$$

Here $R_0$ is a constant, which is of the order of the range of nuclear force. It is believed to be the average nucleon size and is known as nuclear unit radius ($R_0$).

$R_0 = 1.2 \times 10^{-15}$ m = 1.2 fm

**(ii)**

The density of nuclear matter is the ratio of the mass of a nucleus to its volume.

Let A be the mass number and R be the radius of a nucleus. If m is the average mass of a nucleon, then

Mass of nucleus = mA

Volume of nucleus $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (R_0 A^{1/3})^3 = \frac{4}{3}\pi R_0^3 A$ (From .....(1))

$\therefore$ Nuclear density $(\rho_{nu}) = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$

or

$$\boxed{\rho_{nu} = \frac{mA}{\frac{4}{3}\pi R_0^3 A} = \frac{3m}{4\pi R_0^3}}$$

Clearly, nuclear density is independent of :

(1) mass number A, and (2) the size of the nucleus R.

**28.** **(a)** Two charged conducting spheres of radii a and b are connected to each other by a wire. Find the ratio of the electric fields at their surfaces. **3**

**OR**

**(b)** A parallel plate capacitor (A) of capacitance C is charged by a battery to voltage V. The battery is disconnected and an uncharged capacitor (B) of capacitance 2C is connected across A. Find the ratio of

(i) final charges on A and B.

(ii) total electrostatic energy stored in A and B finally and that stored in A initially.

(a) दो आवेशित चालक गोले जिनकी त्रिज्या a और b हैं किसी तार द्वारा एक दूसरे से संयोजित हैं । इनके पृष्ठों पर विद्युत क्षेत्रें का अनुपात ज्ञात कीजिए । 3

**अथवा**

(b) धारिता C के किसी समान्तर पट्टिका संधारित्र (A) को किसी बैटरी द्वारा वोल्टता V तक आवेशित किया गया है। इस संधारित्र से बैटरी को असंबद्ध करके 2C धारिता के किसी अनावेशित संधारित्र (B) को संधारित्र के सिरों से संबद्ध कर दिया गया है। ज्ञात कीजिए :

(i) A और B पर अंतिम आवेशों का अनुपात

(ii) अन्तिमतः A और B में संचित कुल स्थिरविद्यत ऊर्जा और आरम्भ में A में संचित ऊर्जा का अनुपात

**Sol.** (a) Let a be the radius of a sphere A , $Q_A$ be the charge on the sphere, and $C_A$ be the capacitance of the sphere. Let b the radius of a sphere B, $Q_B$ be the charge on the sphere, and $C_B$ be the capacitance of the sphere.

Since the two sphere are connected with a wire, their potential (V) will became equal.

Let $E_A$ be the electric field of sphere A and $E_B$ be the electric field of sphere B. Therefore, their ratio

$$\frac{E_A}{E_B} = \frac{Q_A}{4\pi \in_0 \times a^2} \times \frac{b^2 \times 4\pi \in_0}{Q_B}$$

$$\frac{E_A}{E_B} = \frac{Q_A}{Q_B} \times \frac{b^2}{a^2} \text{ .....(1)}$$

However, $\frac{Q_A}{Q_B} = \frac{C_A V}{C_B V}$

And $\frac{C_A}{C_B} = \frac{a}{b}$

$\therefore \frac{Q_A}{Q_B} = \frac{a}{b}$ .....(2)

putting the value of (2) in (1) , we obtain

$\therefore \frac{E_A}{E_B} = \frac{ab^2}{ba^2} = \frac{b}{a}$

**(b)** Common Potential $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$V = \frac{CV + 2C \times 0}{3C} = \frac{V}{3}$

**(I)** Charge on A, $Q_A = \frac{CV}{3}$

Charge on B, $Q_B = \frac{2CV}{3}$

$\frac{Q_A}{Q_B} = \frac{1}{2}$

**(II)** initial energy store in A, $U_i = \frac{1}{2} CV^2$

Final energy in A & B, $U_f = \frac{1}{2}C\left(\frac{V}{3}\right)^2 + \frac{1}{2}2C\left(\frac{V}{3}\right)^2$

$U_f = \frac{CV^2}{18} + \frac{CV^2}{9} = \frac{1}{6} CV^2$

$\frac{U_f}{U_{in}} = \frac{1}{3}$

**29.** A potential difference V is applied across a conductor of length l and cross sectional area A. Briefly explain how the current density j in the conductor will be affected if **3**
(a) the potential difference V is doubled
(b) the conductor were gradually stretched to reduce its cross-sectional area to $\frac{A}{2}$ and then the same potential difference V applied across it.
लम्बाई l और अनुप्रस्थ–काट क्षेत्रफल A के किसी चालक के सिरों पर विभवान्तर V को अनुप्रयुक्त किया गया है। संक्षेप में व्याख्या कीजिए कि चालक में धारा घनत्व j किस प्रकार प्रभावित होगा यदि
(a) विभवान्तर V दो गुना हो जाता है,
(b) चालक को धीरे–धीरे खींचकर उसके अनुप्रस्थ–काट के क्षेत्रफल को घटाकर $\frac{A}{2}$ कर दिया जाता है और फिर समान विभवान्तर V को अनुप्रयक्त किया जाता है ।

