

**Series SGN**

कोड नं. **55/3**  
Code No.

रोल नं. 

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Roll No.

परीक्षार्थी कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें ।

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

- कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **19** हैं ।
- प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए कोड नम्बर को छात्र उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।
- कृपया जाँच कर लें कि इस प्रश्न-पत्र में **26** प्रश्न हैं ।
- कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, प्रश्न का क्रमांक अवश्य लिखें ।
- 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 ।
- Please check that this question paper contains **19** printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains **26** questions.
- **Please write down the Serial Number of the question before attempting it.**
- 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.

**भौतिक विज्ञान (सैद्धांतिक)**

**PHYSICS (Theory)**

निर्धारित समय : 3 घण्टे

अधिकतम अंक : 70

Time allowed : 3 hours

Maximum Marks : 70

**सामान्य निर्देश :**

- (i) **सभी प्रश्न अनिवार्य हैं । इस प्रश्न-पत्र में कुल 26 प्रश्न हैं ।**
- (ii) **इस प्रश्न-पत्र के पाँच भाग हैं : खण्ड अ, खण्ड ब, खण्ड स, खण्ड द और खण्ड य ।**
- (iii) **खण्ड अ में पाँच प्रश्न हैं, प्रत्येक का एक अंक है । खण्ड ब में पाँच प्रश्न हैं, प्रत्येक के दो अंक हैं । खण्ड स में बारह प्रश्न हैं, प्रत्येक के तीन अंक हैं । खण्ड द में चार अंक का एक मूल्याधारित प्रश्न है और खण्ड य में तीन प्रश्न हैं, प्रत्येक के पाँच अंक हैं ।**
- (iv) **प्रश्न-पत्र में समग्र पर कोई विकल्प नहीं है । तथापि, दो अंकों वाले एक प्रश्न में, तीन अंकों वाले एक प्रश्न में और पाँच अंकों वाले तीनों प्रश्नों में आन्तरिक चयन प्रदान किया गया है । ऐसे प्रश्नों में आपको दिए गए चयन में से केवल एक प्रश्न ही करना है ।**
- (v) **जहाँ आवश्यक हो, आप निम्नलिखित भौतिक नियतांकों के मानों का उपयोग कर सकते हैं :**

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

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

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

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

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$\text{इलेक्ट्रॉन का द्रव्यमान (m}_e\text{)} = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{न्यूट्रॉन का द्रव्यमान} = 1.675 \times 10^{-27} \text{ kg}$$

$$\text{प्रोटॉन का द्रव्यमान} = 1.673 \times 10^{-27} \text{ kg}$$

$$\text{आवोगाद्रो संख्या} = 6.023 \times 10^{23} \text{ प्रति ग्राम मोल}$$

$$\text{बोल्ट्ज़मान नियतांक} = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

**General Instructions :**

- (i) *All questions are compulsory. There are **26** questions in all.*
- (ii) *This question paper has **five** sections : Section A, Section B, Section C, Section D and Section E.*
- (iii) *Section A contains **five** questions of **one** mark each, Section B contains **five** questions of **two** marks each, Section C contains **twelve** questions of **three** marks each, Section D contains one value based question of **four** marks and Section E contains **three** questions of **five** marks each.*
- (iv) *There is no overall choice. However, an internal choice has been provided in **one** question of **two** marks, **one** question of **three** marks and all the **three** questions of **five** marks weightage. You have to attempt only **one** of the choices in such questions.*
- (v) *You may use the following values of physical constants wherever necessary :*

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

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

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

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

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$\text{Mass of electron (} m_e \text{)} = 9.1 \times 10^{-31} \text{ kg}$$

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

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

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

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

**खण्ड अ**

**SECTION A**

1. लघु तरंग प्रसारण सेवाओं द्वारा प्रचारण (संचरण) की कौन-सी विधा प्रयुक्त की जाती है ? 1  
Which mode of propagation is used by short wave broadcast services ?

