Series S3RQP/3

Set-3

प्रश्न-पत्र कोड
Q.P. Code **55/3/3**

रोल नं.
Roll No.

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

भौतिक विज्ञान (सैद्धान्तिक)

PHYSICS (Theory)

निर्धारित समय : 3 घण्टे *अधिकतम अंक : 70*

Time allowed : 3 hours *Maximum Marks : 70*

	नोट		NOTE
(I)	कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **27** हैं ।	(I)	Please check that this question paper contains **27** printed pages.
(II)	कृपया जाँच कर लें कि इस प्रश्न-पत्र में **33** प्रश्न हैं ।	(II)	Please check that this question paper contains **33** questions.
(III)	प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।	(III)	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.
(IV)	**कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें ।**	(IV)	**Please write down the serial number of the question in the answer-book before attempting it.**
(V)	इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक छात्र केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।	(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 students will read the question paper only and will not write any answer on the answer-book during this period.

सामान्य निर्देश :

निम्नलिखित निर्देशों को ध्यानपूर्वक पढ़िए और उनका पालन कीजिए :

(i) *इस प्रश्न-पत्र में* ***33*** *प्रश्न हैं । **सभी** प्रश्न **अनिवार्य** हैं ।*

(ii) *यह प्रश्न-पत्र* ***पाँच*** *खण्डों में विभाजित है – **खण्ड क, ख, ग, घ** एवं **ङ** ।*

(iii) ***खण्ड क*** *में प्रश्न संख्या* ***1*** *से* ***16*** *तक बहुविकल्पीय प्रकार के प्रश्न हैं । प्रत्येक प्रश्न* ***1*** *अंक का है ।*

(iv) ***खण्ड ख*** *में प्रश्न संख्या* ***17*** *से* ***21*** *तक अति लघु-उत्तरीय प्रकार के प्रश्न हैं । प्रत्येक प्रश्न* ***2*** *अंकों का है ।*

(v) ***खण्ड ग*** *में प्रश्न संख्या* ***22*** *से* ***28*** *तक लघु-उत्तरीय प्रकार के प्रश्न हैं । प्रत्येक प्रश्न* ***3*** *अंकों का है ।*

(vi) ***खण्ड घ*** *में प्रश्न संख्या* ***29*** *तथा* ***30*** *प्रकरण अध्ययन आधारित प्रश्न हैं । प्रत्येक प्रश्न* ***4*** *अंकों का है ।*

(vii) ***खण्ड ङ*** *में प्रश्न संख्या* ***31*** *से* ***33*** *तक दीर्घ-उत्तरीय प्रकार के प्रश्न हैं । प्रत्येक प्रश्न* ***5*** *अंकों का है ।*

(viii) *प्रश्न-पत्र में समग्र विकल्प नहीं दिया गया है । यद्यपि, खण्ड क के अतिरिक्त अन्य खण्डों के कुछ प्रश्नों में आंतरिक विकल्प का चयन दिया गया है ।*

(ix) *ध्यान दें कि दृष्टिबाधित परीक्षार्थियों के लिए एक अलग प्रश्न-पत्र है ।*

(x) *कैल्कुलेटर का उपयोग **वर्जित** है ।*

जहाँ आवश्यक हो, आप निम्नलिखित भौतिक नियतांकों के मानों का उपयोग कर सकते हैं :

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

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

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

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

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

इलेक्ट्रॉन का द्रव्यमान $(m_e) = 9{\cdot}1 \times 10^{-31}$ kg

न्यूट्रॉन का द्रव्यमान $= 1{\cdot}675 \times 10^{-27}$ kg

प्रोटॉन का द्रव्यमान $= 1{\cdot}673 \times 10^{-27}$ kg

आवोगाद्रो संख्या $= 6{\cdot}023 \times 10^{23}$ प्रति ग्राम मोल

बोल्ट्ज़मान नियतांक $= 1{\cdot}38 \times 10^{-23}$ JK^{-1}

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

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

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

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

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

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

Mass of electron $(m_e) = 9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron $= 1{\cdot}675 \times 10^{-27}$ kg

Mass of proton $= 1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number $= 6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1{\cdot}38 \times 10^{-23}$ JK^{-1}

खण्ड क

1. 2 μF संधारित्र की पट्टिकाओं P_1 तथा P_2 पर क्रमश: 25 V तथा – 25 V विभव है । पट्टिका P_1 पर आवेश होगा :

(A) 0·02 mC (B) 0·1 mC

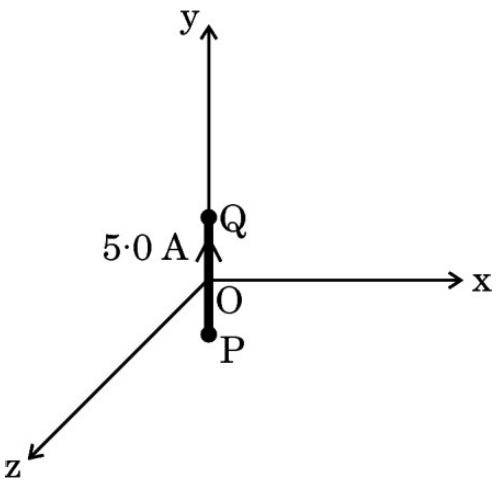
(C) 0·1 μC (D) 1 μC

2. किसी प्रोटॉन को बिन्दु P_1 से बिन्दु P_2 तक ले जाया गया है, ये दोनों बिन्दु किसी विद्युत क्षेत्र में स्थित हैं । बिन्दु P_1 और P_2 पर विभव क्रमश: – 5 V और + 5 V हैं । यह मानते हुए कि बिन्दुओं P_1 और P_2 पर प्रोटॉन की गतिज ऊर्जाएँ शून्य हैं, तो प्रोटॉन पर किया गया कार्य है :

(A) $-1{\cdot}6 \times 10^{-18}$ J (B) $1{\cdot}6 \times 10^{-18}$ J

(C) शून्य (D) $0{\cdot}8 \times 10^{-18}$ J

3. आरेख में दर्शाए अनुसार तार के किसी 2·0 cm लम्बे खण्ड से, जो y-अक्ष के अनुदिश रखा गया है, धनात्मक y-दिशा में 5·0 A धारा प्रवाहित हो रही है । इस खण्ड (परिपथ के भाग) के कारण बिन्दु (3 m, 4 m, 0) पर चुम्बकीय क्षेत्र है :



(A) $(0{\cdot}12 \text{ nT})\ \hat{j}$

(B) $-(0{\cdot}10 \text{ nT})\ \hat{j}$

(C) $-(0{\cdot}24 \text{ nT})\ \hat{k}$

(D) $(0{\cdot}24 \text{ nT})\ \hat{k}$

SECTION A

1. The plates P_1 and P_2 of a 2 μF capacitor are at potentials 25 V and – 25 V respectively. The charge on plate P_1 will be :

(A) 0·02 mC (B) 0·1 mC

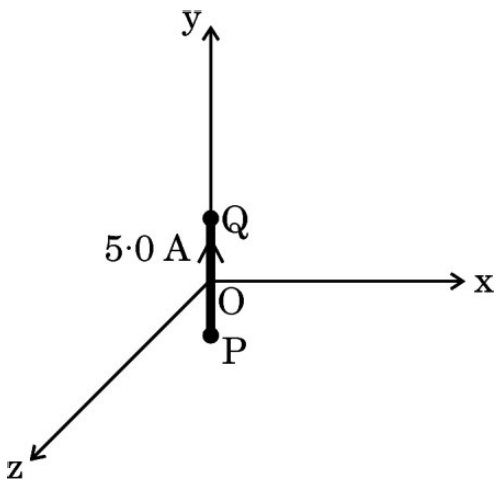
(C) 0·1 μC (D) 1 μC

2. A proton is taken from point P_1 to point P_2, both located in an electric field. The potentials at points P_1 and P_2 are – 5 V and + 5 V respectively. Assuming that kinetic energies of the proton at points P_1 and P_2 are zero, the work done on the proton is :

(A) $-1{\cdot}6 \times 10^{-18}$ J (B) $1{\cdot}6 \times 10^{-18}$ J

(C) Zero (D) $0{\cdot}8 \times 10^{-18}$ J

3. A 2·0 cm segment of wire, carrying 5·0 A current in positive y-direction lies along y-axis, as shown in the figure. The magnetic field at a point (3 m, 4 m, 0) due to this segment (part of a circuit) is :



(A) $(0{\cdot}12 \text{ nT})\ \hat{j}$

(B) $-(0{\cdot}10 \text{ nT})\ \hat{j}$

(C) $-(0{\cdot}24 \text{ nT})\ \hat{k}$

(D) $(0{\cdot}24 \text{ nT})\ \hat{k}$

4. निम्नलिखित में से कौन-सा प्रतिचुम्बकीय पदार्थ है ?

(A) गैडोलिनियम

(B) सोडियम

(C) कॉपर क्लोराइड

(D) सोडियम क्लोराइड

5. कोई धारावाही वृत्ताकार पाश जिसका चुम्बकीय आघूर्ण $\vec{M}$ है, किसी बाह्य चुम्बकीय क्षेत्र $\vec{B}$ में ऊर्ध्वाधर तल में इस प्रकार निलंबित है कि इसका तल $\vec{B}$ के अभिलम्बवत् है । इस पाश को $\vec{B}$ के लम्बवत् अक्ष के परित: 45° पर घूर्णित कराने में किया गया कार्य किसके निकटतम है ?

(A) – 0·3 MB (B) 0·3 MB

(C) – 1·7 MB (D) 1·7 MB

6. किसी प्रत्यावर्ती वोल्टता $v = (157\ V) \sin \omega t$ का इसके प्रथम अर्द्ध-चक्र में औसत मान होगा :

(A) 157 V

(B) $\frac{157}{\sqrt{2}}$ V

(C) 78·5 V

(D) 100 V

7. किसी ऐसी परिनालिका पर विचार कीजिए जिसकी लम्बाई l,अनुप्रस्थ-काट क्षेत्रफल A तथा फेरों की संख्या नियत है । इस परिनालिका के स्वप्रेरकत्व में वृद्धि होगी यदि :

(A) l और A दोनों में वृद्धि हो

(B) l में कमी और A में वृद्धि हो

(C) l में वृद्धि और A में कमी हो

(D) l और A दोनों में कमी हो

4. Which of the following is a diamagnetic substance ?

(A) Gadolinium

(B) Sodium

(C) Copper chloride

(D) Sodium chloride

5. A current carrying circular loop of magnetic moment $\vec{M}$ is suspended in a vertical plane in an external magnetic field $\vec{B}$ such that its plane is normal to $\vec{B}$. The work done in rotating this loop by 45° about an axis perpendicular to $\vec{B}$ is closest to :

(A) – 0·3 MB (B) 0·3 MB

(C) – 1·7 MB (D) 1·7 MB

6. The average value of the alternating voltage $v = (157\ V) \sin \omega t$ over its first half-cycle is :

(A) 157 V

(B) $\frac{157}{\sqrt{2}}$ V

(C) 78·5 V

(D) 100 V

7. Consider a solenoid of length l and area of cross-section A with fixed number of turns. The self-inductance of the solenoid will increase if :

(A) both l and A are increased

(B) l is decreased and A is increased

(C) l is increased and A is decreased

(D) both l and A are decreased

8. कोई समतल विद्युत-चुम्बकीय तरंग $+x$ दिशा में वायु में गमन कर रही है । किसी विशेष क्षण पर इसका विद्युत-क्षेत्र $\vec{E}$, $+y$ दिशा के अनुदिश है । इसी क्षण इसका चुम्बकीय क्षेत्र $\vec{B}$ किस दिशा के अनुदिश है ?

(A) $+z$ दिशा के अनुदिश तथा $\vec{E}$ के साथ कला में

(B) $-z$ दिशा के अनुदिश तथा $\vec{E}$ के साथ कला में

(C) $+z$ दिशा के अनुदिश तथा $\vec{E}$ के साथ कला में नहीं

(D) $-z$ दिशा के अनुदिश तथा $\vec{E}$ के साथ कला में नहीं

9. समान वेग से गतिमान कोई प्रोटॉन और कोई ऐल्फा कण किसी लक्ष्य नाभिक पर उपगमन करते हैं । ये क्षणिक विराम में आते हैं और फिर अपनी दिशाओं को व्युत्क्रमित करते हैं । प्रोटॉन के उपगमन की निकटतम दूरी तथा ऐल्फा कण के उपगमन की निकटतम दूरी का अनुपात होगा :

(A) $\frac{1}{2}$ (B) 2

(C) $\frac{1}{4}$ (D) 4

10. गतिज ऊर्जा K के किसी इलेक्ट्रॉन से संबद्ध द्रव्य तरंग की तरंगदैर्घ्य λ है । यदि इलेक्ट्रॉन की गतिज ऊर्जा दो गुनी कर दी जाए, तो संबद्ध तरंगदैर्घ्य हो जाएगी :

(A) $\frac{\lambda}{\sqrt{2}}$

(B) $\frac{\lambda}{2}$

(C) $\sqrt{2}\ \lambda$

(D) 2λ

8. A plane electromagnetic wave is travelling in air in + x direction. At a particular moment, its electric field $\vec{E}$ is along + y direction. At that moment, the magnetic field $\vec{B}$ is along :

(A) + z direction and in phase with $\vec{E}$

(B) – z direction and in phase with $\vec{E}$

(C) + z direction and out of phase with $\vec{E}$

(D) – z direction and out of phase with $\vec{E}$

9. A proton and an alpha particle having equal velocities approach a target nucleus. They come momentarily to rest and then reverse their directions. The ratio of the distance of closest approach of the proton to that of the alpha particle will be :

(A) $\frac{1}{2}$ (B) 2

(C) $\frac{1}{4}$ (D) 4

10. The wavelength of matter wave associated with an electron of kinetic energy K is λ. If the kinetic energy of the electron is doubled, the associated wavelength becomes :

(A) $\frac{\lambda}{\sqrt{2}}$

(B) $\frac{\lambda}{2}$

(C) $\sqrt{2}\ \lambda$

(D) $2\ \lambda$

11. हाइड्रोजन परमाणु के बोर मॉडल में कोई इलेक्ट्रॉन $n = 2$ स्तर से $n = 1$ स्तर को संक्रमण करता है । इसके परिक्रमण काल में :

(A) 87·5% की वृद्धि होगी

(B) 87·5% की कमी होगी

(C) 43·75% की वृद्धि होगी

(D) 43·75% की कमी होगी

12. Si का मादन पंचसंयोजी तत्त्व के साथ किया गया है । अतिरिक्त इलेक्ट्रॉन को मुक्त करने के लिए आवश्यक ऊर्जा है लगभग :

(A) 0·01 eV (B) 0·05 eV

(C) 0·72 eV (D) 1·1 eV

*प्रश्न संख्या **13** से **16** अभिकथन (A) और कारण (R) प्रकार के प्रश्न हैं । दो कथन दिए गए हैं — जिनमें एक को अभिकथन (A) तथा दूसरे को कारण (R) द्वारा अंकित किया गया है । सही उत्तर नीचे दिए गए कोडों (A), (B), (C) और (D) में से चुनकर दीजिए ।*

(A) अभिकथन (A) और कारण (R) दोनों सही हैं और कारण (R), अभिकथन (A) की सही व्याख्या करता है ।

(B) अभिकथन (A) और कारण (R) दोनों सही हैं, परन्तु कारण (R), अभिकथन (A) की सही व्याख्या ***नहीं*** करता है ।

(C) अभिकथन (A) सही है, परन्तु कारण (R) ग़लत है ।

(D) अभिकथन (A) ग़लत है तथा कारण (R) भी ग़लत है ।

13. *अभिकथन (A) :* किसी अर्धचालक में, चालन बैण्ड के इलेक्ट्रॉनों की ऊर्जा संयोजकता बैण्ड के इलेक्ट्रॉनों की ऊर्जा से कम होती है ।

कारण (R) : किसी अर्धचालक में दाता ऊर्जा स्तर संयोजकता बैण्ड के ठीक ऊपर होता है ।

11. An electron makes a transition from n = 2 level to n = 1 level in the Bohr model of a hydrogen atom. Its period of revolution :

(A) increases by 87·5%

(B) decreases by 87·5%

(C) increases by 43·75%

(D) decreases by 43·75%

12. Si is doped with a pentavalent element. The energy required to set the additional electron free is about :

(A) 0·01 eV (B) 0·05 eV

(C) 0·72 eV (D) 1·1 eV

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

13. *Assertion (A) :* In a semiconductor, the electrons in the conduction band have lesser energy than those in the valence band.