**Sol.**

(i) $V = IR$

$I = \frac{V}{R}$

$J = \frac{i}{A}$

$j = \frac{V}{RA}$ $\quad j \propto V$

if $V' = 2V$

$j' = 2j$

(ii) $V = V'$

$A\ell = A'\ell'$

$A\ell = \frac{A}{2}\ell'$

$\ell' = 2\ell$

$R = \frac{\rho\ell}{A}$

$R' = \frac{\rho\ell'}{A'} = \frac{\rho\, \ell/2}{A/2}$

$R' = 4R$

$j = \frac{i}{A}$

$j = \frac{V}{RA}$

$j' = \frac{V}{R'A'}$

$= \frac{V}{4R \times \frac{A}{2}}$

$j' = \frac{V}{2RA}$

$j' = \frac{j}{2}$

**30.** A resistor of 50 Ω, a capacitor of $\left(\frac{25}{\pi}\right)$ μF and an inductor of $\left(\frac{4}{\pi}\right)$ H are connected in series across an ac source whose voltage (in volt) is given by V= 70 sin (100 π t), Calculate: **3**

(a) the net reactance of the circuit,

(b) the impedence of the circuit

(c) the effective value of current in the circuit

50 Ω के किसी प्रतिरोधक, $\left(\frac{25}{\pi}\right)$ μF के किसी संधारित्र तथा $\left(\frac{4}{\pi}\right)$ H के किसी प्रेरक को श्रेणी में उसके सिरों को किसी ac स्रोत जिसकी वोल्टता ;वोल्ट मेंद्ध V= 70 sin(100πt) है, से संयोजित किया गया है। परिकलित कीजिए :

(a)परिपथ का नेट प्रतिघात

(b) परिपथ की प्रतिबाधा

(c) परिपथ में प्रभावी धारा का मान

**Sol.** $R = 50\Omega$

$C = \left(\frac{25}{\pi}\right)\mu F = \frac{25}{\pi}\times 10^{-6} F$

$L = \left(\frac{4}{\pi}\right)$ H

$V = 70 \sin(100\pi t)$

$V = V_0 \sin(\omega t)$

So, $V_0 = 70$ V

$\omega = 100\pi$ Rad/sec.

$\therefore \quad X_L = \omega L = 100\pi \times \frac{4}{\pi} = 400\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{100\,\pi \times \frac{25}{\pi}\times 10^{-6}}$$

$$= \frac{10^4}{25} = 400\Omega$$

(i) Net Reactance $= X_L - X_C$

$= 400 - 400 = 0\ \Omega$

(ii) Impedence $z = \sqrt{R^2 + (X_L - X_C)^2} = R = 50\Omega$

(iii) Effective value of current $I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{V_o}{R\sqrt{2}} = \frac{V_0}{R\sqrt{2}} = \frac{70}{50\sqrt{2}}$

$$= \frac{7}{5\sqrt{2}} A$$

**SECTION – D** / खण्ड –घ

**31.** **(a)** (i) Define coefficient of self-induction. Obtain an expression for self-inductance of a long solenoid of length l, area of cross section A having N turns.

(ii) Calculate the self-inductance of a coil using the following data obtained when an AC source of frequency $\left(\frac{200}{\pi}\right)$ Hz and a DC source is applied across the coil. **5**

| AC Source | | |
|---|---|---|
| S. No. | V(Volts) | I(A) |
| 1 | 3.0 | 0.5 |
| 2 | 6.0 | 1.0 |
| 3 | 9.0 | 1.5 |

| DC Source | | |
|---|---|---|
| S.No. | V(Volts) | I(A) |
| 1 | 4.0 | 1.0 |
| 2 | 6.0 | 1.5 |
| 3 | 8.0 | 2.0 |

**OR**

**(b) (i)** With the help of a labelled diagram, describe the principle and working of an ac generator. Hence, obtain an expression for the instantaneous value of the emf generated.

**(ii)** The coil of an ac generator consists of 100 turns of wire, each of area 0.5 $m^2$. The resistance of the wire is 100 Ω. The coil is rotating in a magnetic field of 0.8 T perpendicular to its axis of rotation, at a constant angular speed of 60 radian per second. Calculate the maximum emf generated and power dissipated in the coil.