2. किसी तत्व के चार नाभिक संलयित होकर कोई भारी नाभिक बनाते हैं जिसमें ऊर्जा का उन्मोच होता है। जनक अथवा संतति नाभिकों में से किसकी बंधन ऊर्जा प्रति न्यूक्लिऑन अधिक होगी ? 1

Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two — the parent or the daughter nucleus — would have higher binding energy per nucleon ?

3. (a) जल शोधन, तथा (b) नेत्र शल्य-चिकित्सा में उपयोग होने वाले विद्युत्-चुम्बकीय विकिरणों के नाम लिखिए। 1

Name the electromagnetic radiations used for (a) water purification, and (b) eye surgery.

4. समान आवृत्ति और विभिन्न तीव्रताओं के दो आपतित विकिरणों के लिए अनुप्रयुक्त वोल्टता के साथ प्रकाश-विद्युत् धारा के विचरण को दर्शाने वाले ग्राफ़ खींचिए। उच्चतर तीव्रता के विकिरण के लिए ग्राफ़ को अंकित कीजिए। 1

Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different intensities. Mark the graph for the radiation of higher intensity.

5. समान्तर पथों पर गतिमान एक प्रोटॉन और एक इलेक्ट्रॉन किसी एकसमान चुम्बकीय क्षेत्र, जो इनके गमनपथों के लम्बवत् कार्यरत है, में प्रवेश करते हैं। इनमें से कौन-सा उच्च आवृत्ति के वृत्तीय पथ में गति करेगा ? 1

A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency ?

**खण्ड ब**

**SECTION B**

6. 15 V शिखर वोल्टता की किसी वाहक तरंग का उपयोग किसी संदेश सिग्नल के प्रेषण के लिए किया गया है। 60% मॉडुलन सूचकांक प्राप्त करने के लिए मॉडुलक सिग्नल की शिखर वोल्टता ज्ञात कीजिए।

2

A carrier wave of peak voltage 15 V is used to transmit a message signal. Find the peak voltage of the modulating signal in order to have a modulation index of 60%.

7. यदि 412.5 nm तरंगदैर्घ्य का प्रकाश नीचे दिए गए धातुओं पर आपतित होता है, तो कौन-सी धातु प्रकाश-विद्युत् उत्सर्जन दर्शाएगी और क्यों ?

2

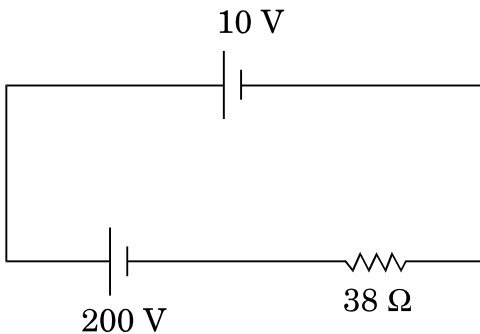
धातु	कार्य-फलन (eV)
Na	1.92
K	2.15
Ca	3.20
Mo	4.17

If light of wavelength 412.5 nm is incident on each of the metals given below, which ones will show photoelectric emission and why ?

Metal	Work Function (eV)
Na	1.92
K	2.15
Ca	3.20
Mo	4.17

8. आरेख में दर्शाए अनुसार उपेक्षणीय आन्तरिक प्रतिरोध का कोई एक 10 V का सेल 38 Ω आन्तरिक प्रतिरोध और 200 V विद्युत्-वाहक बल (emf) की किसी बैटरी के सिरो से पार्श्व में संयोजित है। परिपथ में धारा का मान ज्ञात कीजिए।