Reason (R) : Donor energy level is just above the valence band in a semiconductor.

14. *अभिकथन (A) :* प्रकाश-विद्युत प्रभाव प्रकाश की कणात्मक प्रकृति को निदर्शित करता है ।

कारण (R) : प्रकाश-विद्युत धारा आपतित विकिरणों की आवृत्ति के अनुक्रमानुपाती होती है ।

15. *अभिकथन (A) :* कोई प्रोटॉन और कोई इलेक्ट्रॉन किसी एकसमान चुम्बकीय क्षेत्र $\vec{B}$ में समान संवेग $\vec{p}$ से इस प्रकार प्रवेश करते हैं कि $\vec{p}$ चुम्बकीय क्षेत्र $\vec{B}$ के लम्बवत् है । ये दोनों समान त्रिज्या के वृत्तीय पथ पर गमन करेंगे ।

कारण (R) : किसी चुम्बकीय क्षेत्र में कक्षीय त्रिज्या r का मान $\frac{p}{qB}$ के बराबर होता है ।

16. *अभिकथन (A) :* कोई उत्तल लेंस किसी द्रव में डुबोए जाने पर लुप्त हो जाता है ।

कारण (R) : लेंस के पदार्थ और द्रव दोनों के अपवर्तनांक समान हैं ।

खण्ड ख

17. (क) किसी चालक में मुक्त इलेक्ट्रॉनों के 'विश्रांति काल' से क्या तात्पर्य है ? यह दर्शाइए कि किसी चालक के प्रतिरोध को $R = \frac{m l}{n e^2 \tau A}$ द्वारा व्यक्त किया जा सकता है, यहाँ प्रतीकों के अपने सामान्य अर्थ हैं । *2*

अथवा

(ख) किसी व्हीटस्टोन सेतु का परिपथ आरेख खींचिए । वह शर्त प्राप्त कीजिए जब इस परिपथ के गैल्वेनोमीटर से कोई धारा प्रवाहित नहीं होती है । *2*

18. किसी खगोलीय दूरदर्शक की आवर्धन क्षमता 24 है । सामान्य समायोजन में, इसके दो लेंसों के बीच की दूरी 150 cm है । अभिदृश्यक लेंस की फोकस दूरी ज्ञात कीजिए । *2*

14. *Assertion (A) :* Photoelectric effect demonstrates the particle nature of light.

Reason (R) : Photoelectric current is proportional to frequency of incident radiation.

15. *Assertion (A) :* A proton and an electron enter a uniform magnetic field $\vec{B}$ with the same momentum $\vec{p}$ such that $\vec{p}$ is perpendicular to $\vec{B}$. They describe circular paths of the same radius.

Reason (R) : In a magnetic field, orbital radius r is equal to $\frac{p}{qB}$.

16. *Assertion (A) :* A convex lens, when immersed in a liquid, disappears.

Reason (R) : The refractive indices of material of the lens and the liquid are equal.

SECTION B

17. (a) What is meant by 'relaxation time' of free electrons in a conductor ? Show that the resistance of a conductor can be expressed by $R = \frac{m l}{n e^2 \tau A}$, where symbols have their usual meanings. *2*

OR

(b) Draw the circuit diagram of a Wheatstone bridge. Obtain the condition when no current flows through the galvanometer in it. *2*

18. The magnifying power of an astronomical telescope is 24. In normal adjustment, distance between its two lenses is 150 cm. Find the focal length of the objective lens. *2*

19. संतत (स्थायी) व्यतिकरण पैटर्न किसे कहते हैं ? इस प्रकार के व्यतिकरण पैटर्न को प्राप्त करने की शर्तें क्या हैं ? *2*

20. पोटैशियम (कार्य-फलन 2·3 eV) पर 600 nm तरंगदैर्घ्य का प्रकाश आपतन करता है । क्या इलेक्ट्रॉनों का प्रकाशिक-उत्सर्जन होगा ? वह सबसे लम्बी तरंगदैर्घ्य क्या है जो इलेक्ट्रॉनों का प्रकाशिक-उत्सर्जन करेगी ? (hc = 1240 eV. nm लीजिए) *2*

21. मान लीजिए किसी शुद्ध Si क्रिस्टल में प्रति घन मीटर 5×10^{28} परमाणु हैं । इसका मादन बोरॉन की 1 ppm सांद्रता द्वारा किया गया है । होलों और इलेक्ट्रॉनों की सांद्रता परिकलित कीजिए, दिया गया है $n_i = 1{\cdot}5 \times 10^{16}\ m^{-3}$ । क्या यह मादित क्रिस्टल n-प्रकार का है अथवा p-प्रकार का, उल्लेख कीजिए । *2*

खण्ड ग

22. जब किसी तार के सिरों पर 1·0 V विभवान्तर अनुप्रयुक्त किया जाता है, तो उससे 1·6 A की धारा प्रवाहित होती है । इस तार की लम्बाई 1·0 m तथा इसकी अनुप्रस्थ-काट का क्षेत्रफल $1{\cdot}0 \times 10^{-7}\ m^2$ है । परिकलित कीजिए : *3*

(क) तार के सिरों के बीच विद्युत क्षेत्र

(ख) धारा घनत्व

(ग) औसत विश्रान्ति काल (τ)

(तार में मुक्त इलेक्ट्रॉनों का संख्या घनत्व $9{\cdot}0 \times 10^{28}\ m^{-3}$ है)

23. कोई इलेक्ट्रॉन (आवेश – e, द्रव्यमान m) किसी हाइड्रोजन परमाणु में नाभिक की परिक्रमा त्रिज्या r के वृत्त में कर रहा है । कक्षीय कोणीय संवेग $\vec{L}$ के पदों में चुम्बकीय द्विध्रुव आघूर्ण $\vec{\mu_e}$ के लिए सदिश रूप में व्यंजक व्युत्पन्न कीजिए । घूर्ण चुम्बकीय अनुपात किसे कहते हैं ? *3*

24. सिद्ध कीजिए कि प्रेरित आवेश चुम्बकीय फ्लक्स में नेट परिवर्तन पर निर्भर करता है और फ्लक्स परिवर्तन के समय अन्तराल पर निर्भर नहीं करता है । *3*

19. What is a sustained or stable interference pattern ? What are the conditions for obtaining such an interference pattern ? *2*

20. Light of wavelength 600 nm is incident on potassium (work function 2·3 eV). Will photoemission of electrons occur ? What is the longest wavelength that will cause photoemission of electrons ? *2*

(Take hc = 1240 eV. nm)

21. Suppose a pure Si crystal has 5×10^{28} atoms m^{-3}. It is doped by 1 ppm concentration of boron. Calculate the concentration of holes and electrons, given that $n_i = 1{\cdot}5 \times 10^{16}$ m^{-3}. Is the doped crystal n-type or p-type ? *2*

SECTION C

22. A current of 1·6 A flows through a wire when a potential difference of 1·0 V is applied across it. The length and cross-sectional area of the wire are 1·0 m and $1{\cdot}0 \times 10^{-7}$ m^2 respectively. Calculate : *3*

(a) Electric field across the wire

(b) Current density

(c) Average relaxation time (τ)

(Number density of free electrons in the wire is $9{\cdot}0 \times 10^{28}$ m^{-3})

23. An electron (charge – e, mass m) is revolving around a nucleus, in a hydrogen atom, in a circle of radius r. Derive an expression, in vector form, for the magnetic dipole moment, $\vec{\mu}_e$ in terms of its orbital angular momentum $\vec{L}$. What is gyromagnetic ratio ? *3*

24. Prove that induced charge depends on the net change in the magnetic flux and not on the time interval of the flux change. *3*

25. निर्वात में किसी विद्युत-चुम्बकीय तरंग के विद्युत क्षेत्र को इस प्रकार दिया गया है :

$$\vec{E} = (6{\cdot}3 \text{ N/C}) [\cos (1{\cdot}5 \text{ rad/m}) y + (4{\cdot}5 \times 10^8 \text{ rad/s}) t] \hat{i}$$

(क) तरंग की तरंगदैर्घ्य और आवृत्ति ज्ञात कीजिए ।

(ख) इस तरंग के चुम्बकीय क्षेत्र का आयाम क्या है ?

(ग) इस तरंग के चुम्बकीय क्षेत्र के लिए व्यंजक लिखिए । *3*

26. हाइड्रोजन परमाणु के लिए बोर के सिद्धांत का दूसरा अभिगृहीत लिखिए । सिद्ध कीजिए कि किसी हाइड्रोजन परमाणु की बोर कक्षा की त्रिज्या n^2 के अनुक्रमानुपाती होती है, जहाँ n मुख्य क्वान्टम संख्या है । *3*

27. (क) परमाणु द्रव्यमान मात्रक (u) को परिभाषित कीजिए ।

(ख) किसी ड्यूटेरॉन को इसके अवयवों (प्रोटॉन और न्यूट्रॉन) में पृथक् करने के लिए आवश्यक ऊर्जा परिकलित कीजिए । दिया गया है : *3*

$m(D) = 2{\cdot}014102 \text{ u}$

$m_H = 1{\cdot}007825 \text{ u}$

$m_n = 1{\cdot}008665 \text{ u}$

28. (क) किसी p-n संधि डायोड का V – I अभिलाक्षणिक प्राप्त करने के लिए परिपथ आरेख खींचिए । (i) अग्रदिशिक बायस, और (ii) पश्चदिशिक बायस में V – I अभिलाक्षणिक के मुख्य लक्षणों की संक्षेप में व्याख्या कीजिए । *3*

अथवा

(ख) ऊर्जा बैण्ड आरेखों के आधार पर किसी (i) विद्युतरोधी, (ii) अर्धचालक और (iii) चालक के बीच विभेदन कीजिए । *3*

25. The electric field in an electromagnetic wave in vacuum is given by :

$$\vec{E} = (6{\cdot}3 \text{ N/C}) [\cos (1{\cdot}5 \text{ rad/m}) y + (4{\cdot}5 \times 10^8 \text{ rad/s}) t] \hat{i}$$

(a) Find the wavelength and frequency of the wave.

(b) What is the amplitude of the magnetic field of the wave ?

(c) Write an expression for the magnetic field of this wave. *3*

26. State Bohr's second postulate for his theory of hydrogen atom. Prove that the radius of Bohr's orbit of a hydrogen atom is directly proportional to n^2, where n is the principal quantum number. *3*

27. (a) Define atomic mass unit (u).

(b) Calculate the energy required to separate a deuteron into its constituent parts (a proton and a neutron). Given : *3*

$m(D) = 2{\cdot}014102$ u

$m_H = 1{\cdot}007825$ u

$m_n = 1{\cdot}008665$ u

28. (a) Draw the circuit diagrams for obtaining the V – I characteristics of a p-n junction diode. Explain briefly the salient features of the V – I characteristics in (i) forward biasing, and (ii) reverse biasing. *3*

OR

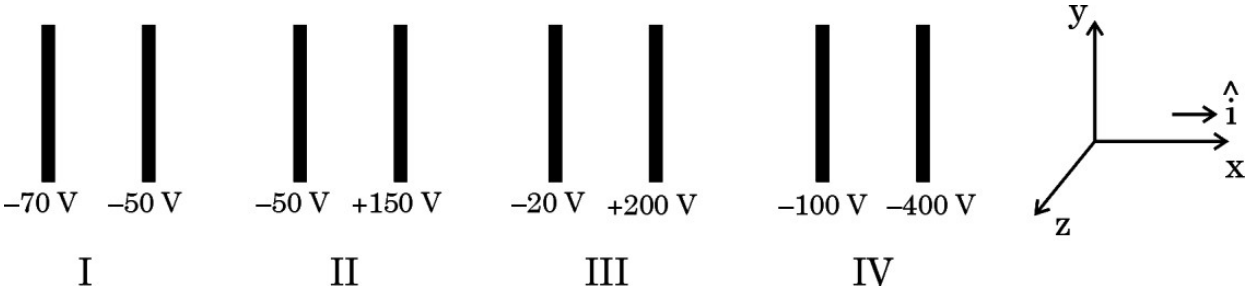
(b) On the basis of energy band diagrams, distinguish between (i) an insulator, (ii) a semiconductor, and (iii) a conductor. *3*

खण्ड घ

प्रकरण अध्ययन आधारित प्रश्न

*प्रश्न संख्या **29** तथा **30** प्रकरण अध्ययन आधारित प्रश्न हैं । निम्नलिखित अनुच्छेदों को पढ़ कर दिए गए प्रश्नों के उत्तर दीजिए ।*

29. आरेख में समान्तर सर्वसम चालक पट्टिकाओं के चार जोड़े, जिनमें सभी में पट्टिकाओं के बीच 2·0 cm दूरी का समान पृथकन है, x-अक्ष के लम्बवत् व्यवस्थित किए गए हैं । प्रत्येक पट्टिका का विद्युत विभव अंकित है । पट्टिकाओं के किसी जोड़े के बीच विद्युत क्षेत्र एकसमान है तथा पट्टिकाओं के अभिलम्बवत् है ।



(i) पट्टिकाओं के किस जोड़े के लिए विद्युत क्षेत्र $\vec{E}$, $\hat{i}$ के अनुदिश है ? *1*

(A) I (B) II

(C) III (D) IV

(ii) किसी इलेक्ट्रॉन को जोड़े IV की पट्टिकाओं के बीच मध्य मुक्त किया गया है । यह : *1*

(A) नियत चाल से $\hat{i}$ के अनुदिश गमन करेगा

(B) नियत चाल से $-\hat{i}$ के अनुदिश गमन करेगा

(C) $\hat{i}$ के अनुदिश त्वरित होगा

(D) $-\hat{i}$ के अनुदिश त्वरित होगा

(iii) मान लीजिए किसी भी सेट की बायीं पट्टिका जिसे $x = 0$ m पर लिया गया है, पर विभव V_0 है । तब उन पट्टिकाओं के बीच सेट के किसी बिन्दु $(0 \le x \le 2$ cm) पर विभव V को इस प्रकार व्यक्त किया जा सकता है : *1*

(A) $V = V_0 + \alpha x$ (B) $V = V_0 + \alpha x^2$

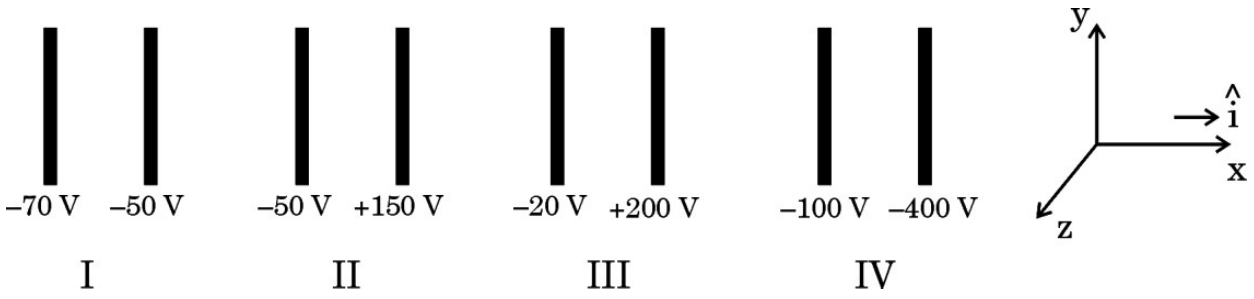
(C) $V = V_0 + \alpha x^{1/2}$ (D) $V = V_0 + \alpha x^{3/2}$

यहाँ α कोई धनात्मक अथवा ऋणात्मक नियतांक है ।

SECTION D
Case Study Based Questions

*Questions number **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.*

29. The figure shows four pairs of parallel identical conducting plates, separated by the same distance 2·0 cm and arranged perpendicular to x-axis. The electric potential of each plate is mentioned. The electric field between a pair of plates is uniform and normal to the plates.