(a)(i) स्व–प्रेरण गुणांक की परिभाषा लिखिए । N फेरों वाली लम्बाई / तथा अनुप्रस्थ–काट क्षेत्रफल A की किसी परिनालिका के स्व–प्रेरकत्व के लिए व्यंजक प्राप्त कीजिए ।

(ii) नीचे दिए गए आँकड़ों का उपयोग करके किसी कुण्डली का स्व–प्रेरकत्व परिकलित कीजिए । इन आँकड़ों को कुण्डली के सिरों पर $\left(\frac{200}{\pi}\right)$ Hz आवृत्ति के AC स्त्रोत और DC स्त्रोत को अनुप्रयुक्त करके प्राप्त किया गया है ।

| AC स्त्रोत | | |
|---|---|---|
| क्रम संख्या | V(वोल्ट) | I(एम्पियर) |
| 1 | 3.0 | 0.5 |
| 2 | 6.0 | 1.0 |
| 3 | 9.0 | 1.5 |

| DC स्त्रोत | | |
|---|---|---|
| क्रम संख्या | V(वोल्ट) | I(एम्पियर) |
| 1 | 4.0 | 1.0 |
| 2 | 6.0 | 1.5 |
| 3 | 8.0 | 2.0 |

**अथवा**

**(b)** (i) नामांकित आरेख की सहायता से किसी ac जनित्र के सिद्धान्त और कार्यविधि का वर्ण कीजिए । इसका उपयोग करके उत्पन्न emf के तात्क्षणिक मान के लिए व्यंजक व्युत्पन्न कीजिए ।

(ii) किसी ac जनित्र की कुण्डली में तार के 100 फेरे हैं जिनमें प्रत्येक का क्षेत्रफल 0.5$m^2$ है । तार का प्रतिरोध 100Ω है। यह कुण्डली अपने घूर्णन अक्ष के लम्बवत 0.8 T के चुम्बकीय क्षेत्र में 60 रेडियन प्रति सेकण्ड की नियत कोणीय चाल से घूर्णन कर रही है। इस कुण्डली में जनित अधिकतम emf और शक्ति क्षय परिकलित कीजिए ।

**Sol.** **(a)**

**(i) Coefficient of self - induction :** At any instant, the magnetic flux $\phi$ linked with a coil is proportional to the current I through it, i.e.,

$$\phi \propto I$$

or $$\phi = LI$$

where L is a constant for the given coil and is called self - inductance.

If I = 1A, then $\phi$ = L

Thus the self - inductance of a coil is numerically equal to the magnetic flux linked with a coil when a unit current flows through it.

Consider a long solenoid of length and radius r with r << and having n turns per unit length. If a current I flows through the coil, then the magnetic field inside the coil is almost constant and is given by

$$B = \mu_0 nI$$

Magnetic flux linked with each turn

$$= BA = \mu_0 nIA$$

where $A = \pi r^2$ = the cross - sectional area of the solenoid.

$\therefore$ Magneitc flux linked with the entire solenoid is

$\phi$ = Flux linked with each turn × total number of turns

$$= \mu_0 nIA \times n\ell = \mu_0 n^2 IA\ell$$

But $\phi$ = LI

$\therefore$ Self inductance of the long solenoid is

$$L = \mu_0 n^2 A\ell$$

If N is the total number of turns in the solenoid, then n = N /l and so

$$L = \frac{\mu_0 N^2 A}{\ell}$$

If the coil is wound over a material of high relative magnetic permeability $\mu_r$ (e.g., soft iron), then

$$L = \mu_r \mu_0 n^2 \ell A = \frac{\mu_r \mu_0 N^2 A}{\ell}$$

**(ii)** For AC Source :

$$f = \left(\frac{200}{\pi}\right) Hz$$

$$\because \omega = 2\pi f = 2\pi \left(\frac{200}{\pi}\right) = 400 \text{ Rad/s}$$

$\because X_L = \omega L \Rightarrow L = \frac{X_L}{\omega}$

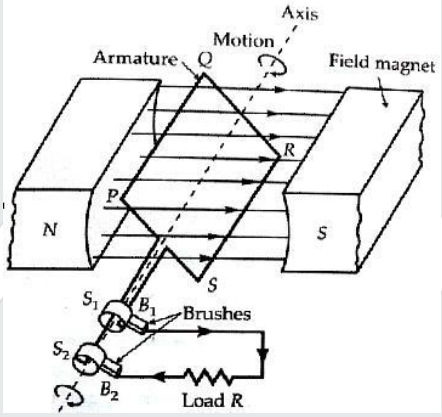
(1) $L = \frac{6}{400} H$ $\quad \because X_L = \frac{V}{I} = \frac{3}{0.5} = 6\Omega$

(ii) $L = \frac{6}{400} H$ $\quad \because X_L = \frac{V}{I} = \frac{6}{1} = 6\Omega$

(iii) $L = \frac{6}{400} H$ $\quad \because X_L = \frac{V}{I} = \frac{9}{1.5} = 6\Omega$

(b) (i) 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, so the magnetic flux linked with the coil changes hence an induced emf and 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

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

$\omega$ = 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

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}(NBA\cos\omega t) = NBA\omega\sin\omega t$$

or

$$\varepsilon = \varepsilon_0 \sin\omega t$$

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.