2

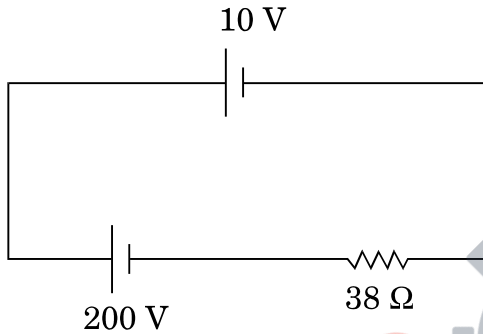


अथवा

किसी सेल के विद्युत्-वाहक बल (emf) निर्धारण के लिए पोटेंशियोमीटर व्यवस्था में खुले परिपथ में सेल का संतुलन बिन्दु 350 cm पर है। जब सेल के बाह्य परिपथ में  $9 \Omega$  का एक प्रतिरोध प्रयुक्त किया जाता है, तो संतुलन बिन्दु 300 cm पर स्थानान्तरित हो जाता है। सेल का आन्तरिक प्रतिरोध ज्ञात कीजिए।

2

A 10 V cell of negligible internal resistance is connected in parallel across a battery of emf 200 V and internal resistance  $38 \Omega$  as shown in the figure. Find the value of current in the circuit.



**OR**

In a potentiometer arrangement for determining the emf of a cell, the balance point of the cell in open circuit is 350 cm. When a resistance of  $9 \Omega$  is used in the external circuit of the cell, the balance point shifts to 300 cm. Determine the internal resistance of the cell.

9. (a) अवरक्त तरंगों को प्रायः ऊष्मा तरंगें क्यों कहा जाता है ? स्पष्ट कीजिए।
- (b) “विद्युत्-चुम्बकीय तरंगें संवेग वहन करती हैं” इस कथन से आप क्या समझते हैं ?
- (a) Why are infra-red waves often called heat waves ? Explain.
- (b) What do you understand by the statement, “Electromagnetic waves transport momentum” ?
10. दो विद्युत् बल्बों P और Q के प्रतिरोधों का अनुपात 1 : 2 है। ये श्रेणीक्रम में किसी बैटरी के सिरों से संयोजित हैं। इन बल्बों में शक्ति क्षय का अनुपात ज्ञात कीजिए।
- Two electric bulbs P and Q have their resistances in the ratio of 1 : 2. They are connected in series across a battery. Find the ratio of the power dissipation in these bulbs.

2

2

**खण्ड स**

**SECTION C**

11. CE अभिविन्यास में किसी n-p-n ट्रांजिस्टर के प्ररूपी निवेश और निर्गत अभिलक्षणिक खींचिए । यह दर्शाइए कि इन अभिलक्षणिकों का उपयोग (a) निवेश प्रतिरोध ( $r_i$ ), तथा (b) धारा प्रवर्धन गुणांक ( $\beta$ ) को निर्धारित करने में किस प्रकार किया जा सकता है । 3
- Draw the typical input and output characteristics of an n-p-n transistor in CE configuration. Show how these characteristics can be used to determine (a) the input resistance ( $r_i$ ), and (b) current amplification factor ( $\beta$ ).
12. (a) कोई छात्रा दो p-n संधि डायोडों का उपयोग करके प्रत्यावर्ती धारा को दिष्ट धारा में परिवर्तित करना चाहती है । उसके द्वारा उपयोग किए जाने वाले परिपथ का नामांकित परिपथ आरेख खींचिए और इसकी क्रियाविधि की व्याख्या कीजिए । 3
- (b) NAND गेट के लिए सत्यमान सारणी और परिपथ प्रतीक बताइए ।
- (a) A student wants to use two p-n junction diodes to convert alternating current into direct current. Draw the labelled circuit diagram she would use and explain how it works.
- (b) Give the truth table and circuit symbol for NAND gate.
13. (a) बंधन ऊर्जा प्रति न्यूक्लिऑन ( $BE/A$ ) और द्रव्यमान संख्या A के बीच ग्राफ़ का उपयोग करते हुए नाभिकीय विखण्डन और नाभिकीय संलयन की प्रक्रियाओं की व्याख्या कीजिए । 3
- (b) किसी रेडियोऐक्टिव समस्थानिक (रेडियोऐक्टिव आइसोटोप) की अर्ध-आयु 10 वर्ष है । इसकी सक्रियता 3.125% तक घटने में कितना समय लगेगा ?
- (a) Explain the processes of nuclear fission and nuclear fusion by using the plot of binding energy per nucleon ( $BE/A$ ) versus the mass number A.
- (b) A radioactive isotope has a half-life of 10 years. How long will it take for the activity to reduce to 3.125% ?
14. (a) लम्बी दूरी के प्रेषणों के लिए संदेश सिग्नलों के मॉडुलन की आवश्यकता के तीन कारण बताइए । 3
- (b) ग्राफ़ द्वारा कोई श्रव्य सिग्नल (ध्वनि संकेत), कोई वाहक तरंग और कोई आयाम मॉडुलित तरंग दर्शाइए ।
- (a) Give three reasons why modulation of a message signal is necessary for long distance transmission.
- (b) Show graphically an audio signal, a carrier wave and an amplitude modulated wave.