(i) For which pair of the plates is the electric field $\vec{E}$ along $\hat{i}$? *1*

(A) I (B) II

(C) III (D) IV

(ii) An electron is released midway between the plates of pair IV. It will : *1*

(A) move along $\hat{i}$ at constant speed

(B) move along $-\hat{i}$ at constant speed

(C) accelerate along $\hat{i}$

(D) accelerate along $-\hat{i}$

(iii) Let V_0 be the potential at the left plate of any set, taken to be at x = 0 m. Then potential V at any point ($0 \le x \le 2$ cm) between the plates of that set can be expressed as : *1*

(A) $V = V_0 + \alpha x$ (B) $V = V_0 + \alpha x^2$

(C) $V = V_0 + \alpha x^{1/2}$ (D) $V = V_0 + \alpha x^{3/2}$

where α is a constant, positive or negative.

(iv) (क) मान लीजिए पट्टिकाओं के जोड़ों I, II, III और IV के बीच विद्युत क्षेत्रों के परिमाण क्रमश: E_1, E_2, E_3 और E_4 हैं । तब : *1*

(A) $E_1 > E_2 > E_3 > E_4$ (B) $E_3 > E_4 > E_1 > E_2$

(C) $E_4 > E_3 > E_2 > E_1$ (D) $E_2 > E_3 > E_4 > E_1$

अथवा

(ख) किसी इलेक्ट्रॉन को सेट I की दायीं पट्टिका से सीधे ही बायीं पट्टिका की ओर प्रक्षेपित किया गया है । यह ठीक पट्टिका पर विराम में आ जाता है । जिस चाल से इसे प्रक्षेपित किया गया था वह है लगभग : *1*
($e/m = 1{\cdot}76 \times 10^{11}$ C/kg लीजिए)

(A) $1{\cdot}3 \times 10^5$ m/s (B) $2{\cdot}6 \times 10^6$ m/s

(C) $6{\cdot}5 \times 10^5$ m/s (D) $5{\cdot}2 \times 10^7$ m/s

30. विवर्तन और व्यतिकरण निकटतम परिघटनाएँ हैं जो एक साथ घटती हैं । विवर्तन ऐसी परिघटना है जिसमें प्रकाश बाधा के कोणों (शीर्षों) पर झुकता है, जबकि प्रकाश के व्यतिकरण में तरंगों के संयोजन से एक नया तरंग पैटर्न बनता है । व्यतिकरण के लिए कम-से-कम विवर्तन करती दो तरंगों का होना आवश्यक है । अत: विवर्तन बिना व्यतिकरण के हो सकता है, जबकि व्यतिकरण बिना विवर्तन के नहीं हो सकता है ।

किसी अपारदर्शी पदार्थ में दो झिरियाँ हैं, जिनमें प्रत्येक की चौड़ाई 2 μm है तथा उनके बीच की दूरी 6 μm है, झिरियों पर तरंगदैर्घ्य 450 nm के एकवर्णी प्रकाश का लम्बवत् आपतन कराकर परदे पर संयुक्त व्यतिकरण और विवर्तन पैटर्न प्राप्त होता है ।

(i) विवर्तन पैटर्न के आवरण के केन्द्रीय शीर्ष के भीतर बनने वाले व्यतिकरण फ्रिंजों के शीर्षों की संख्या होगी : *1*

(A) 2 (B) 3

(C) 4 (D) 6

(ii) झिरियों के बीच की दूरी को समान रखते हुए यदि झिरियों की चौड़ाई दो गुनी कर दें, तो बनने वाले व्यतिकरण के शीर्षों की संख्या होगी : *1*

(A) 1 (B) 2

(C) 3 (D) 4

(iv) (a) Let E_1, E_2, E_3 and E_4 be the magnitudes of the electric field between the pairs of plates, I, II, III and IV respectively. Then : *1*

(A) $E_1 > E_2 > E_3 > E_4$ (B) $E_3 > E_4 > E_1 > E_2$

(C) $E_4 > E_3 > E_2 > E_1$ (D) $E_2 > E_3 > E_4 > E_1$

OR

(b) An electron is projected from the right plate of set I directly towards its left plate. It just comes to rest at the plate. The speed with which it was projected is about :
(Take (e/m) $=1{\cdot}76 \times 10^{11}$ C/kg) *1*

(A) $1{\cdot}3 \times 10^5$ m/s (B) $2{\cdot}6 \times 10^6$ m/s

(C) $6{\cdot}5 \times 10^5$ m/s (D) $5{\cdot}2 \times 10^7$ m/s

30. Diffraction and interference are closely related phenomena that occur together. Diffraction is the phenomenon of bending of light around the edges of the obstacle, while interference is the combination of waves that results in a new wave pattern. In order to get interference, there must be at least two waves that are diffracting. So while diffraction can occur without interference, interference cannot occur without diffraction.

Two slits of width 2 μm each in an opaque material are separated by a distance of 6 μm. Monochromatic light of wavelength 450 nm is incident normally on the slits. One finds a combined interference and diffraction pattern on the screen.

(i) The number of peaks of the interference fringes formed within the central peak of the envelope of the diffraction pattern will be : *1*

(A) 2 (B) 3

(C) 4 (D) 6

(ii) The number of peaks of the interference formed if the slit width is doubled while keeping the distance between the slits same will be : *1*

(A) 1 (B) 2

(C) 3 (D) 4

(iii) (क) यदि 450 nm के स्थान पर 680 nm तरंगदैर्ध्य के प्रकाश का एक अन्य प्रकाश प्रयोग किया जाता है, तो विवर्तन पैटर्न के आवरण के केन्द्रीय शीर्ष में बनने वाले व्यतिकरण के शीर्षों की संख्या होगी : *1*

(A) 2 (B) 4

(C) 6 (D) 9

अथवा

(ख) इस प्रकरण अध्ययन में वर्णित एकल झिरी द्वारा प्रकाश के विवर्तन पर विचार कीजिए । पहला निम्निष्ठ जिस कोण θ पर गिरेगा, वह कोण है : *1*

(A) $\sin^{-1}(0{\cdot}12)$ (B) $\sin^{-1}(0{\cdot}225)$

(C) $\sin^{-1}(0{\cdot}32)$ (D) $\sin^{-1}(0{\cdot}45)$

(iv) झिरियों से $\frac{4}{3}$ m की दूरी पर स्थित परदे के 1 m पर व्यतिकरण के कारण बनने वाली चमकीली फ्रिंज़ों की संख्या है : *1*

(A) 2 (B) 3

(C) 6 (D) 10

खण्ड ङ

31. (क) (i) किसी समान्तर पट्टिका संधारित्र, जिसकी पट्टिकाओं के बीच कोई परावैद्युत माध्यम है, की धारिता के लिए व्यंजक प्राप्त कीजिए ।

(ii) 0·2 m त्रिज्या के किसी धात्विक खोखले गोले को 6 μC आवेश दिया गया है । इस गोले के (i) पृष्ठ और (ii) केन्द्र पर विभव ज्ञात कीजिए । *5*

अथवा

(ख) (i) त्रिज्या R के किसी पतले चालक गोलीय खोल पर + Q आवेश स्थित है । गाउस के प्रमेय का उपयोग करके खोल के किसी बिन्दु (i) जो खोल के भीतर है, तथा (ii) जो खोल से बाहर है, पर विद्युत क्षेत्र के लिए व्यंजक व्युत्पन्न कीजिए ।

(ii) यह दर्शाइए कि समान आवेश घनत्व (σ) के लिए चालक पट्टिका अथवा पृष्ठ के प्रकरण में विद्युत क्षेत्र किसी कुचालक शीट के विद्युत क्षेत्र का दो गुना होता है । *5*

(iii) (a) If instead of 450 nm light, another light of wavelength 680 nm is used, number of peaks of the interference formed in the central peak of the envelope of the diffraction pattern will be : *1*

(A) 2 (B) 4

(C) 6 (D) 9

OR

(b) Consider the diffraction of light by a single slit described in this case study. The first minimum falls at an angle θ equal to : *1*

(A) $\sin^{-1}(0{\cdot}12)$ (B) $\sin^{-1}(0{\cdot}225)$

(C) $\sin^{-1}(0{\cdot}32)$ (D) $\sin^{-1}(0{\cdot}45)$

(iv) The number of bright fringes formed due to interference on 1 m of screen placed at $\frac{4}{3}$ m away from the slits is : *1*

(A) 2 (B) 3

(C) 6 (D) 10

SECTION E

31. (a) (i) Obtain the expression for the capacitance of a parallel plate capacitor with a dielectric medium between its plates.

(ii) A charge of 6 μC is given to a hollow metallic sphere of radius 0·2 m. Find the potential at (i) the surface and (ii) the centre of the sphere. *5*

OR

(b) (i) A charge + Q is placed on a thin conducting spherical shell of radius R. Use Gauss's theorem to derive an expression for the electric field at a point lying (i) inside and (ii) outside the shell.

(ii) Show that the electric field for same charge density (σ) is twice in case of a conducting plate or surface than in a nonconducting sheet. *5*

32. (क) (i) (1) किसी गैल्वेनोमीटर की धारा सुग्राहिता से क्या तात्पर्य है ? उन कारकों का उल्लेख कीजिए जिन पर यह निर्भर करती है ।

(2) किसी गैल्वेनोमीटर जिसका प्रतिरोध G है, को किसी प्रतिरोध R का उपयोग करके (0 – V) परिसर के वोल्टमीटर में परिवर्तित किया गया है । इसी गैल्वेनोमीटर को $\left(0 - \frac{V}{2}\right)$ परिसर के वोल्टमीटर में परिवर्तित करने के लिए आवश्यक प्रतिरोध का मान, R और G के पदों में ज्ञात कीजिए ।

(ii) 5 Ω प्रतिरोध की किसी कुण्डली से गुज़रने वाले चुम्बकीय फ्लक्स में समय के साथ इस प्रकार वृद्धि होती है :

$$\phi = (2{\cdot}0\ t^3 + 5{\cdot}0\ t^2 + 6{\cdot}0\ t)\ \text{mWb}$$

t = 2 s पर कुण्डली में प्रेरित धारा का परिमाण ज्ञात कीजिए । *5*

अथवा

(ख) (i) N फेरों तथा अनुप्रस्थ-काट क्षेत्रफल A की किसी आयताकार कुण्डली को स्थायी कोणीय चाल ω से किसी एकसमान चुम्बकीय क्षेत्र में घूर्णन कराया गया है । किसी भी समय पर कुण्डली में प्रेरित वि.वा. बल (emf) के लिए व्यंजक प्राप्त कीजिए ।

(ii) दो समतलीय तथा संकेन्द्री वृत्ताकार पाश L_1 और L_2 अपने केन्द्रों को संपाती रखते हुए समाक्ष स्थित हैं । L_1 और L_2 की त्रिज्याएँ क्रमश: 1 cm और 100 cm हैं । इन पाशों का अन्योन्य प्रेरकत्व परिकलित कीजिए । ($\pi^2 = 10$ लीजिए) *5*

33. (क) (i) किसी त्रिभुजाकार प्रिज़्म से अपवर्तन को दर्शाने वाली प्रकाश किरण का पथ आरेखित कीजिए और A, i और e के पदों में विचलन कोण (δ) के लिए व्यंजक प्राप्त कीजिए । यहाँ प्रतीकों के अपने सामान्य अर्थ हैं । आपतन कोण के साथ विचलन कोण के विचरण को दर्शाने के लिए ग्राफ खींचिए ।

32. (a) (i) (1) What is meant by current sensitivity of a galvanometer ? Mention the factors on which it depends.

(2) A galvanometer of resistance G is converted into a voltmeter of range (0 – V) by using a resistance R. Find the resistance, in terms of R and G, required to convert it into a voltmeter of range $\left(0 - \frac{V}{2}\right)$.

(ii) The magnetic flux through a coil of resistance 5 Ω increases with time as :

$$\phi = (2{\cdot}0\ t^3 + 5{\cdot}0\ t^2 + 6{\cdot}0\ t)\ \text{mWb}$$

Find the magnitude of induced current through the coil at t = 2 s. *5*

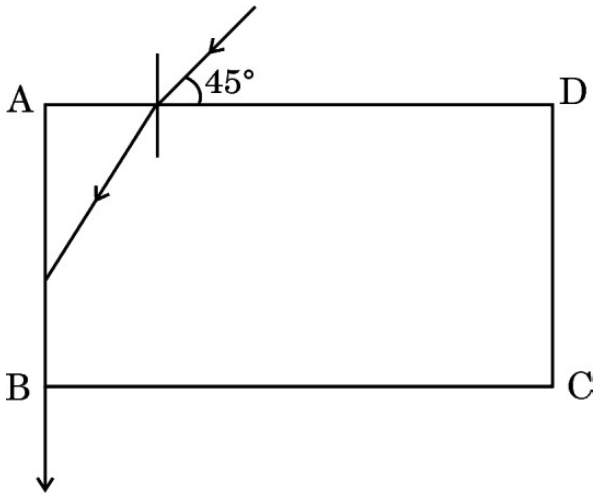
OR

(b) (i) A rectangular coil of N turns and area of cross-section A is rotated at a steady angular speed ω in a uniform magnetic field. Obtain an expression for the emf induced in the coil at any instant of time.

(ii) Two coplanar and concentric circular loops L_1 and L_2 are placed coaxially with their centres coinciding. The radii of L_1 and L_2 are 1 cm and 100 cm respectively. Calculate the mutual inductance of the loops. (Take $\pi^2 = 10$) *5*

33. (a) (i) Trace the path of a ray of light showing refraction through a triangular prism and hence obtain an expression for angle of deviation (δ) in terms of A, i and e, where symbols have their usual meanings. Draw a graph showing the variation of angle of deviation with the angle of incidence.