(b) (ii) N = 100

A = $0.5m^2$

R = 100 Ω

B = 0.8T

ω = 60 Rad/s

$\varepsilon = BNA\omega\sin\theta$ $\quad\because$ for $\varepsilon_{max} \Rightarrow \sin\theta = 1$

$\varepsilon_{max} = 0.8 \times 100 \times 0.5 \times 60 = 2400$ V

$$P = \frac{\varepsilon^2}{R} = \frac{2400 \times 2400}{100} = 57600\,W$$

**32.** (a) (i) State Huygen's principle. With the help of a diagram, show how a plane wave is reflected from a surface. Hence verify the law of reflection. **5**

(ii) A concave mirror of focal length 12 cm forms a three times magnified virtual image of an object. Find the distance of the object from the mirror.

**OR**

**(b)** (i) Draw a labelled ray diagram showing the image formation by a refracting telescope. Define its magnifying power. Write two limitations of a refracting telescope over a reflecting telescope.

**(ii)** The focal lengths of the objective and the eye-piece of a compound microscope are 1.0 cm and 2.5 cm respectively. Find the tube length of the microscope for obtaining a magnification of 300.

(a)(i) हाइगेन्स – सिद्धान्त लिखिए। आरेख की सहायता से यह दर्शाइए कि कोई समतल तरंग किसी पृष्ठ से कैसे परावर्तित होती है। इसका उपयोग करके परावर्तन के नियम का सत्यापन कीजिए । 5

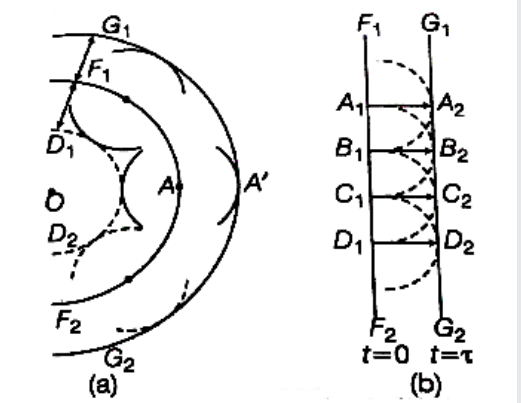
(ii) 12 cm फोकस दूरी का कोई अवतल दर्पण किसी बिम्ब का तीन गुना आवर्धित आभासी प्रतिबिम्ब बनाता है । दर्पण से बिम्ब की दूरी ज्ञात कीजिए ।

अथवा

**(b)**(i) अपवर्ती दूरदर्शक द्वारा प्रतिबिम्ब बनना दर्शाने के लिए नामांकित किरण आरेख खींचिए । इसकी आवर्धन क्षमता की परिभाषा लिखिए । परावर्ती दूरदर्शक की तुलना दूरदर्शक की दो सीमाएँ लिखिए।

(ii) किसी संयुक्त सूक्ष्मदर्शी के अभिदृश्यक और नेत्रिका लेंसों की फोकस दूरियाँ क्रमशः 1.0 cm और 2.5 cm हैं। 300 आवर्धन प्राप्त करने के लिए इस सूक्ष्मदर्शी की नलिका की लम्बाई ज्ञात कीजिए ।

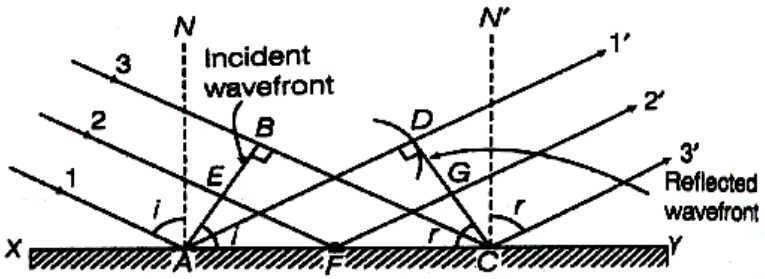
**Sol.** (a) (i) Huygen's principle states that every point on a wave front may be considered as a source of secoundry waves.




In Fig. (a) $F_1F_2$ is the section of the given spherical wavefront and $G_1G_2$ is the new wavefront in the forward direction. In Fig. (b), $F_1F_2$ is the section of the given plane wavefront and $G_1G_2$ is the new wavefront in the forward direction.