15. (a) यंग के प्रयोग में व्यतिकरण करती हुई दो सर्वसम झिरियों में से किसी एक को काँच से ढक दिया जाए, ताकि इससे गुज़रने वाले प्रकाश की तीव्रता घट कर 50% रह जाए, तो इस व्यतिकरण पैटर्न में फ्रिंजों की अधिकतम और न्यूनतम तीव्रताओं का अनुपात ज्ञात कीजिए ।
- (b) यदि एकवर्णी प्रकाश के स्थान पर श्वेत प्रकाश का उपयोग किया जाए, तो आप किस प्रकार की फ्रिंजों के प्रेक्षण की अपेक्षा करते हैं ?

3

- (a) If one of two identical slits producing interference in Young's experiment is covered with glass, so that the light intensity passing through it is reduced to 50%, find the ratio of the maximum and minimum intensity of the fringe in the interference pattern.
- (b) What kind of fringes do you expect to observe if white light is used instead of monochromatic light ?

16. (a) हाइड्रोजन परमाणु में स्थायी कक्षों की परिभाषा के लिए बोर के अभिगृहीत का उल्लेख कीजिए । दे ब्रॉग्ली की परिकल्पना किस प्रकार इन कक्षों के स्थायित्व की व्याख्या करती है ?
- (b) आरम्भ में निम्नतम अवस्था में कोई हाइड्रोजन परमाणु किसी फ़ोटॉन को अवशोषित करता है, जो उसे  $n = 4$  स्तर तक उत्तेजित कर देता है । फ़ोटॉन की आवृत्ति का अनुमान लगाइए ।

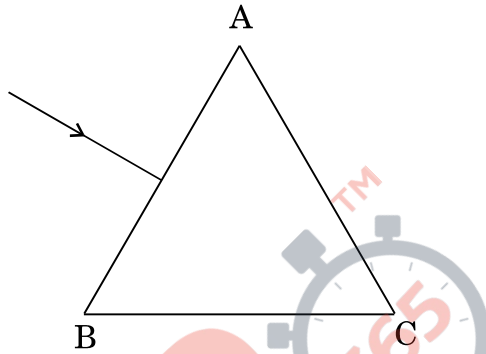
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- (a) State Bohr's postulate to define stable orbits in hydrogen atom. How does de Broglie's hypothesis explain the stability of these orbits ?
- (b) A hydrogen atom initially in the ground state absorbs a photon which excites it to the  $n = 4$  level. Estimate the frequency of the photon.

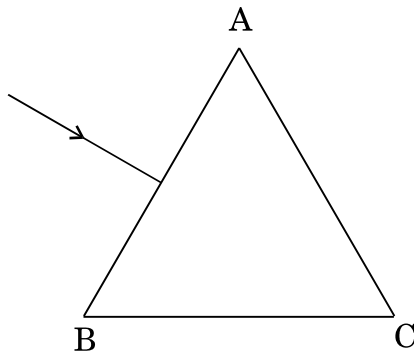


17. (a) उचित आरेख का उपयोग करके यह दर्शाइए कि किसी पारदर्शी काँच के पृष्ठ से परावर्तन द्वारा अध्रुवित प्रकाश को किस प्रकार रैखिकतः ध्रुवित किया जा सकता है ।
- (b)  $\frac{4}{3}$  अपवर्तनांक के जल में स्थित  $\frac{3}{2}$  अपवर्तनांक के काँच के किसी समबाहु प्रिज़्म के फलक AB पर कोई प्रकाश किरण चित्रानुसार अभिलम्बवत् आपतन करती है । फलक AC से टकराने पर क्या यह किरण पूर्ण आन्तरिक परावर्तित होगी ? अपने उत्तर की पुष्टि कीजिए ।