(ii) आरेख में कोई प्रकाश किरण किसी पारदर्शी द्रव से भरे पतले काँच के बॉक्स पर उसके एक फलक से $45°$ के कोण पर आपतन करती है । निर्गत किरण फलक AB के अनुदिश गमन करती है । द्रव का अपवर्तनांक ज्ञात कीजिए । *5*

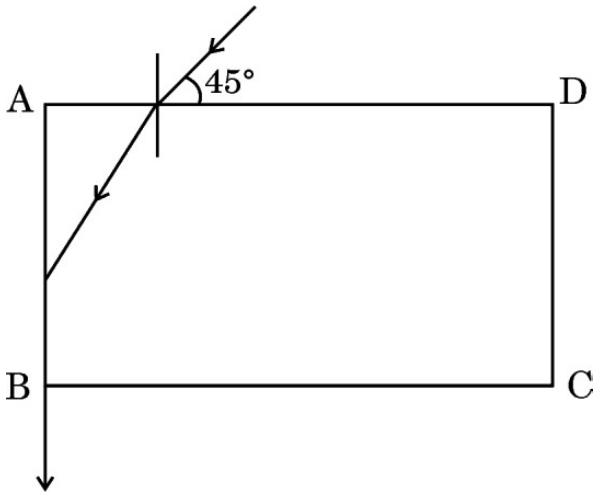


अथवा

(ख) (i) दो कला-संबद्ध प्रकाश स्रोतों से निकलने वाली दो प्रकाश तरंगों, जिनमें प्रत्येक का आयाम 'a' तथा आवृत्ति ω है, के विस्थापन $y_1 = a \cos \omega t$ और $y_2 = a \cos (\omega t + \phi)$ द्वारा निरूपित किए गए हैं । यहाँ ϕ दोनों तरंगों के बीच कलान्तर है । ये दोनों प्रकाश तरंगें किसी बिन्दु पर अध्यारोपण करती हैं । उस बिन्दु पर परिणामी तीव्रता के लिए व्यंजक प्राप्त कीजिए ।

(ii) यंग के द्विझिरी प्रयोग में, जब दो झिरियों से निकलने वाली तरंगें किसी परदे के दो बिन्दुओं पर (i) $\frac{\lambda}{6}$ और (ii) $\frac{\lambda}{12}$ के पथान्तर पर पहुँचती हैं, तो इन बिन्दुओं पर तीव्रताओं का अनुपात ज्ञात कीजिए । *5*

(ii) In the figure, a ray of light is incident on a transparent liquid contained in a thin glass box at an angle of 45° with its one face. The emergent ray passes along the face AB. Find the refractive index of the liquid. *5*



OR

(b) (i) The displacement of two light waves, each of amplitude 'a' and frequency ω, emanating from two coherent sources of light, are given by $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$. ϕ is the phase difference between the two waves. These light waves superpose at a point. Obtain the expression for the resultant intensity at that point.

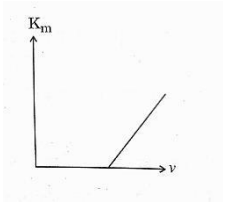
(ii) In Young's double slit experiment, find the ratio of intensities at two points on a screen when waves emanating from two slits reaching these points have path differences (i) $\frac{\lambda}{6}$ and (ii) $\frac{\lambda}{12}$. *5*

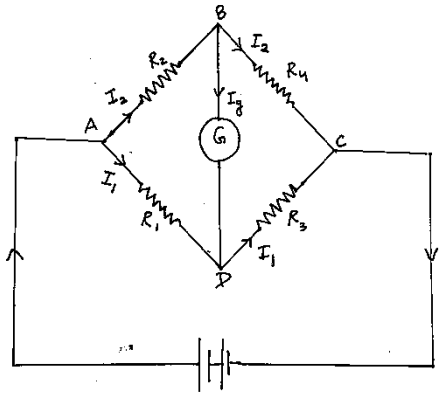
Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior School Certificate Examination, 2024
SUBJECT PHYSICS (CODE 55/3/1)

General Instructions: -

1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers. These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after delibration and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark(√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right (**✓**)while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.

9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 0-70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

MARKING SCHEME : PHYSICS (042)			
CODE :55/3/1			
Q.NO.	**VALUE POINTS/ EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	SECTION-A		
1.	(B) Spherical surface	**1**	**1**
2.	(B) 1.6×10^{-18} J	**1**	**1**
3.	(C) –(0.24 nT) $\hat{k}$	**1**	**1**
4.	(D) remain stationary	**1**	**1**
5.	(B) 0.3 MB	**1**	**1**
6.	(C) 15.0 V	**1**	**1**
7.	(B) l is decreased and A is increased	**1**	**1**
8.	(B) Gamma rays	**1**	**1**
9.	(B) 2	**1**	**1**
10.	(C) 	**1**	**1**
11.	(B) decreased by 87.5%	**1**	**1**
12.	(B) 0.05 eV	**1**	**1**
13.	(D) Assertion (A) is false and Reason (R) is also false.	**1**	**1**
14.	(C) Assertion (A) is true but Reason (R) is false.	**1**	**1**
15.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion(A).	**1**	**1**
16.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion(A).	**1**	**1**
	SECTION- B		
17.	**(a)** Meaning of relaxation time ½ Derivation of R 1 ½ Average time between two successive collisions of electron in presence of electric field Drift velocity of an electron $\upsilon_d = \frac{eE}{m}\tau \quad ---(i)$ Current flowing through a conductor of length l and area of cross section A $I = neA\upsilon_d \quad ---(ii)$ $I = \frac{ne^2AE\tau}{m} = \frac{ne^2A\tau V}{ml}$ $R = \frac{V}{I} = \frac{ml}{ne^2\tau A}$ **OR** **(b)** Circuit diagram of Wheatstone bridge ½ Obtaining the condition when no current flows through galvanometer 1½	½ ½ ½ ½	**2**



By applying Kirchoff's loop rule to closed loops ADBA and CBDC

$-I_1R_1 + 0 + I_2R_2 = 0$ -----(i) $[I_g = 0]$ ½

$I_2R_4 + 0 - I_1R_3 = 0$ -----(ii) ½

From eq (i)-

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$ ½

From eq (ii)-

$$\frac{I_1}{I_2} = \frac{R_4}{R_3}$$

Hence,

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$ ½ **2**

18.

Finding the focal length of objective lens 2

Magnifying power = 24 , Distance between lenses =150 cm

$\frac{f_o}{f_e} = 24$ ½

$f_o + f_e = 150\,\text{cm}$ ½

$f_e = 6\,\text{cm}$ ½

$f_o = 144\,\text{cm}$ ½ **2**

19.

(a) Explanation of magnification 1
(b) Explanation 1

(a) Yes, it offers magnification. ½

We can keep the small object much closer to the eye than 25 cm and hence have it subtend a large angle. ½

(b) Yes, ½

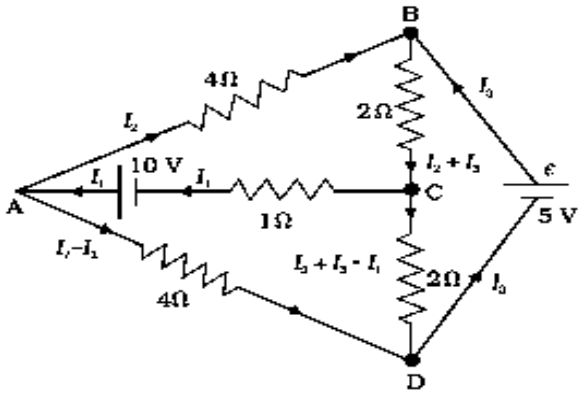
Rays converging to a point behind a plane or convex mirror are reflected to a point in front of the mirror on a screen ½ **2**

20.

Calculation of number of photons per second 2

Total Energy gained per second from photon= IA

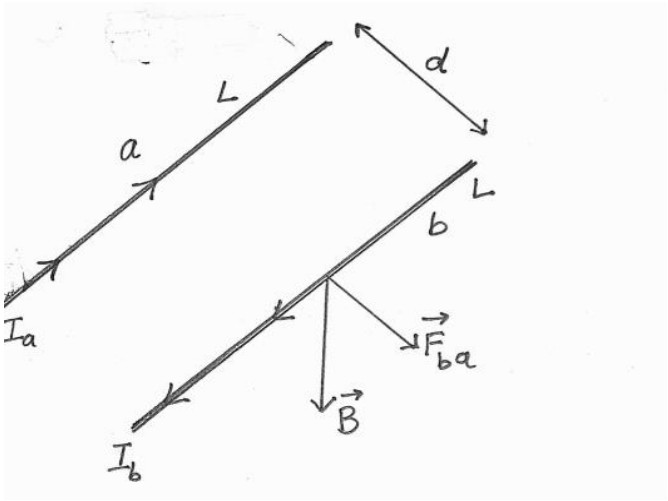
$E = N\,h\nu$ ½

	$IA = N \times \frac{hc}{\lambda}$ $N = \frac{[IA]\lambda}{hc}$ $N = \frac{[0.1\times10^{-9}\times0.4\times10^{-4}]\times500\times10^{-9}}{6.6\times10^{-34}\times3\times10^{8}}$ $N = 1.01\times10^{4}$	1 ½	2
21.	Calculation of concentration of holes & electrons 2 $n_e n_h = n_i^2$ $n_h \approx 5\times10^{22}/m^3$ $n_e = \frac{n_i^2}{n_h}$ $n_e = \frac{(1.5\times10^{16})^2}{5\times10^{22}}$ $n_e = 4.5\times10^{9}/m^3$ $n_h > n_e$, it is a p- type crystal	½ ½ ½ ½	2
	SECTION- C		
22.	Determination of current in branches AB, AC, BC 1+1+1  For closed loop ADCA , $10-4(I_1-I_2)+2(I_2+I_3-I_1)-I_1=0$ $7I_1-6I_2-2I_3=10$ ------(i) For closed loop ABCA , $10-4I_2-2(I_2+I_3)-I_1=0$ $I_1+6I_2+2I_3=10$ ------(ii) For closed loop BCDED , $5-2(I_2+I_3)-2(I_2+I_3-I_1)=0$ $2I_1-4I_2-4I_3=-5$ -----(iii) Current in branch AB = $I_2=\frac{5}{8}A$ Current in branch AC = $I_1=2.5A$ Current in branch BC = $I_2+I_3=2.5A$	½ ½ ½ ½ ½ ½	3

23.

Reason for exerting force on straight parallel conductors	½
Derivation for force per unit length	2
Explanation of nature of Force	½

One conductor experiences a force due to magnetic field of the other conductor ½



½

Magnetic field produced by conductor 'a' at all points along the length of conductor 'b'

$$B_a = \frac{\mu_0 I_a}{2\pi d}$$ ½

Force on conductor 'b' due to this magnetic field

$$F_{ba} = I_b L B_a$$ ½

$$F_{ba} = \frac{\mu_0 I_a I_b L}{2\pi d}$$

$$f_{ba} = \frac{F_{ba}}{L} = \frac{\mu_0 I_a I_b}{2\pi d}$$ directed away from a ½

$$f_{ab} = \frac{F_{ab}}{L} = \frac{\mu_0 I_a I_b}{2\pi d}$$ directed away from b

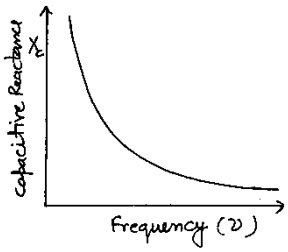
Repulsive, the forces acting on them are away from each other. ½ **3**

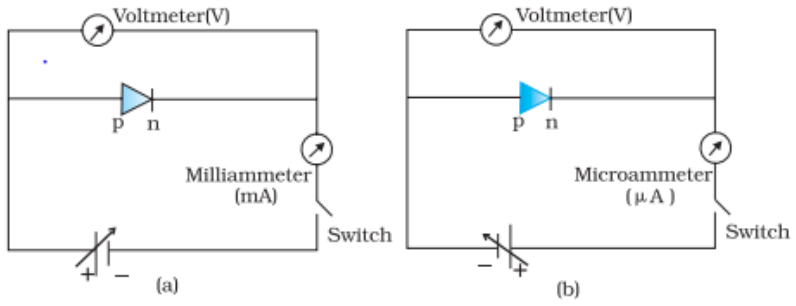
24.

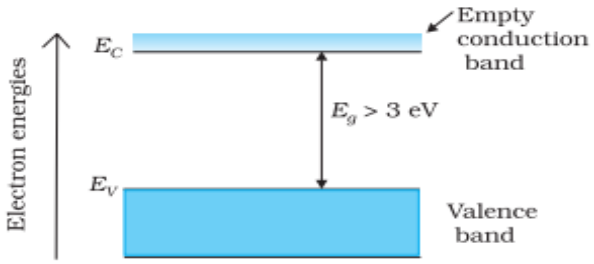
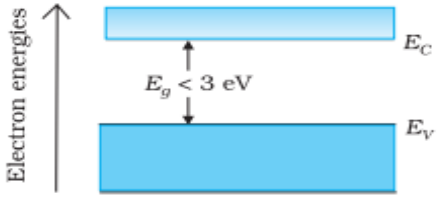
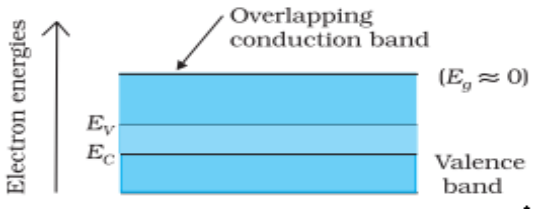
(a) Identifying the element X	½
(b) Writing the formula for reactance	½
(c) Showing variation of reactance with frequency	1
(d) Explanation of behavior of element with	
(i) an ac circuit	½
(ii) a dc circuit	½

(a) Capacitor ½

(b) $X_c = \frac{1}{\omega c}$ ½

	(c)  	**1**	
	(d) (i) For ac X_c is finite and therefore allows the ac to pass. (ii) For dc X_c is infinite and therefore does not allow the dc to pass.	½ ½	**3**
25.	(a) Finding the wavelength and frequency 1+1 (b) Finding the amplitude of magnetic field ½ (c) Writing expression for magnetic field ½ (a) $k = \frac{2\pi}{\lambda}$ $\lambda = \frac{2\pi}{K} = \frac{4\pi}{3}\text{m} = 4.18\text{m}$ $\omega = 2\pi\upsilon$ $\nu = \frac{\omega}{2\pi} = \frac{4.5\times10^{8}}{2\pi}\text{Hz}$ $\nu = \frac{9}{4\pi}\times10^{8}\text{ Hz}$ $\nu = 7.16\times10^{-1}\text{ Hz}$ (b) $B_0 = \frac{E_0}{c}$ $B_0 = \frac{6.3}{3\times10^{8}} = 2.1\times10^{-8}\text{T}$ (c) $\vec{B} = 2.1\times10^{-8}[(\cos 1.5\,\text{rad/m})\,y + (4.5\times10^{8}\,\text{rad/s})\,t]\hat{k}\,\text{T}$	½ ½ ½ ½ ½	**3**
26.	Statements of Bohr's first and second Postulates ½+½ Derivation of expression for radius of nth orbit 2 • **Bohr's first postulate** An electron in an atom revolves in certain stable orbits without the emission of radiant energy. • **Bohr's second postulate** Electron revolves around the nucleus only in those orbits for which the angular momentum is integral multiple of $\frac{h}{2\pi}$. Electrostatic force between revolving electron and nucleus provides requisite centripetal force $\frac{mv_n^2}{r_n} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_n^2}$	½ ½ ½	