### Laws of Reflection at a Plane Surface

Let 1, 2, 3 be the incident rays and 1', 2', 3' be the corresponding reflected rays.




Laws of reflection by Huygens' principle

If c is the speed of the light, t is the time taken by light to go from B to C or A to D or E to G through F, then

$$t = \frac{EF}{c} + \frac{FG}{c} \quad \text{....(i)}$$

In $\Delta AEF$ $\sin i = \frac{EF}{AF}$

In $\Delta FGC$, $\sin r = \frac{FG}{FC}$

or $t = \frac{AF \sin i}{c} + \frac{FC \sin r}{c}$

$$\Rightarrow t = \frac{AC \sin r + AF(\sin i - \sin r)}{c} \quad [\because FC = AC - AF]$$

For rays of light from different parts on the incident wavefront, the values of AF are different. But light from different points of the incident wavefront should take the same time to reach the corresponding points on the reflected wavefront.

So, t should not depend upon AF. This is possible only, if

$\sin i - \sin r = 0$

i.e. $\sin i = \sin r$

or $\angle i = \angle r$ .....(ii)

which is the first law of reflection.

(i) $f = -12cm$

$m = 3 = -\frac{v}{u}$

$v = -3u$

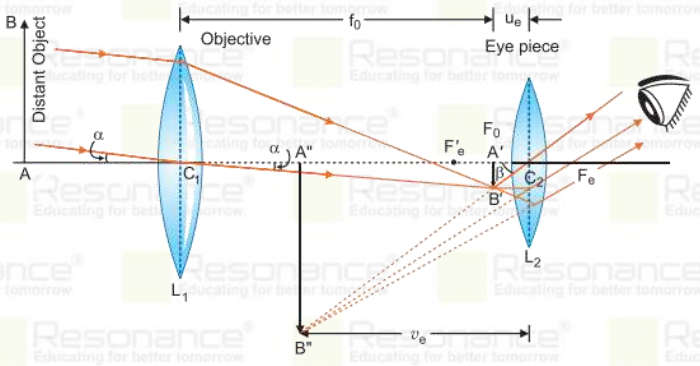
$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\frac{1}{-12} = \frac{1}{-3u} + \frac{1}{u}$

$u = -8cm$

**OR**

**(b)** **(i)**



**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.*,

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

Limitations of a refracting telescope over a reflecting telescope :-

(a) The image formed by reflecting type telescope is brighter than that formed by refracting telescope.

(b) The image formed by the reflecting type telescope is more magnified than that formed by the refracting type telescope

(b) (ii) $f_0 = 1$ cm, $f_e = 2.5$ cm

$$m = \frac{-L}{f_0}\left(1+\frac{D}{f_e}\right)$$

$$300 = \frac{-L}{1}\left(1+\frac{25}{2.5}\right)$$

$$300 = -L\,(11)$$

$$|L| = \frac{300}{11}\text{cm}$$

**33.** **(a) (i)** Use Gauss' law to obtain an expression for the electric field due to an infinitely long thin straight wire with uniform linear charge density λ. **5**

**(ii)** An infinitely long positively charged straight wire has a linear charge density λ. An electron is revolving in a circle with a constant speed v such that the wire passes through the centre, and is perpendicular to the plane, of the circle. Find the kinetic energy of the electron in terms of magnitudes of its charge and linear charge density λ on the wire.

**(iii)** Draw a graph of kinetic energy as a function of linear charge density λ.

**OR**

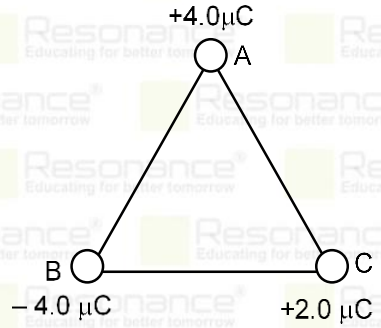
**(b) (i)** Consider two identical point charges located at points (0, 0) and (a, 0).

(1) Is there a point on the line joining them at which the electric field is zero?

(2) Is there a point on the line joining them at which the electric potential is zero? Justify your answers for each case.

**(ii)** State the significance of negative value of electrostatic potential energy of a system of charges.

Three charges are placed at the corners of an Equilateral triangle ABC of side 2.0 m as shown in figure. Calculate the electric potential energy of the system of three charges.