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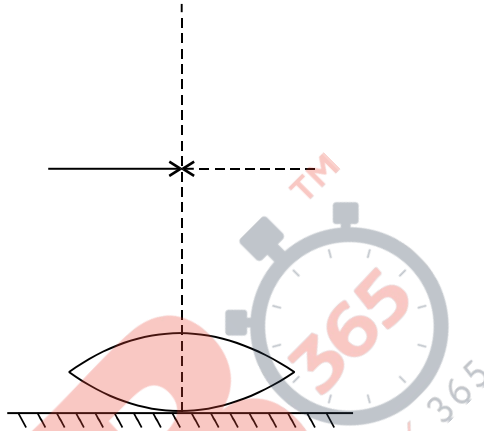


- (a) Show using a proper diagram how unpolarised light can be linearly polarised by reflection from a transparent glass surface.
- (b) The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index  $\frac{3}{2}$ , placed in water of refractive index  $\frac{4}{3}$ . Will this ray suffer total internal reflection on striking the face AC ? Justify your answer.

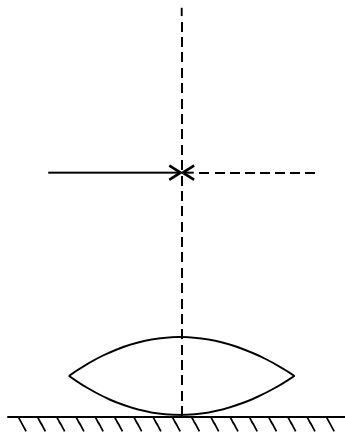


18. अपवर्तनांक 1.5 के काँच से बना वक्रता त्रिज्या R का कोई सममित उभयोत्तल लेंस चित्रानुसार किसी समतल दर्पण के शीर्ष पर स्थित द्रव की सतह पर रखा है। कोई प्रकाशिक सुई अपनी नोक को इस लेंस के मुख्य अक्ष पर रखते हुए, अक्ष पर अपने वास्तविक, उल्टे प्रतिबिम्ब के संपाती होने तक गमन करती है। लेंस से सुई की मापित दूरी  $x$  है। द्रव की सतह को हटाने और प्रयोग को दोहराने पर यह दूरी  $y$  पाई जाती है।  $x$  और  $y$  के पदों में द्रव के अपवर्तनांक के लिए व्यंजक प्राप्त कीजिए।

3



A symmetric biconvex lens of radius of curvature  $R$  and made of glass of refractive index 1.5, is placed on a layer of liquid placed on top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be  $x$ . On removing the liquid layer and repeating the experiment, the distance is found to be  $y$ . Obtain the expression for the refractive index of the liquid in terms of  $x$  and  $y$ .



19. (a) लोहे के एक वलय जिसकी आपेक्षिक चुम्बकशीलता  $\mu_r$  है, पर  $n$  लपेट प्रति मीटर की विद्युत्-रोधी ताँबे के तार की लपेटन है। जब लपेटों में  $I$  धारा प्रवाहित होती है, तो वलय में चुम्बकीय क्षेत्र के लिए व्यंजक ज्ञात कीजिए।
- (b) किसी चुम्बकीय पदार्थ की चुम्बकीय प्रवृत्ति 0.9853 है। चुम्बकीय पदार्थ का प्रकार पहचानिए। किसी एकसमान चुम्बकीय क्षेत्र में इस पदार्थ के टुकड़े को रखने पर क्षेत्र-पैटर्न में होने वाले रूपान्तरण को आरेखित कीजिए।
- (a) An iron ring of relative permeability  $\mu_r$  has windings of insulated copper wire of  $n$  turns per metre. When the current in the windings is  $I$ , find the expression for the magnetic field in the ring.
- (b) The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field.