	$v_n = \frac{e}{\sqrt{4\pi\varepsilon_0 m r_n}}$ ------(i) $mv_n r_n = \frac{nh}{2\pi}$ ------(ii) using equations (i) and (ii) $r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{e^2}$	½ ½ ½	**3**
27.	(a) Definition of atomic mass unit (u) 1 (b) Calculation of energy required 2 (a) atomic mass unit (u) is defined as 1/12th of the mass of the carbon (^{12}C) atom. (b) $m\left({}_1H^2\right) \rightarrow m\left({}_1H^1\right) + m\left({}_0n^1\right)$ $Q = (m_R - m_P) \times 931.5\,MeV$ $= (2.014102 - 1.007825 - 1.008665) \times 931.5\,MeV$ $= -0.002388 \times 931.5\,MeV$ $= -2.224\,MeV$ Hence energy required is 2.224 MeV	**1** ½ ½ ½ ½	**3**
28.	**(a)** (a) Drawing the circuit diagram for V-I characteristics 1 Salient features of V-I characteristics in (i) Forward biasing 1 (ii) Reverse biasing 1  **[any one circuit diagram]** **Salient features** (i) **Forward biasing**- After threshold voltage or cut in voltage diode current increases significantly (exponentially), even for a small increase in the diode bias voltage. (ii) **Reverse biasing**- Current is very small (~μA) and almost remains constant and it increases rapidly after breakdown voltage. **OR**	**1** **1** **1**	

	(b) Energy band diagrams Difference between (i) an insulator (ii) a semiconductor (iii) a metal 1+1+1 (i)  (ii)  (iii)  	**1** **1** **1** **3**
	SECTION- D		
29.	(i) (D) IV (ii) (D) accelerate along $-\hat{i}$ (iii) (A) V= $V_0 + \alpha x$ (iv) (a) (C) $E_4 > E_3 > E_2 > E_1$ **OR** (b) (B) 2.6×10^6 m/s	**1** **1** **1** **1**	**4**
30.	(i) (D) 6 (ii) (C) 3 (iii) (a) (C) 6 **OR** (b) $\sin^{-1}(0.225)$ (iv) (D) 10	**1** **1** **1** **1**	**4**
	SECTION-E		
31.	**(a)** (i) Obtaining expression for the capacitance 3 (ii) Finding the electric potential 2 (i) at the surface (ii) at the centre (i) When a dielectric slab is inserted between the plates of capacitor, there is induced charge density σ_P which opposes the original charge density		

(σ) on the plate of capacitance. ½

Electric field with dielectric medium is

$E = \frac{(\sigma - \sigma_P)}{\varepsilon_0}$ ½

$V = E \times d = \frac{(\sigma - \sigma_P)}{\varepsilon_0} d$ ½

$(\sigma - \sigma_P) = \frac{\sigma}{K}$ ½

$V = \frac{\sigma d}{\varepsilon_0 K} = \frac{Qd}{A\varepsilon_0 K}$ ½

$C = \frac{Q}{V} = \frac{K\varepsilon_0 A}{d}$ ½

(ii) Electric potential due to a point charge

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ ½

(i) At the surface

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{9\times10^9\times6\times10^{-6}}{0.2}$ ½

$V = 2.7 \times 10^5$ V ½

(ii) Since electric field inside the hollow sphere is zero, hence V is same as that of the surface and remains constant throughout the volume. ½

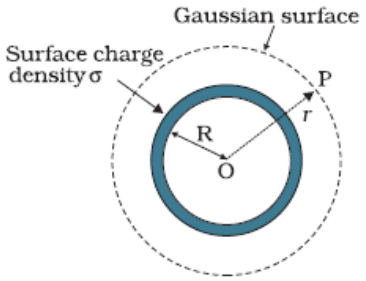
$V = 2.7 \times 10^5$ V

OR

(b)

(i) Expression for electric field at a point lying	
(i) inside	1
(ii) outside	2
(ii) Explanation	2

(i) <u>Field inside the shell</u>



The Flux through the Gaussian surface is

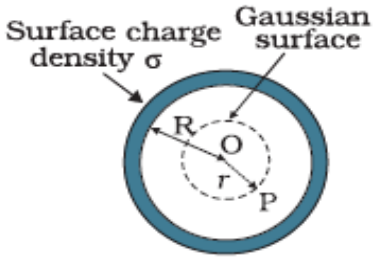
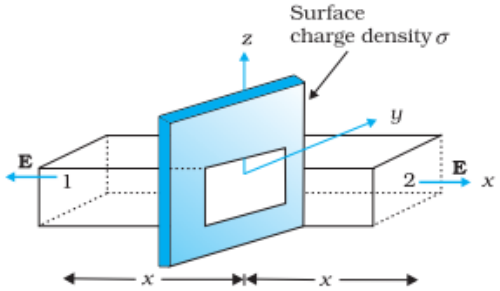
$= E \times 4\pi R^2$ ½

In this case Gaussian surface encloses no charge.

Hence $E \times 4\pi R^2 = 0$

$E = 0$ ½

(Note: Award full credit of this part if a student writes directly E=0, mentioning as there is no charge enclosed by Gaussian surface)

	(ii) <u>Field outside the shell</u>-  Electric flux through Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ Charge enclosed by the Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ Using Gauss's law: $\int \vec{E}.\overrightarrow{ds} = \frac{Q}{\varepsilon_0}$ $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ $E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2} = \frac{q}{4\pi\varepsilon_0 r^2}$ (ii) For conducting sheet, Electric field due to a conducting sheet $E_c = \frac{\sigma}{\varepsilon_0}$  For non-conducting sheet $E_{nc} = \frac{\sigma}{2\varepsilon_0}$ Since surface charge density is same. $2E_{nc} = E_c$	½ ½ ½ ½ ½ ½ ½	**5**
32.	**(a)** (i)(1) Meaning of current sensitivity, mentioning factors 2 (2) Finding the required resistance 1½ (ii) Finding the induced current 1½ (i) (1). Current sensitivity of galvanometer is defined as the deflection per unit current. **Alternatively**, $\frac{\phi}{I} = \frac{NBA}{K}$ **Factors** Number of turns in coil, Magnetic field intensity, Area of coil, Torsional Constant **(Any two)**	**1** ½+½	

(2) $R = \frac{V}{I} - G$ for (0-V) Range ½

$R_1 = \frac{V}{2I} - G$ for (0-$\frac{V}{2}$) Range ½

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

$R_1 = \left(\frac{R+G}{2}\right) - G$

$R_1 = \frac{R-G}{2}$ ½

(ii) $\phi = (2.0t^3 + 5.0t^2 + 6.0t)$ mWb

$|\varepsilon| = \frac{d\phi}{dt} = 50 \times 10^{-3}$ V ½

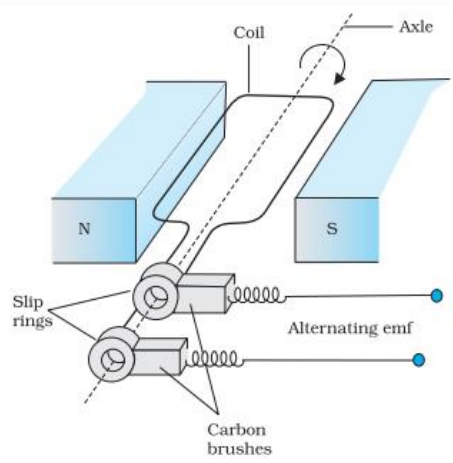
I= $\frac{|\varepsilon|}{R}$ ½

I= $\frac{50\times10^{-3}}{5}$ A=10 mA ½

OR

(b)

(i) Obtaining the expression of emf induced	3
(ii) Calculation of mutual inductance	2



1

(i) The flux at any instant t is

$\phi = NBA\cos\theta$=NBA cosωt ½

From Faraday's law

$\boldsymbol{\varepsilon = -\frac{d\phi_B}{dt}}$ ½

$= -NBA\frac{d}{dt}(\cos\omega t)$ ½

$\boldsymbol{\varepsilon} = -NBA\,\omega\sin\omega t$ ½

(ii) $M = \frac{\mu_0\pi r_1^2}{2r_2} = \frac{4\pi\times10^{-7}\times\pi r_1^2}{2r_2}$ ½+½

$= \frac{2\times10\times10^{-7}\times(10^{-2})^2}{100\times10^{-7}}$ ½

$= 2 \times 10^{-10}$ H ½

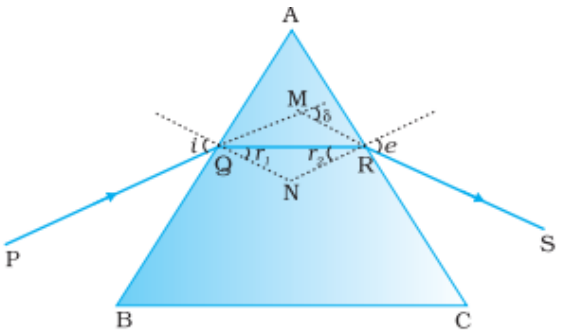
5

33.

(a)

(i) Tracing the path of ray	½
Obtaining an expression for angle of deviation	1½
Drawing Graph	1
(ii) Finding the refractive index	2

(i)



½

For quadrilateral AQNR,

$\angle A + \angle QNR = 180^o$ --- (i) ½

For triangle QNR

$r_1 + r_2 + \angle QNR = 180^o$ ---- (ii)

comparing equation (i) and (ii)

$r_1 + r_2 = A$ ------ (iii) ½

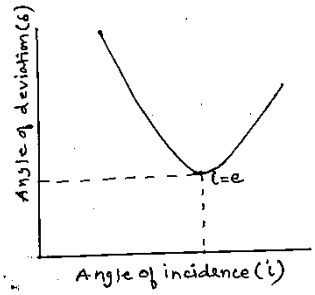
The angle of deviation

$\delta = (i - r_1) + (e - r_2)$ ------ (iv)

from equation (iii) and (iv)

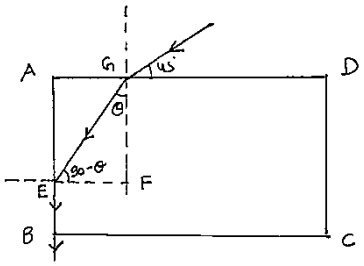
$\delta = i + e - A$ ½

Graph



1

(ii)



$\frac{sin\,45^0}{sin\,\theta} = \mu$

$\frac{1}{\sqrt{2}} = \mu\, sin\,\theta$ ½

For second surface,

$\frac{\sin(90^0 - \theta)}{\sin 90^0} = \frac{1}{\mu}$ ½

$\frac{1}{\sqrt{2}}\frac{\cos\theta}{\sin\theta} = 1$

$\tan\theta = \frac{1}{\sqrt{2}}$ ½

From the triangle GEF

$\sin\theta = \frac{1}{\sqrt{3}}$ ½

$\mu = \sqrt{\frac{3}{2}}$

OR

(b)

(i) Expression for resultant intensity	3
(ii) Ratio of intensities	2

(i) $y_1 = a\cos\omega t$

$y_2 = a\cos(\omega t + \phi)$

According to the principle of superposition

$y = y_1 + y_2$ ½

$y = a\cos\omega t + a\cos(\omega t + \phi)$

$y = a\cos\omega t + a\cos\omega t\cos\phi - a\sin\omega t\sin\phi$

$y = a\cos\omega t(1 + \cos\phi) - a\sin\phi\sin\omega t$ ½

Let,

$a(1 + \cos\phi) = A\cos\theta$ ------- (i)

$a\sin\phi = A\sin\theta$ --------(ii) ½

Squaring and adding equation (i) and (ii)

$A^2 = a^2(1+\cos\phi)^2 + a^2\sin^2\phi$

$= a^2(1 + \cos^2\phi + 2\cos\phi) + a^2\sin^2\phi$

$= 2a^2(1 + \cos\phi)$ ½

$= 4a^2\cos^2\phi/2$ ½

$I \alpha A^2$

$I = kA^2$

where k is constant

$I = 4ka^2\cos^2\phi/2$ ½

[Award full credit for this part for any other alternative methods]

(ii) $\phi_1 = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \pi/3$ ½

$I_1 = 4I_0\cos^2\phi/2$

$= 4I_0\cos^2(\pi/6)$

$I_1 = 3I_0$ ½

$\phi_2 = \frac{2\pi}{\lambda} \times \frac{\lambda}{12} = \pi/6$

$I_2 = 4I_0\cos^2(\pi/12)$ ½

$I_2 = 4I_0\cos^2 15^0$

$\frac{I_1}{I_2} = \frac{3}{4\cos^2 15^0}$ ½ **5**

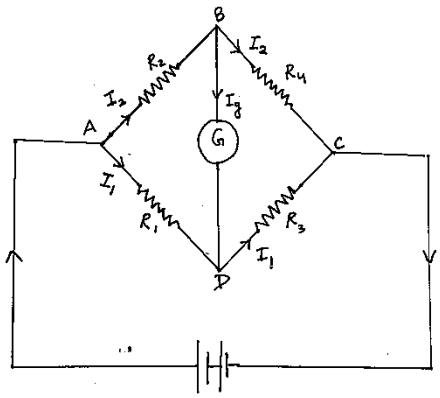
Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior School Certificate Examination, 2024
SUBJECT PHYSICS (CODE 55/3/2)

General Instructions: -

1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers. These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after delibration and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark(√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right **(✓)**while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.

9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 0-70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

	MARKING SCHEME : PHYSICS (042)		
	CODE: 55/3/2		
Q.NO.	**VALUE POINT/ EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	SECTION A		
1.	(C) –q and Q + q	**1**	**1**
2.	(B) 1.6 x 10^{-18} J	**1**	**1**
3.	(C) –(0.24nT) $\hat{k}$	**1**	**1**
4.	(D) Repel each other with a force $\frac{\mu_o I^2}{2\pi a}$, per unit length	**1**	**1**
5.	(B) 0.3 MB	**1**	**1**
6.	(D) 0.1 C	**1**	**1**
7.	(B) *l* is decreased and A is increased	**1**	**1**
8.	(C) X- rays	**1**	**1**
9.	(B) 2	**1**	**1**
10.	(C) $\phi_3 > \phi_2 > \phi_1$	**1**	**1**
11.	(B) decreases by 87.5%	**1**	**1**
12.	(B) 0.05 eV	**1**	**1**
13.	(D) Assertion (A) is false and Reason (R) is also false	**1**	**1**
14.	(C) Assertion (A) is true but Reason (R) is false	**1**	**1**
15.	(A) Both Assertion (A) and Reason (R) is the correct explanation of the Assertion(A)	**1**	**1**
16.	(A) Both Assertion (A) and Reason (R) is the correct explanation of the Assertion(A)	**1**	**1**
	SECTION B		
17.	**(a)** Meaning of relaxation time ½; Derivation of R 1 ½ Average time between two successive collisions of electron in presence of electric field. ½ Drift velocity of an electron $\upsilon_d = \frac{eE}{m}\tau \quad ---(i)$ ½ Current flowing through a conductor of length *l* and area of cross section A $I = neA\upsilon_d \quad ---(ii)$ $I = \frac{ne^2AE\tau}{m} = \frac{ne^2A\tau V}{ml}$ ½ $R = \frac{V}{I} = \frac{ml}{ne^2\tau A}$ ½ **OR** **(b)** Circuit diagram of Wheatstone bridge ½; Obtaining the condition when no current flows through galvanometer 1½		**2**



½

By applying Kirchoff's loop rule to closed loops ADBA and CBDC

$-I_1R_1 + 0 + I_2R_2 = 0$ -----(i) $[I_g = 0]$

$I_2R_4 + 0 - I_1R_3 = 0$ -----(ii) ½

From eq (i)-

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

From eq (ii)-

$$\frac{I_1}{I_2} = \frac{R_4}{R_3}$$ ½

Hence,

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$ ½ **2**

18.