(a)(i) गाउस नियम का उपयोग करके एकसमान रैखिक आवेश घनत्व $\lambda$ के किसी अनन्ततः लम्बे सीधे पतले तार के कारण विद्युत क्षेत्र के लिए कोई व्यंजक प्राप्त कीजिए ।

(ii) किसी अनन्ततः लम्बे धनावेशित सीधे तार का रैखिक आवेश घनत्व $\lambda$ है । कोई इलेक्ट्रॉन इस तार को केन्द्र मानकर, वृत्ताकार पथ पर इस तार की परिक्रमा, तार के लम्बवत तल में किसी नियत चाल पे $v$ से कर रहा है। आवेश के परिमाण और तार पर रैखिक आवेश घनत्व $\lambda$ के पदों में इलेक्ट्रॉन की गतिज ऊर्जा ज्ञात कीजिए ।

(iii) रैखिक आवेश घनत्व $\lambda$ को फलन मानकर गतिज ऊर्जा के लिए ग्राफ खींचिए । 5

**अथवा**

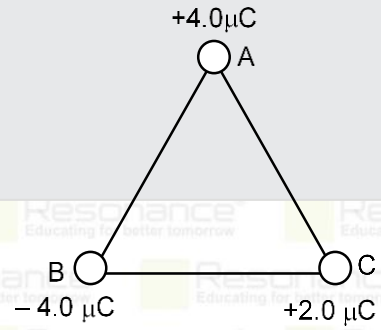
(b) (i) दो सर्वसम बिन्दु आवेशों पर विचार कीजिए जो बिन्दुओं (0, 0) और (a,0) पर स्थित हैं ।

(1) क्या इन दोनों को जोड़ने वाली रेखा पर ऐसा कोई बिन्दु है जिस पर विद्युत क्षेत्र शून्य हैं ?

(2) क्या इन दोनों को जोड़ने वाली रेखा पर ऐसा कोई बिन्दु है जिस पर विद्युत विभव शून्य है ? प्रत्येक प्रकरण के उत्तर की पुष्टि कीजिए ।

(ii) आवेशों के निकाय की स्थिरविद्युत स्थितिज ऊर्जा के ऋणात्मक मान के महत्व का उल्लेख कीजिए ।

आरेख में दर्शाए अनुसार तीन आवेश 2.0m भुजा के किसी समबाहु त्रिभुज ABC के शीर्षों पर स्थित हैं। इन तीनों आवेशों के निकाय की वैद्युत स्थितिज ऊर्जा परिकलित कीजिए ।



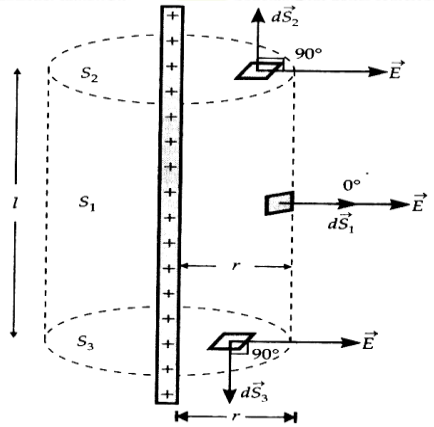

**Sol.** **(a) (i) Electric field due to an infinitely long straight charged wire :**

Consider a thin infinitely long straight thin wire having uniform linear charge density $\lambda$ $Cm^{-1}$

By symmetry, the field $\vec{E}$ of the line charge is directed radially outwards and its magnitude is same at all points equidistant from the line charge. To determine the field at a distance r from the line charge, we

choose a cylindrical Gaussian surface of radius r, length $l$ and with its axis along the line charge. As shown in figure it has curved surface $S_1$ and flat circular ends $S_2$ and $S_3$. Obviously,

$\overrightarrow{dS_1} \parallel \vec{E}$, $\overrightarrow{dS_2} \perp \vec{E}$ and $\overrightarrow{dS_3} \perp \vec{E}$. So only the curved surface contributes towards the total flux.




Cylindrical Gaussian surface for line charge.

So, the total electric flux through the surface will be :

$$\phi_E = \oint_S \vec{E}.\overrightarrow{dS} = \oint_{S_1} \vec{E}.\overrightarrow{dS_1} + \oint_{S_2} \vec{E}.\overrightarrow{dS_2} + \oint_{S_3} \vec{E}.\overrightarrow{dS_3}$$

$$= \int_{S_1} EdS_1\cos 0° + \int_{S_2} EdS_2\cos 90° + \int_{S_3} EdS_3\cos 90°$$

$$= E\int dS_1 + 0 + 0$$

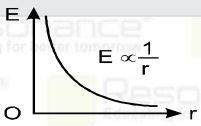
= E × area of the curved surface

or $\phi_E$ = E × 2 $\pi r l$

Charge enclosed by the Gaussian surface, q = $\lambda l$

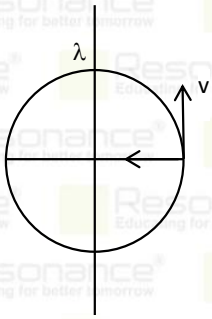
Using Gauss's theorem, $\phi_E = \frac{q}{\varepsilon_0}$, we get

or $E2\pi r l = \frac{\lambda l}{\varepsilon_0}$ or $\boxed{E = \frac{\lambda}{2\pi\varepsilon_0 r}}$ or $\boxed{E = \frac{2k\lambda}{r}}$