3

20. 6 J/T चुम्बकीय आघूर्ण का कोई छड़ चुम्बक 0.44 T के किसी एकसमान बाह्य चुम्बकीय क्षेत्र से  $60^\circ$  पर संरेखित है। परिकल्पित कीजिए (a) चुम्बक के चुम्बकीय आघूर्ण को (i) चुम्बकीय क्षेत्र के अभिलम्बवत्, (ii) चुम्बकीय क्षेत्र के विपरीत संरेखित करने के लिए, चुम्बक को घुमाने में किया गया कार्य, तथा (b) प्रकरण (ii) में अंतिम दिग्विन्यास (अभिविन्यास) में चुम्बक पर बल-आघूर्ण।

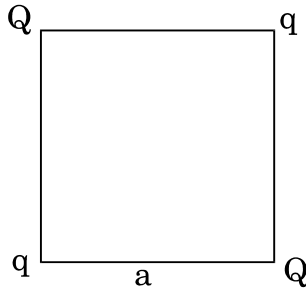
3

A bar magnet of magnetic moment 6 J/T is aligned at  $60^\circ$  with a uniform external magnetic field of 0.44 T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final orientation in case (ii).

21. (a) किसी धात्विक तार की 'चालकता' पद की परिभाषा दीजिए। इसका SI मात्रक लिखिए।
- (b) किसी चालक में मुक्त इलेक्ट्रॉनों की अभिकल्पना का उपयोग करके संख्या घनत्व और विश्रांति काल के पदों में तार की चालकता के लिए व्यंजक व्युत्पन्न कीजिए। अतः धारा घनत्व और अनुप्रयुक्त विद्युत्-क्षेत्र  $E$  के बीच संबंध प्राप्त कीजिए।
- (a) Define the term 'conductivity' of a metallic wire. Write its SI unit.
- (b) Using the concept of free electrons in a conductor, derive the expression for the conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and the applied electric field  $E$ .

3

22. चार बिन्दु आवेश  $Q$ ,  $q$ ,  $Q$  और  $q$  भुजा 'a' के किसी वर्ग के कोनों पर आरेख में दर्शाए अनुसार स्थित हैं ।



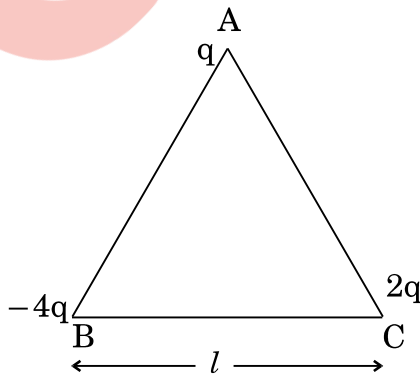
ज्ञात कीजिए

- (a) आवेश  $Q$  पर परिणामी विद्युत् बल, तथा  
(b) इस निकाय की स्थितिज ऊर्जा ।

3

अथवा

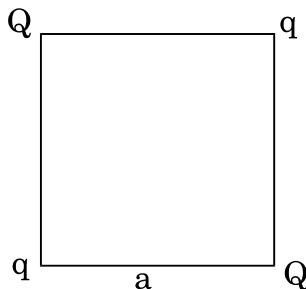
- (a) तीन बिन्दु आवेश  $q$ ,  $-4q$  और  $2q$  भुजा ' $l$ ' के समबाहु त्रिभुज  $ABC$  के शीर्षों पर आरेख में दर्शाए अनुसार स्थित हैं । आवेश  $q$  पर कार्यरत परिणामी विद्युत् बल के परिमाण के लिए व्यंजक प्राप्त कीजिए ।



- (b) आवेशों को अनन्त दूरी तक पृथक् करने के लिए किए जाने वाले कार्य की मात्रा ज्ञात कीजिए ।

3

Four point charges  $Q$ ,  $q$ ,  $Q$  and  $q$  are placed at the corners of a square of side 'a' as shown in the figure.