Finding the focal length of objective lens 2

Magnifying power = 24 , Distance between lenses =150 cm

$$\frac{f_o}{f_e} = 24$$ ½

$f_o + f_e = 150\,\text{cm}$ ½

$f_e = 6\,\text{cm}$ ½

$f_o = 144\,\text{cm}$ ½ **2**

19.

Differences between interference and diffraction of light 1+1

Interference	**Diffraction**
(i) In interference pattern width of each maxima is same.	(i) In diffraction pattern width of central maxima is twice the width of secondary maxima.
(ii) In interference pattern intensity of all maxima is same.	(ii) In diffraction pattern intensity of maxima goes on decreasing as we move away from central maxima.

1+1

[Award full credit if students write any other two differences] **2**

20.

(i) Calculation of Kinetic energy (in eV) 1½
(ii) Stopping potential ½

Using Einstein Photoelectric equation

$$\frac{hc}{\lambda} = K.E_{max} + \phi_0$$ ½

$$K.E_{max} = \frac{hc}{\lambda} - \phi_0$$

$$= \frac{1240 eV nm}{500\, nm} - 2.14 eV$$ ½

$$K.E_{max} = 0.34 eV$$ ½

$$K.E_{max} = eV_0$$

$$\therefore V_0 = 0.34 V$$ ½ **2**

21.

Calculation of concentration of holes and electrons 2

$$n_e n_h = n_i^2$$ ½

$$n_h \approx 5\times10^{22} / m^3$$

$$n_e = \frac{n_i^2}{n_h}$$

$$n_e = \frac{(1.5\times10^{16})^2}{5\times10^{22}}$$ ½

$$n_e = 4.5\times10^{9} / m^3$$ ½

$n_h > n_e$, it is a p- type crystal ½ **2**

SECTION C

22.

Calculation of
(a) emf of battery ½
(b) Internal resistance of battery(r) 1½
(c) external resistance (R) 1

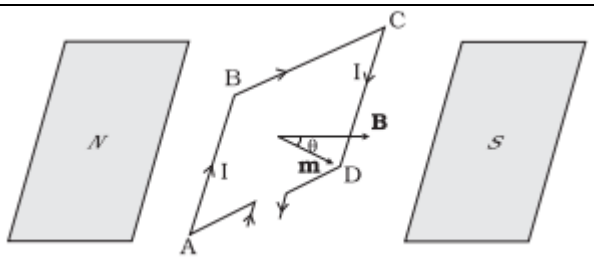
(a) V= *E*=10 V(When key K is open and I=0 A) ½

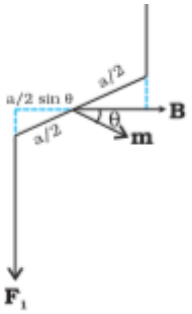
(b) V=*E*-Ir (When key K is closed and I=2 A) ½
6=10-2r ½
r = 2Ω ½

(c) E=I(r+R) ½
10=2(2+R)
R= 3 Ω ½ **3**

23.

Derivation of torque in vector form 3





Forces on the arms BC and DA are, equal opposite and collinear. Hence they will cancel each other. ½

The forces on arms AB and CD are $\vec{F_1}$ and $\vec{F_2}$, equal but not collinear. The magnitude of the torque on the loop is

$\tau = F_1 \frac{a}{2}\sin\theta + F_2 \frac{a}{2}\sin\theta$ ½

$= IabB\sin\theta$

$= mB\sin\theta \quad (m = IA)$ ½

$\vec{\tau} = \vec{m} \times \vec{B}$ ½ **3**

24.

Differences between reactance and impedance 1
Showing Ideal inductor in an ac circuit does not dissipate any power 2

Reactance- It is the measure of opposition to flow of current in ac circuit comprising Inductor or Capacitor. ½

Impedance- It is the measure of opposition to flow of current in ac circuit comprising Resistor, Capacitor and Inductor. ½

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

$I = I_0 \sin(\omega t - \frac{\pi}{2}) = -I_0 \cos\omega t$ ½

$P = \varepsilon I$

$= -\varepsilon_0 I_0 \sin\omega t \cos\omega t$

$= -\frac{\varepsilon_0 I_0}{2} 2\sin\omega t \cos\omega t$

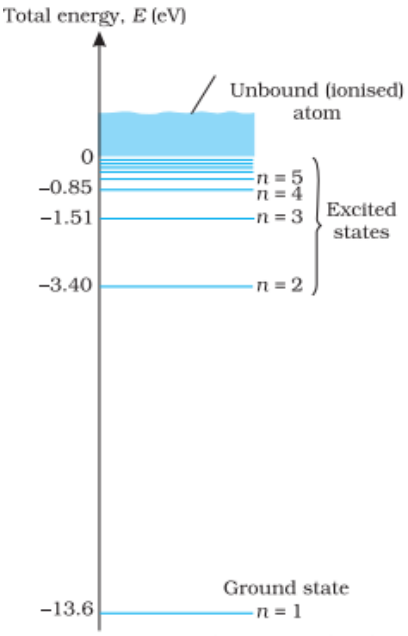
$P = \frac{\varepsilon_0 I_0}{2}\sin 2\omega t$ ½

	$\langle P\rangle = \dfrac{\int_0^T P dt}{\int_0^T dt}$	½	
	$\langle P\rangle = \dfrac{\int_0^T \frac{\varepsilon_0 I_0}{2}\sin 2\omega t dt}{T}$		
	$= \dfrac{\varepsilon_0 I_0}{2T}\int_0^T \sin 2\omega t dt$		
	$= -\dfrac{\varepsilon_0 I_0}{2T}(\cos\omega t)_0^T = \dfrac{\varepsilon_0 I_0}{2T}(1-1)$		
	$\langle P\rangle = 0$	½	
	Hence average power associated with inductor is zero.		
	Alternatively		
	$P = \varepsilon_{rms} I_{rms}\cos\phi$	**1**	
	For inductive circuit		
	$\phi = \pi/2$		
	$P = \varepsilon_{rms} I_{rms}\cos\dfrac{\pi}{2}$	½	
	$P = 0$	½	**3**
25.	(a) Finding the wavelength and frequency 1+1 (b) Finding the amplitude of magnetic field ½ (c) Writing expression for magnetic field ½		
	(a) $k = \dfrac{2\pi}{\lambda}$	½	
	$\lambda = \dfrac{2\pi}{K} = \dfrac{4\pi}{3}\text{m} = 4.18\,\text{m}$	½	
	$\omega = 2\pi\upsilon$		
	$\nu = \dfrac{\omega}{2\pi} = \dfrac{4.5\times10^8}{2\pi}\text{ Hz}$	½	
	$\nu = \dfrac{9}{4\pi}\times10^8\text{ Hz}$	½	
	$\nu = 7.16\times10^{-1}\text{ Hz}$		
	(b) $B_0 = \dfrac{E_0}{c}$		
	$B_0 = \dfrac{6.3}{3\times10^8} = 2.1\times10^{-8}\text{T}$	½	
	(c) $\vec{B} = 2.1\times10^{-8}[(\cos 1.5\,\text{rad/m})\,y + (4.5\times10^8\,\text{rad/s})\,t]\hat{k}\,\text{T}$	½	**3**

26.

Explanation of origin of spectral lines of hydrogen atom	1
Energy level diagram showing various spectral series of hydrogen atom	2

When an electron makes a transition from higher energy level to a lower energy orbit, a photon is emitted having energy equal to energy difference between these two orbits. **1**



2

[Do not deduct marks for not showing transition in diagram] **3**

27.

(a) Definition of atomic mass unit (u)	1
(b) Calculation of energy required	2

(a) atomic mass unit (u) is defined as $1/12^{th}$ of the mass of the carbon (^{12}C) atom. **1**

(b) $m\left({}_1H^2\right) \rightarrow m\left({}_1H^1\right) + m\left({}_0n^1\right)$ **½**

$Q = (m_R - m_P) \times 931.5\,MeV$

$= (2.014102 - 1.007825 - 1.008665) \times 931.5\,MeV$ **½**

$= -0.002388 \times 931.5\,MeV$ **½**

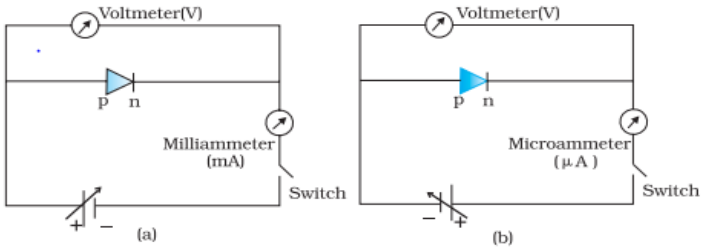
$= -2.224\,MeV$

Hence energy required is 2.224 MeV **½** **3**

28.

(a)

(a) Drawing the circuit diagram for V-I characteristics	1
Salient features of V-I characteristics in	
(i) Forward biasing	1
(ii) Reverse biasing	1



[any one circuit diagram] **1**

Salient features

(i) **Forward biasing**- After threshold voltage or cut in voltage diode current increase significantly (exponentially), even for a small increase in the diode bias voltage. **1**

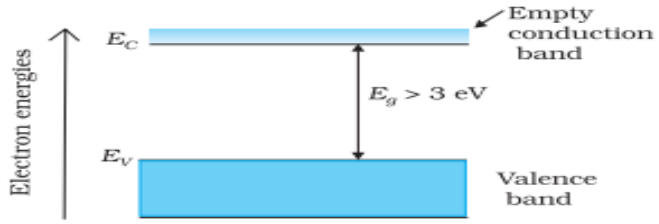
(ii) **Reverse biasing**- Current is very small (~μA) and almost remains constant and it increases rapidly after breakdown voltage. **1**

OR

(b)

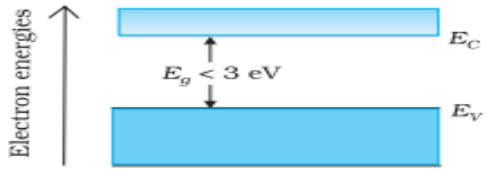
Energy band diagrams Difference between (i) an insulator (ii) a semiconductor (iii) a metal 1+1+1

(i)



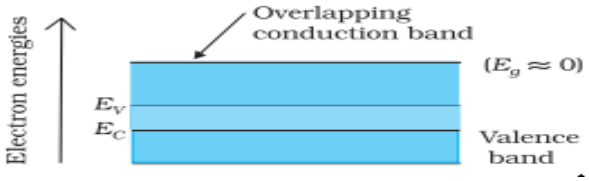
1

(ii)



1

(iii)



1 **3**

SECTION D

29.

(i) (D) IV **1**

(ii) (D) accelerate along $-\hat{i}$ **1**

(iii) (A) $V = V_0 + \alpha x$ **1**

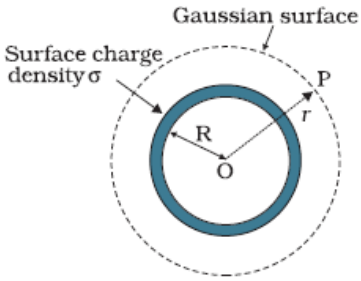
(iv) (a) (C) $E_4 > E_3 > E_2 > E_1$ **1**

OR

(b) (B) 2.6×10^6 m/s **1** **4**

30.	(i) (D) 6 (ii) (C) 3 (iii) (a) (C) 6 **OR** (b) (B) $\sin^{-1}(0.225)$ (iv) (D) 10	**1** **1** **1** **1**	**4**
	SECTION E		
31.	**(a)** (i) Obtaining expression for the capacitance 3 (ii) Finding the electric potential 2 (i) at the surface (ii) at the centre (i) When a dielectric slab is inserted between the plates of capacitance, there is induced charge density σ_P which opposes the original charge density (σ) on the plate of capacitance. Electric field with dielectric medium is $E = \frac{(\sigma-\sigma_P)}{\varepsilon_0}$ $V=E\times d = \frac{(\sigma-\sigma_P)}{\varepsilon_0} d$ $(\sigma - \sigma_P) = \frac{\sigma}{K}$ $V=\frac{\sigma d}{\varepsilon_0 K} = \frac{Qd}{A\varepsilon_0 K}$ $C = \frac{Q}{V} = \frac{K\varepsilon_0 A}{d}$ (ii) Electric potential due to a point charge $V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (i) At the surface $V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{9\times10^9\times6\times10^{-6}}{0.2}$ $V = 2.7\times10^5$ V (ii) Since electric field inside the hollow sphere is zero, hence V is same as that of the surface and remains constant throughout the volume.. $V = 2.7\times10^5$ V **OR** **(b)** (i) Expression for electric field at appoint lying (i) inside 1 (ii) outside 2 (ii) Explanation 2	½ ½ ½ ½ ½ ½ ½ ½	

(i) Field inside the shell



The Flux through the Gaussian surface is

$= E \times 4\pi R^2$ ½

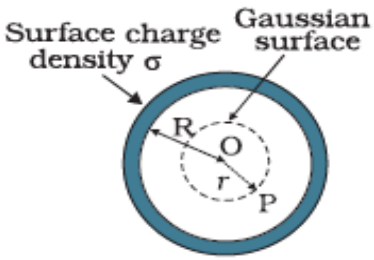
In this case Gaussian surface enclosed no charge.

Hence $E \times 4\pi R^2 = 0$

$E = 0$ ½

(Note: Award full credit of this part if a student writes directly E=0, mentioning as there is no charge enclosed by Gaussian surface)

(ii) Field outside the shell-



½

Electric flux through Gaussian surface

$$E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$$ ½

Charge enclosed by the Gaussian surface

$$E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$$ ½

Using Gauss's law:

$$\int \vec{E}.\overrightarrow{ds} = \frac{Q}{\varepsilon_0}$$ ½

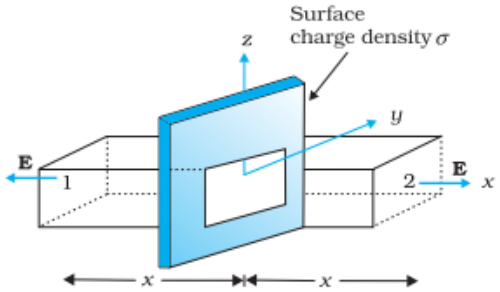
$$E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$$

$$E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2} = \frac{q}{4\pi\varepsilon_0 r^2}$$

(ii) For conducting sheet,

Electric field due to a conducting sheet ½

$$E_c = \frac{\sigma}{\varepsilon_0}$$



For non-conducting sheet

$E_{nc} = \frac{\sigma}{2\varepsilon_0}$ ½

Since surface charge density is same.