Variation of electric field (E) due to an infinitely long straight charged wire with distance (r)

**(ii)**




$$E = \frac{2K\lambda}{r}$$

$$F = Ee$$

$$F = \frac{2K\lambda e}{r}$$

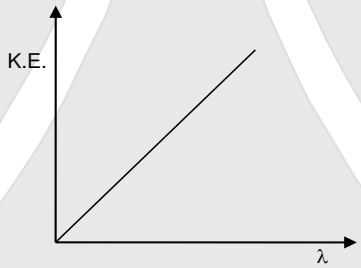
$$\frac{mv^2}{r} = \frac{2K\lambda e}{r}$$

$$mv^2 = 2K\lambda e$$

$$\because \frac{1}{2}mv^2 = \frac{2K\lambda e}{2}$$

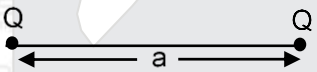
$$KE = K\lambda e$$

**(iii)**




**OR**

(b) (i)




(1) Electric Field is zero at midpoint between charges.
(2) Here Electric potential in not zero. For zero electric potential, we required unlike charges.

(ii) The Negetive value of electrostatic potential energy represent the attraction force between charges.

P.E. $= U_{AB} + U_{BC} + U_{CA}$

$$\because U = \frac{Kq_1q_1}{r}$$

$$= -\frac{K\times4\times4\times10^{-12}}{2} - \frac{K\times4\times2\times10^{-12}}{2} + \frac{K\times4\times2\times10^{-12}}{2}$$

$$\text{P.E.} = U = -\frac{9\times10^9\times16}{2}\times10^{-12}$$

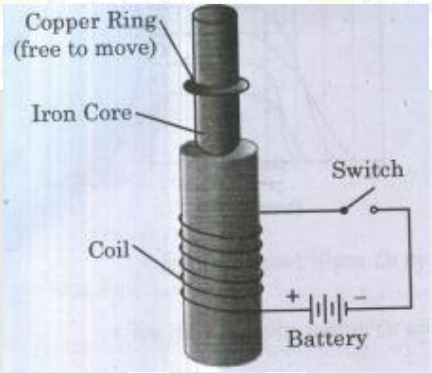
$$= -7.2\times10^{-2} \text{ joule}$$

## SECTION – E खण्ड ङ

**Note:** Questions number 34 and 35 are case study based questions. Read the following paragraph and answer the questions.

**नोट :** प्रश्न संख्या 34 और 35 केस आधारित प्रश्न हैं। नीचे दिए गए अनुच्छेद का अध्ययन करके प्रश्नों के उत्तर दीजिए ।

**34.** **(a)** Consider the experimental set up shown in the figure. This jumping ring experiment is an outstanding demonstration of some simple laws of Physics. A conducting non-magnetic ring is placed over the vertical core of a solenoid. When current is passed through the solenoid, the ring is thrown off.




Answer the following questions:

(i) Explain the reason of jumping of the ring when the switch is closed in the circuit.

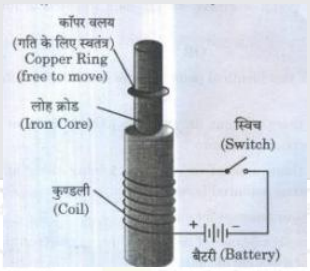
(ii) What will happen if the terminals of the battery are reversed and the switch is closed? Explain.

(iii) Explain the two laws that help us understand this phenomenon.

**OR**

(b) Briefly explain various ways to increase the strength of magnetic field produced by a given solenoid.

(a) आरेख में दर्शायी प्रायोगिक व्यवस्था पर विचार कीजिए। यह झंपन–वलय (jumping ring ) प्रयोग भौतिकी के कुछ नियमों का उत्कृष्ट निदर्शन है। इसमें किसी अचुम्बकीय चालक पदार्थ के वलय को किसी परिनालिका के ऊर्ध्वाधर क्रोड पर रखा जाता है। जब परिनालिका से धारा प्रवाहित की जाती है, तो वलय ऊपर की ओर उछलता है।




निम्न प्रश्नों के उत्तर दीजिए:

(i) जब परिपथ में स्विच को बन्द करते हैं तो वलय के झंपन के कारण की व्याख्या कीजिए ।

(ii) यदि बैटरी के टर्मिनलों को उत्क्रमित कर दें और फिर स्विच को बन्द करें तो क्या होगा ? व्याख्या कीजिए ।

(iii) इस परिघटना को समझने में सहायता करने वाले दो नियमों की व्याख्या कीजिए ।

**अथवा**

(b) किसी दी गई परिनालिका के चुम्बकीय क्षेत्र की प्रबलता में वृद्धि करने के विभिन्न उपायों की संक्षेप में व्याख्या कीजिए ।

**Sol.** (a) When switch is closed, current is passing through the solenoid then magnetic flux is change through the solenoid. According to faraday's law, current is induced in copper coil and the direction of current According to lenz law, apposes the magnetic flux produced by solenoid. So its jump immediately when switch is closed.