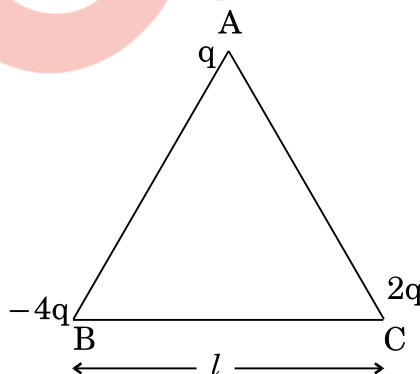


Find the

- (a) resultant electric force on a charge  $Q$ , and
- (b) potential energy of this system.

**OR**

- (a) Three point charges  $q$ ,  $-4q$  and  $2q$  are placed at the vertices of an equilateral triangle  $ABC$  of side ' $l$ ' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge  $q$ .



- (b) Find out the amount of the work done to separate the charges at infinite distance.

**खण्ड द**

**SECTION D**

23. गीता के विद्यालय के शिक्षक विद्यार्थियों को शैक्षिक भ्रमण के लिए शहर से लगभग 200 km की दूरी पर स्थित शक्ति संयंत्र पर ले गए। शिक्षक महोदय ने बताया कि प्रत्यावर्ती धारा (ac) के रूप में विद्युत् ऊर्जा का प्रेषण इतनी लम्बी दूरियों तक शहरों में किया जाता है। प्रत्यावर्ती धारा को उच्च वोल्टता तक उठाया जाता है तथा शहरों में ग्राही स्थानों पर युक्तियों का प्रचालन करने के लिए वोल्टता को घटाया जाता है। इसके परिणामस्वरूप ऊर्जा की बहुत कम हानि होती है। गीता ने शिक्षक महोदय की बात को ध्यानपूर्वक सुना और प्रत्यावर्ती धारा को कम अथवा अधिक वोल्टता में करने के विषय में उनसे प्रश्न पूछे।

- प्रत्यावर्ती वोल्टता को उच्च अथवा निम्न मान तक परिवर्तित करने की युक्ति का नाम लिखिए। इस युक्ति में शक्ति क्षय के एक कारण का उल्लेख कीजिए।
- किसी उदाहरण की सहायता से व्याख्या कीजिए कि दिष्ट धारा की अपेक्षा प्रत्यावर्ती धारा के रूप में लम्बी दूरियों तक ऊर्जा के प्रेषण में शक्ति की हानि किस प्रकार घट जाती है।
- गीता और शिक्षक महोदय प्रत्येक द्वारा प्रदर्शित दो मूल्यों का उल्लेख कीजिए।

4

The teachers of Geeta's school took the students on a study trip to a power generating station, located nearly 200 km away from the city. The teacher explained that electrical energy is transmitted over such a long distance to their city, in the form of alternating current (ac) raised to a high voltage. At the receiving end in the city, the voltage is reduced to operate the devices. As a result, the power loss is reduced. Geeta listened to the teacher and asked questions about how the ac is converted to a higher or lower voltage.

- Name the device used to change the alternating voltage to a higher or lower value. State one cause for power dissipation in this device.
- Explain with an example, how power loss is reduced if the energy is transmitted over long distances as an alternating current rather than a direct current.
- Write two values each shown by the teachers and Geeta.