$2E_{nc} = E_c$ ½ ½ **5**

32.

(a)

(i)(1)Meaning of current sensitivity, mentioning factors	2
(2) Finding the required resistance	1½
(ii) Finding the induced current	1½

(i) (1) Current sensitivity of galvanometer is defined as the deflection per unit current. **1**

Alternatively,

$\frac{\phi}{I} = \frac{NBA}{K}$

Factors

No. of turns in coil, Magnetic field intensity, Area of coil, Torsional Constant **(Any two)** ½+½

(2) $R = \frac{V}{I} - G$ for (0-V) Range ½

$R_1 = \frac{V}{2I} - G$ for (0-V/2) Range ½

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

$R_1 = \left(\frac{R+G}{2}\right) - G$

$R_1 = \frac{R-G}{2}$ ½

(ii) $\phi = (2.0t^3 + 5.0t^2 + 6.0t)$ mWb

$|\varepsilon| = \frac{d\phi}{dt} = 50 \times 10^{-3}$ V ½

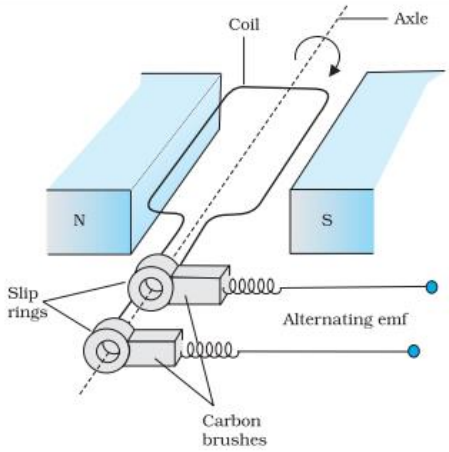
I= $\frac{|\varepsilon|}{R}$ ½

I= $\frac{50\times10^{-3}}{5}$ A=10 mA ½

OR

(b)

(i) Obtaining the expression of emf induced	3
(ii) Calculation of mutual inductance	2



1

(i) The flux at any instant t is

$\phi = NBA\cos\theta$=NBA $\cos\omega t$ ½

From Faraday's law

$\boldsymbol{\varepsilon = -\frac{d\phi_B}{dt}}$ ½

$= -NBA\frac{d}{dt}(\cos\omega t)$ ½

$\boldsymbol{\varepsilon} = -NBA\ \omega\sin\omega t$ ½

(ii) $M = \frac{\mu_0 \pi r_1^2}{2r_2} = \frac{4\pi\times10^{-7}\times\pi r_1^2}{2r_2}$ ½+½

$= \frac{2\times10\times10^{-7}\times(10^{-2})^2}{100\times10^{-7}}$ ½

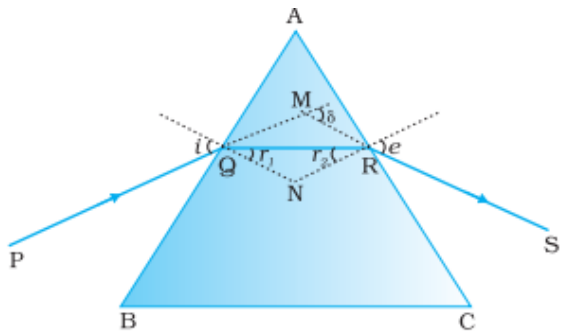
$= 2\times10^{-10}$H ½ **5**

33.

(a)

(i) Tracing the path of Ray	½
Obtaining an expression for angle deviation	1½
Drawing Graph	1
(ii) Finding the refractive index	2

(i)



½

For quadrilateral AQNR,

$\angle A + \angle QNR = 180^o$ --- (i) ½

For triangle QNR

comparing equation (i) and (ii)

$r_1 + r_2 = A$ ------ (iii) ½

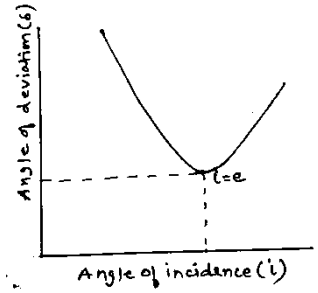
The angle of deviation

$\delta = (i - r_1) + (e - r_2)$ ------ (iv)

from equation (iii) and (iv)

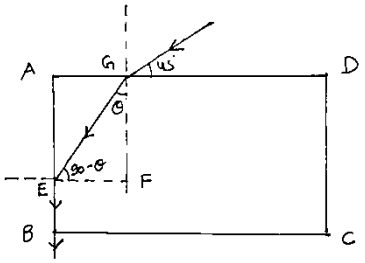
$\delta = i + e - A$ ½

Graph



1

(ii)



$\frac{\sin 45^0}{\sin \theta} = \mu$ ½

$\frac{1}{\sqrt{2}} = \mu \sin \theta$

For second surface,

$\frac{\sin(90^0 - \theta)}{\sin 90^0} = \frac{1}{\mu}$ ½

$\frac{1}{\sqrt{2}} \frac{\cos \theta}{\sin \theta} = 1$

$\tan \theta = \frac{1}{\sqrt{2}}$ ½

From the triangle GEF

$\sin \theta = \frac{1}{\sqrt{3}}$

$\mu = \sqrt{\frac{3}{2}}$ ½

OR

(b)

(i) Expression for resultant intensity	3
(ii) Ratio of intensities	2

(i) $y_1 = a \cos \omega t$

$y_2 = a \cos(\omega t + \phi)$

According to the principle of superposition

$y = y_1 + y_2$

$y = a \cos \omega t + a \cos(\omega t + \phi)$ ½

	$y = a\cos\omega t + a\cos\omega t\cos\phi - a\sin\omega t\sin\phi$ $y = a\cos\omega t(1+\cos\phi) - a\sin\phi\sin\omega t$ Let, $a(1+\cos\phi) = A\cos\theta$ ------- (i) $a\sin\phi = A\sin\theta$ --------(ii) Squaring and adding equation (i) and (ii) $A^2 = a^2(1+\cos\phi)^2 + a^2\sin^2\phi$ $= a^2(1+\cos^2\phi+2\cos\phi) + a^2\sin^2\phi$ $= 2a^2(1+\cos\phi)$ $= 4a^2\cos^2\phi/2$ $I\alpha A^2$ $I = kA^2$ where k is constant $I = 4ka^2\cos^2\phi/2$ (ii) $\phi_1 = \frac{2\pi}{\lambda}\times\frac{\lambda}{6} = \pi/3$ $I_1 = 4I_0\cos^2\phi/2$ $= 4I_0\cos^2(\pi/6)$ $I_1 = 3I_0$ $\phi_2 = \frac{2\pi}{\lambda}\times\frac{\lambda}{12} = \pi/6$ $I_2 = 4I_0\cos^2(\pi/12)$ $I_2 = 4I_0\cos^2 15^0$ $\frac{I_1}{I_2} = \frac{3}{4\cos^2 15^0}$	½ ½ ½ ½ ½ ½ ½ ½	**5**

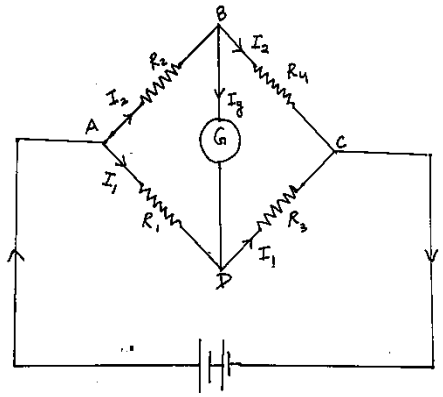
Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior School Certificate Examination, 2024
SUBJECT PHYSICS (CODE 55/3/3)

General Instructions: -

1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers. These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after deliberation and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark (√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right **(✓)**while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.

11	A full scale of marks 0-70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

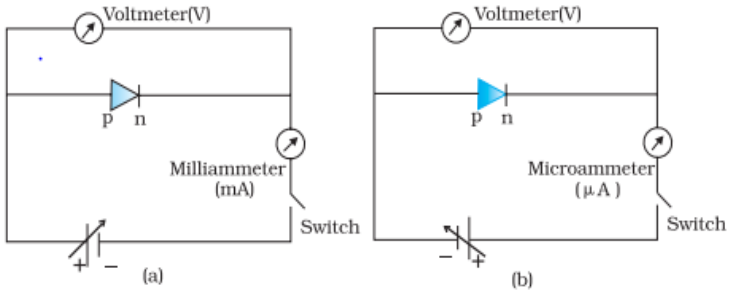
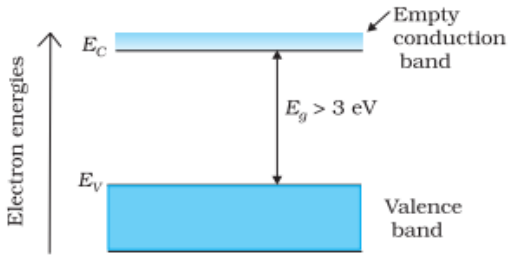
	MARKING SCHEME : PHYSICS (042)		
	CODE: 55/3/3		
Q.NO.	**VALUE POINT/ EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	SECTION A		
1.	(B) 0.1mC	**1**	**1**
2.	(B) 1.6×10^{-18} J	**1**	**1**
3.	(C) –(0.24 nT) $\hat{k}$	**1**	**1**
4.	(D) Sodium Chloride	**1**	**1**
5.	(B) 0.3 MB	**1**	**1**
6.	(D) 100 V	**1**	**1**
7.	(B) l is decreased and A is increased	**1**	**1**
8.	(A) +z direction and in phase with $\vec{E}$	**1**	**1**
9.	(B) 2	**1**	**1**
10.	(A) $\frac{\lambda}{\sqrt{2}}$	**1**	**1**
11.	(B) decreased by 87.5%	**1**	**1**
12.	(B) 0.05 eV	**1**	**1**
13.	(D) Assertion (A) is false and Reason (R) is also false.	**1**	**1**
14.	(C) Assertion (A) is true but Reason (R) is false.	**1**	**1**
15.	(A) Both Assertion (A) and Reason (R) is the correct explanation of the Assertion (A).	**1**	**1**
16.	(A) Both Assertion (A) and Reason (R) is the correct explanation of the Assertion (A).	**1**	**1**
	SECTION B		
17.	Meaning of relaxation time ½ Derivation of R 1½ Average time between two successive collisions of electron in presence of electric field. ½ Drift velocity of an electron $v_d = \frac{eE}{m}\tau \quad ---(i)$ ½ Current flowing through a conductor of length l and area of cross section A $I = neAv_d \quad ---(ii)$ $I = \frac{ne^2AE\tau}{m} = \frac{ne^2A\tau V}{ml}$ ½ $R = \frac{V}{I} = \frac{ml}{ne^2\tau A}$ ½ **OR** Circuit diagram of Wheatstone bridge ½ Obtaining the condition when current flows through galvanometer 1½		

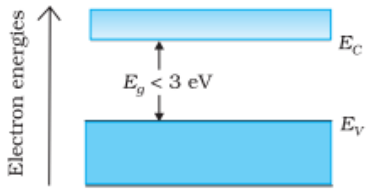
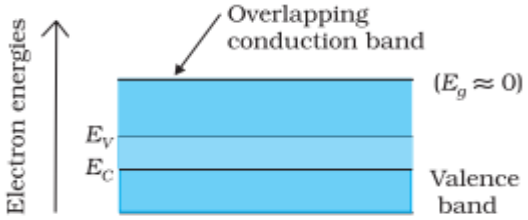
	 By applying Kirchoff's loop rule to closed loops ADBA and CBDC $-I_1R_1 + 0 + I_2R_2 = 0$ -----(i) $[I_g = 0]$ $I_2R_4 + 0 - I_1R_3 = 0$ -----(ii) From eq (i) - $\frac{I_1}{I_2} = \frac{R_2}{R_1}$ From eq (ii) - $\frac{I_1}{I_2} = \frac{R_4}{R_3}$ Hence, $\frac{R_2}{R_1} = \frac{R_4}{R_3}$	½ ½ ½ ½	**2**
18.	Finding the focal length of objective lens 2 Magnifying power =24 , Distance between lenses =150 cm $\frac{f_o}{f_e} = 24$ $f_o + f_e = 150\,\text{cm}$ $f_e = 6\,\text{cm}$ $f_o = 144\,\text{cm}$	½ ½ ½ ½	**2**
19.	Sustained or stable interference 1 Conditions for sustained interference 1 ❖ When position of maxima and minima is not changing with time, interference pattern is called sustained or stable interference. ❖ Light sources must be coherent	**1** **1**	**2**
20.	Possibility of emission of electron 1 Calculation of longest wavelength of emitted electron 1 $E = \frac{hc}{\lambda}$		

	$= \frac{1240\,eV\,nm}{600\,nm}$ $= 2.06\,eV$ $\because$ Work function $\phi_0 = 2.3eV$ $\because E < \phi_0$ No emission will take place. $\lambda_{max} = \frac{hc}{\phi}$ $= \frac{1240\,eV\,nm}{2.3eV}$ $\lambda_{max} = 539.13nm$	½ ½ ½ ½	**2**
21.	Calculation of concentration of holes & electrons 2 $n_e n_h = n_i^2$ $n_h \approx 5\times10^{22}/m^3$ $n_e = \frac{n_i^2}{n_h}$ $n_e = \frac{(1.5\times10^{16})^2}{5\times10^{22}}$ $n_e = 4.5\times10^9/m^3$ $n_h > n_e$, it is a p- type crystal	 ½ ½ ½ ½	**2**
	SECTION C		
22.	Calculation of (a) Electric field across the wire 1 (b) Current density 1 (c) Average relaxation time (ꚍ) 1 (a) $E = \frac{V}{l}$ $= \frac{1.0V}{1.0m} = 1.0$ V/m (b) $J = I/A$ $J = \frac{1.6\,A}{1.0\times10^{-7}\,m^2} = 1.6\times10^7$ A/m^2 (c) $\tau = \frac{m}{ne^2}\frac{J}{E}$ $= \frac{9.1\times10^{-31}\times1\times1.6}{9\times10^{28}\times\left(1.6\times10^{-19}\right)^2}$ $= 6.31\times10^{-14}$s	 ½ ½ ½ ½ ½	**3**

23.	Derivation of magnetic dipole moment 2 ½ Gyromagnetic ratio ½ Electron revolve around the nucleus constitute a current $I = e/T$ $T = \frac{2\pi r}{v}$ $I = \frac{ev}{2\pi r}$ Magnetic moment, M =I.A $\mu_l = \frac{ev.\pi r^2}{2\pi r}$ $\mu_l = \frac{evr}{2}$ $(L = mvr)$ Since electron has negative charge, μ_l is opposite in direction of an electron of angular momentum L. $\overrightarrow{\mu_l} = -\frac{e}{2m}\vec{L}$ **Gyromagnetic ratio**- The ratio of magnetic moment to angular momentum is called gyromagnetic ratio. That is, $\frac{\mu_e}{L} = \frac{e}{2m}$ **[Note- give half mark of gyromagnetic ratio to each student, if it is not attempted]]**	½ ½ ½ ½ ½ ½	**3**
24.	Proof of induced charge 3 Using Faraday's law of electromagnetic induction $\lvert\varepsilon\rvert = \frac{\triangle\phi}{\triangle t}$ $I = \frac{\lvert\varepsilon\rvert}{R}$ $I = \frac{1}{R}\left(\frac{\triangle\phi}{\triangle t}\right)$ $\frac{\triangle Q}{\triangle t} = \frac{1}{R}\left(\frac{\triangle\phi}{\triangle t}\right)$ $\triangle Q = \frac{\triangle\phi}{R}$ Hence induced charge depends on change in magnetic flux, not on the time interval of flux change.	½ ½ ½ ½ ½ ½	**3**
25.	(a) Finding the wavelength and frequency 1+1 (b) Finding the amplitude of magnetic field ½ (c) Writing expression for magnetic field ½		