(ii) Only direction get reversed

(iii) (i) Faraday's law for electromagnetic induction

(ii) Lenz's law for direction

**OR**

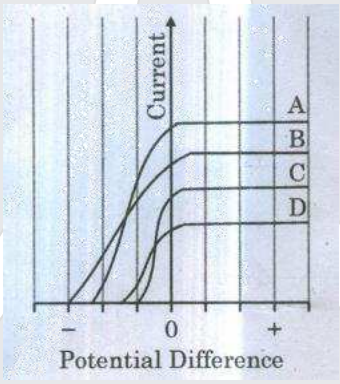
(b) $B = \mu_0 ni = \mu_0 \frac{N}{\ell} i$

(i) With increase is number of term per unit length

(ii) Inserting care material (soft iron)

(iii) By increasing current.

**35.** **(a)** Figure shows the variation of photoelectric current measured in a photo cell circuit as a function of the potential difference between the plates of the photo cell when light beams A, B, C and D of different wavelengths are incident on the photo cell. Examine the given figure and answer the following questions:




(i) Which light beam has the highest frequency and why?

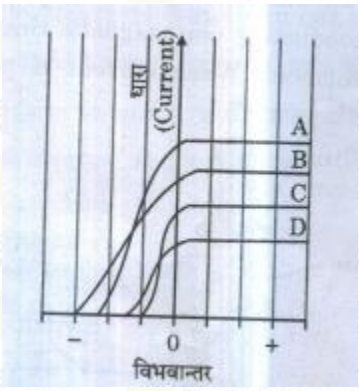
(ii) Which light beam has the longest wavelength and why?

(iii) Which light beam ejects photoelectrons with maximum momentum and why? **4**

**OR**

**(b)** What is the effect on threshold frequency and stopping potential on increasing the frequency of incident beam of light? Justify your answer

(a) दिए गए आरेख में किसी प्रकाश विद्युत सेल परिपथ में उसकी पट्टिकाओं के बीच विभवान्तर को फलन मानकर मापी गयी प्रकाश विद्युत धारा के विचरण को दर्शाया गया है जबकि सेल पर विभिन्न तरंगदैर्ध्यों के प्रकाश पुंज A, B, C और D आपतन करते हैं। दिए गए आरेख का परीक्षण कीजिए और निम्न प्रश्नों के उत्तर दीजिए ।




(i) किस प्रकाश पुंज की आवृत्ति उच्चतम है और क्यों ?

(ii) किस प्रकाश पुंज की तरंगदैर्ध्य अधिकतम है और क्यों ?

(iii) किस प्रकाश पुंज द्वारा सबसे अधिक संवेग से प्रकाशनज इलेक्ट्रॉन उत्सर्जित होते हैं और क्यों ?

**अथवा**

(b) आपतित प्रकाश पुंज की आवृत्ति में वृद्धि करने पर देहली आवृत्ति और निरोधी विभव पर क्या प्रभाव होता है ? अपने उत्तर की पुष्टि कीजिए।

**Sol.** (i) The light beam (B) has the highest frequency because its has highest stopping potential.

(ii) $\because c = \upsilon\lambda \Rightarrow \lambda = \frac{c}{\upsilon} \Rightarrow \uparrow \lambda \propto \frac{1}{\upsilon_{\downarrow}}$

here lowest frequency for light beam (C) So light beam (C) has the longest wavelength.

(iii) $\because P = \sqrt{2mk}$

Here K.E. Related to frequency so the light beam (B) has maximum stopping potential , frequency , K.E. and momentum

**OR**

(b) If frequency Increases then threshold frequency doen not change because depends on nature of the materials but stopping potential also Increases ($\upsilon \propto V_0$).

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| 2. | SECTION-II | 50/45 | 40/35 | 45 Minutes* |
| 3. | SECTION-III | 60 | 50 | 45 Minutes* |

*Not yet announced by NTA.

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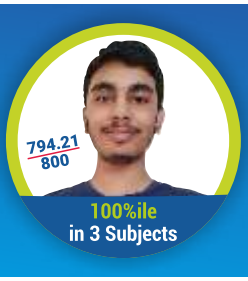


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