	(a) $k = \frac{2\pi}{\lambda}$ $\lambda = \frac{2\pi}{K} = \frac{4\pi}{3}\text{m} = 4.18\text{m}$ $\omega = 2\pi\upsilon$ $\nu = \frac{\omega}{2\pi} = \frac{4.5\times10^{8}}{2\pi}\text{Hz}$ $\nu = \frac{9}{4\pi}\times10^{8}\text{ Hz}$ $\nu = 7.16\times10^{-1}\text{ Hz}$ (b) $B_0 = \frac{E_0}{c}$ $B_0 = \frac{6.3}{3\times10^{8}} = 2.1\times10^{-8}\text{T}$ (c) $\vec{B} = 2.1\times10^{-8}[(\cos 1.5\,\text{rad/m})\,y + (4.5\times10^{8}\,\text{rad/s})\,t]\hat{k}\,\text{T}$	½ ½ ½ ½ ½	**3**
26.	Statement of Bohr's second postulates ½ Derivation of $r_n \propto n^2$ 2½ **Bohr's second postulate** Electron revolves around the nucleus only in those orbits for which the angular momentum in some integral multiple of h/2π. Electrostatic force between revolving electron & nucleus provide requisite centripetal force $\frac{mv_n^2}{r_n} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_n^2}$ $v_n = \frac{e}{\sqrt{4\pi\varepsilon_0 m r_n}}$ _____(i) $mv_n r_n = \frac{nh}{2\pi}$ _____(ii) From eqn. (i) and (ii) $r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2\frac{4\pi\varepsilon_0}{e^2}$ $r_n \propto n^2$	½ ½ ½ ½ ½ ½	**3**
27.	(a) Definition of Atomic mass unit (u) 1 (b) Calculation of energy required 2 (a) Atomic mass unit (u) is defined as 1/12th of the mass of the carbon (^{12}C) atom. (b) $m\left({}_1H^2\right) \rightarrow m\left({}_1H^1\right) + m\left({}_0n^1\right)$ $Q = (m_R - m_P)\times 931.5\,MeV$	**1** ½	

	$=(2.014102-1.007825-1.008665)\times 931.5\,MeV$ $=-0.002388\times 931.5\,MeV$ $=-2.224\,MeV$ Hence energy required is 2.224 MeV	½ ½ ½	 **3**
28.	**(a)** (a) Drawing of circuit diagram for V-I characteristics 1 Salient features of V-I characteristics in (i) Forward biasing 1 (ii) Reverse biasing 1		
	 	**1**	
	[any one circuit diagram]		
	Salient features (i) **Forward biasing**- After threshold voltage or cut in voltage diode current increases significantly (exponentially), even for a small increase in the bias voltage.	**1**	
	(ii) **Reverse biasing**- Current is very small (~μA) and almost remains constant and it increases rapidly after breakdown voltage.	**1**	
	OR		
	(b) Energy band diagrams Difference between (i) an insulator (ii) a semiconductor (iii) a metal 1+1+1		
	(i)  	**1**	

	(ii)  (iii)  	**1** **1**	**3**
	SECTION D		
29.	(i) (D) IV (ii) (D) accelerate along $-\hat{i}$ (iii) (A) $V = V_0 + \alpha x$ (iv) (a) (C) $E_4 > E_3 > E_2 > E_1$ OR (b) (B) 2.6×10^6 m/s	**1** **1** **1** **1**	**4**
30.	(i) (D) 6 (ii) (C) 3 (iii) (a) (C)6 OR (b) (B) $\sin^{-1}(0.225)$ (iv) (D) 10	**1** **1** **1** **1**	**4**
	SECTION E		
31.	**(a)** (i) Obtaining expression for the capacitance 3 (ii) Finding the electric potential 2 (i) at the surface (ii) at the centre When a dielectric slab is inserted between the plates of capacitance there is induced charge density σ_P which opposes the original charge density (σ) on the plate of capacitance. Electric field with dielectric medium is $E = \frac{(\sigma - \sigma_P)}{\varepsilon_0}$ $V = E \times d = \frac{(\sigma - \sigma_P)}{\varepsilon_0} d$ $(\sigma - \sigma_P) = \frac{\sigma}{K}$ $V = \frac{\sigma d}{\varepsilon_0 K} = \frac{Qd}{A\varepsilon_0 K}$ $C = \frac{Q}{V} = \frac{K\varepsilon_0 A}{d}$	½ ½ ½ ½ ½	

(ii) Electric potential due to a point charge

$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ ½

(i) At the surface

$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r}=\frac{9\times10^9\times6\times10^{-6}}{0.2}$ ½

$V = 2.7 \times 10^5$ V ½

(ii) Since electric field inside the hollow sphere is zero, hence V remains constant throughout the volume.

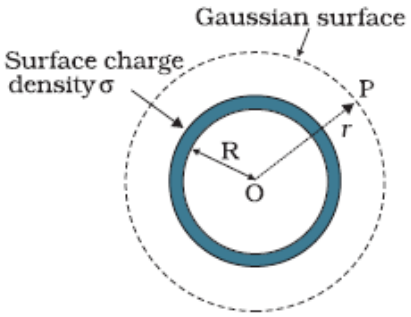
$V = 2.7 \times 10^5$ V ½

OR

(b)

(i) Expression for electric field at appoint lying	
(i) inside	1
(ii) outside	2
(ii) Explanation	2

(i) <u>Field inside the shell</u>



The Flux through the Gaussian surface is

$= E \times 4\pi R^2$ ½

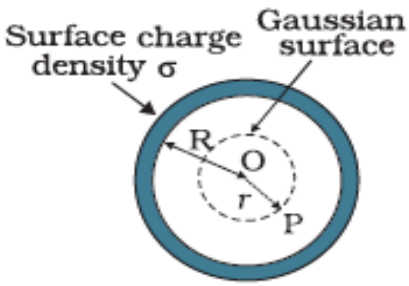
In this case Gaussian surface enclosed no charge.

Hence $E \times 4\pi R^2 = 0$

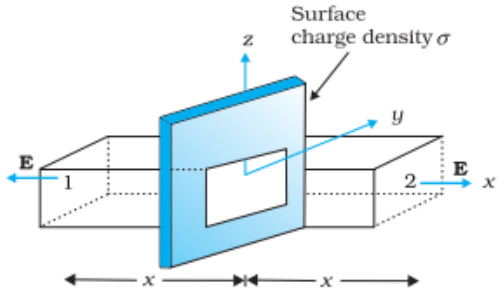
$E = 0$ ½

(Note: Award full credit of this part if a student writes directly E=0, mentioning as there is no charge enclosed by Gaussian surface)

(ii) <u>Field outside the shell</u>-



½

	Electric flux through Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ Charge enclosed by the Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ Using Gauss's law: $\int \vec{E}.\overrightarrow{ds} = \frac{Q}{\varepsilon_0}$ $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ $E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2} = \frac{q}{4\pi\varepsilon_0 r^2}$ (ii) For conducting sheet, Electric field due to a conducting sheet $E_c = \frac{\sigma}{\varepsilon_0}$  For non-conducting sheet $E_{nc} = \frac{\sigma}{2\varepsilon_0}$ Since surface charge density is same. $2E_{nc} = E_c$	½ ½ ½ ½ ½ ½	**5**
32.	**(a)** (i)(1) Meaning of current sensitivity, mentioning factors 2 (2) Finding the required resistance 1½ (ii) Finding the induced current 1½ (i) (1) Current sensitivity of galvanometer is defined as the deflection per unit current. **Alternatively**, $\frac{\phi}{I} = \frac{NBA}{K}$ **Factors** Number of turns in coil, Magnetic field intensity, Area of coil, Torsional Constant **(Any two)** (2) $R = \frac{V}{I} - G$ for (0-V) Range $R_1 = \frac{V}{2I} - G$ for (0-$\frac{V}{2}$) Range $\frac{V}{I} = R + G$ $R_1 = \left(\frac{R+G}{2}\right) - G$	**1** ½+½ ½ ½	

$R_1 = \frac{R-G}{2}$ ½

(ii) $\phi = (2.0t^3 + 5.0t^2 + 6.0t)$ mWb

$|\varepsilon| = \frac{d\phi}{dt} = 50 \times 10^{-3}$ V ½

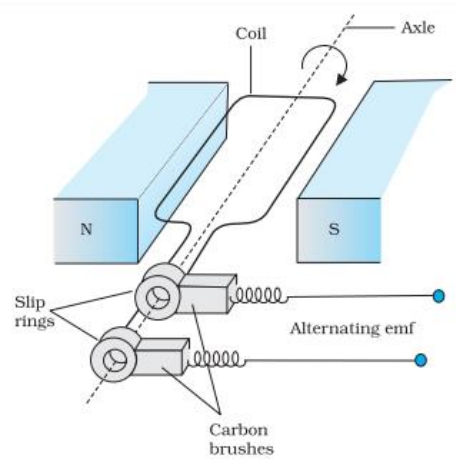
I= $\frac{|\varepsilon|}{R}$ ½

I= $\frac{50\times10^{-3}}{5}$ A=10 mA ½

OR

(b)

(i) Obtaining the expression of emf induced	3
(ii) Calculation of mutual inductance	2



1

(i) The flux at any instant t is

$\phi = NBA\cos\theta$=NBA cosωt ½

From Faraday's law

$\boldsymbol{\varepsilon = -\frac{d\phi_B}{dt}}$ ½

$= -NBA\frac{d}{dt}(\cos\omega t)$ ½

$\boldsymbol{\varepsilon} = -NBA\,\omega\sin\omega t$ ½

(ii) $M = \frac{\mu_0\pi r_1^2}{2r_2} = \frac{4\pi\times10^{-7}\times\pi r_1^2}{2r_2}$ ½+½

$= \frac{2\times10\times10^{-7}\times(10^{-2})^2}{100\times10^{-7}}$ ½

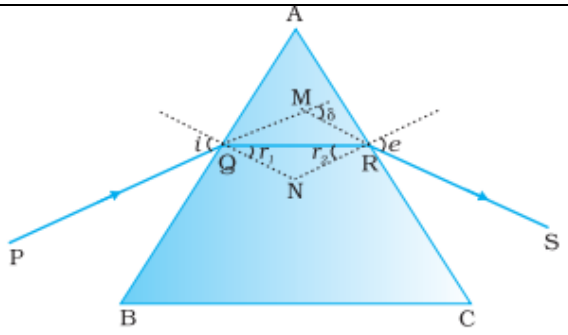
$= 2\times10^{-10}$H ½ **5**

33.

(a)

(i) Tracing the path of Ray	½
Obtaining an expression for angle deviation	1½
Drawing Graph	1
(ii) Finding the refractive index	2

(i)



½

For quadrilateral AQNR,

$\angle A + \angle QNR = 180^o$ --- (i)

For triangle QNR ½

$r_1 + r_2 + \angle QNR = 180^o$ ---- (ii)

comparing equation (i) and (ii)

$r_1 + r_2 = A$ ------ (iii) ½

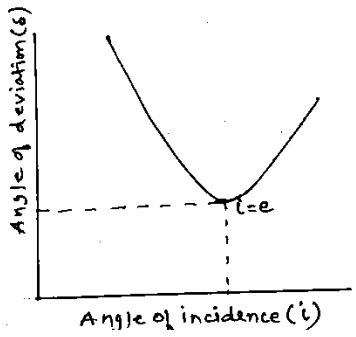
The angle of deviation

$\delta = (i - r_1) + (e - r_2)$ ------ (iv)

from equation (iii) and (iv)

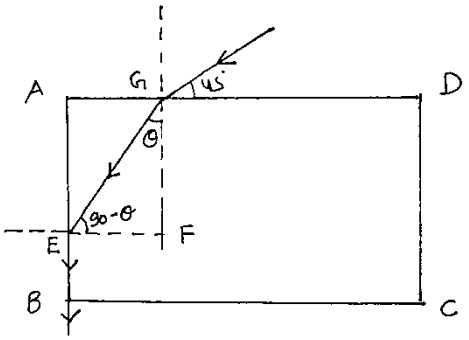
$\delta = i + e - A$ ½

Graph



1

(ii)



$\frac{\sin 45^0}{\sin \theta} = \mu$

$\frac{1}{\sqrt{2}} = \mu \sin \theta$ ½

For second surface,

$\frac{1}{\sqrt{2}} \frac{\cos \theta}{\sin \theta} = 1$ ½

$tan\,\theta = \frac{1}{\sqrt{2}}$ ½

From the triangle GEF

$sin\,\theta = \frac{1}{\sqrt{3}}$

$\mu = \sqrt{\frac{3}{2}}$ ½

OR

(b)

(i) Expression for resultant intensity	3
(ii) Ratio of intensities	2

(i) $y_1 = a\,cos\,\omega\,t$

$y_2 = a\,cos(\omega\,t + \phi)$

According to the principle of superposition

$y = y_1 + y_2$

$y = a\,cos\,\omega\,t + a\,cos(\omega\,t + \phi)$ ½

$y = a\,cos\,\omega\,t + acos\,\omega\,tcos\,\phi - a\,sin\,\omega\,tsin\,\phi$

$y = a\,cos\,\omega\,t(1 + cos\,\phi) - a\,sin\,\phi\,sin\,\omega\,t$ ½

Let,

$a(1 + cos\,\phi) = Acos\,\theta$ ------- (i)

$a\,sin\,\phi = A\ sin\,\theta$ --------(ii)

Squaring and adding equation (i) and (ii) ½

$A^2 = a^2(1+cos\phi)^2 + a^2 sin^2\phi$

$= a^2(1 + cos^2\,\phi + 2\,cos\,\phi) + a^2\,sin^2\,\phi$

$= 2a^2(1 + cos\,\phi)$

$= 4a^2\,cos^2\,\phi\,/2$ ½

$I \alpha A^2$

$I = kA^2$ ½

where k is constant

$I = 4ka^2\,cos^2\,\phi\,/2$ ½

[Award full credit for this part for any other alternative methods]

(ii) $\phi_1 = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \pi/3$ ½

$I_1 = 4I_0\,cos^2\,\phi\,/2$

$= 4I_0\,cos^2(\pi/6)$

$I_1 = 3I_0$ ½

$\phi_2 = \frac{2\pi}{\lambda} \times \frac{\lambda}{12} = \pi/6$

$I_2 = 4I_0\,cos^2(\pi/12)$ ½

$I_2 = 4I_0\,cos^2\,15^0$

$\frac{I_1}{I_2} = \frac{3}{4\,cos^2\,15^0}$ ½ **5**