**खण्ड य**

**SECTION E**

24. (a) किसी प्रत्यावर्ती धारा (ac) जनित्र का सिद्धान्त लिखिए और नामांकित आरेख की सहायता से इसकी क्रियाविधि की व्याख्या कीजिए। घूर्णन अक्ष के लम्बवत् दिशिक किसी चुम्बकीय क्षेत्र  $\vec{B}$  में नियत कोणीय चाल ' $\omega$ ' से घूर्णन करने वाली  $N$  लपेटों और अनुप्रस्थ-काट क्षेत्रफल  $A$  की किसी कुण्डली में प्रेरित विद्युत्-वाहक बल (emf) के लिए व्यंजक प्राप्त कीजिए।
- (b) कोई वायुयान 900 km/hour के वेग से क्षैतिजतः पश्चिम से पूर्व की ओर उड़ रहा है। 20 m विस्तार की इसकी पंखुड़ियों के सिरों के बीच विकसित विभवान्तर परिकलित कीजिए। पृथ्वी के चुम्बकीय क्षेत्र का क्षैतिज घटक  $5 \times 10^{-4}$  T और नति कोण  $30^\circ$  है।

5

**अथवा**

कोई युक्ति X किसी प्रत्यावर्ती धारा (ac) स्रोत  $V = V_0 \sin \omega t$  वोल्टता से संयोजित है। X से प्रवाहित धारा  $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$  है।

- (a) युक्ति X को पहचानिए और इसके प्रतिघात के लिए व्यंजक लिखिए।
- (b) X के लिए प्रत्यावर्ती धारा (ac) के एक चक्र में समय के साथ वोल्टता और धारा के विचरण को दर्शाने के लिए ग्राफ़ खींचिए।
- (c) प्रत्यावर्ती धारा (ac) की आवृत्ति के साथ युक्ति X के प्रतिघात में किस प्रकार विचरण होता है? ग्राफ़ द्वारा इस विचरण को दर्शाइए।
- (d) युक्ति X के लिए फेज़र आरेख खींचिए।
- (a) State the principle of an ac generator and explain its working with the help of a labelled diagram. Obtain the expression for the emf induced in a coil having  $N$  turns each of cross-sectional area  $A$ , rotating with a constant angular speed ' $\omega$ ' in a magnetic field  $\vec{B}$ , directed perpendicular to the axis of rotation.
- (b) An aeroplane is flying horizontally from west to east with a velocity of 900 km/hour. Calculate the potential difference developed between the ends of its wings having a span of 20 m. The horizontal component of the Earth's magnetic field is  $5 \times 10^{-4}$  T and the angle of dip is  $30^\circ$ .

5

**OR**

A device X is connected across an ac source of voltage  $V = V_0 \sin \omega t$ . The current through X is given as  $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ .

- (a) Identify the device X and write the expression for its reactance.
- (b) Draw graphs showing variation of voltage and current with time over one cycle of ac, for X.
- (c) How does the reactance of the device X vary with frequency of the ac ? Show this variation graphically.
- (d) Draw the phasor diagram for the device X.

25. (a) किसी अवतल दर्पण द्वारा किसी बिम्ब का वास्तविक, उल्टा तथा विवर्धित प्रतिबिम्ब बनना दर्शाने के लिए किरण आरेख खींचिए ।
- (b) दर्पण सूत्र प्राप्त कीजिए और रैखिक आवर्धन के लिए व्यंजक लिखिए ।
- (c) अपवर्ती दूरदर्शक की तुलना में परावर्ती दूरदर्शक के दो लाभों की व्याख्या कीजिए । 5

**अथवा**

- (a) तरंगाग्र की परिभाषा दीजिए । हाइगेन्स के सिद्धान्त का उपयोग करके समतल पृष्ठ पर परावर्तन के नियमों का सत्यापन कीजिए ।
- (b) एकल झिरी विवर्तन प्रयोग में झिरी की चौड़ाई उसकी मूल चौड़ाई की दुगुनी की जाती है । केन्द्रीय विवर्तन बैण्ड के साइज़ और तीव्रता पर इसका क्या प्रभाव होगा ? व्याख्या कीजिए ।
- (c) जब किसी दूरस्थ स्रोत से आते हुए प्रकाश के पथ में कोई नन्ही (लघु) वृत्ताकार बाधा रख दी जाती है, तो उस बाधा के केन्द्र पर कोई चमकदार चित्ती दृष्टिगोचर होती है । व्याख्या कीजिए, ऐसा क्यों है । 5

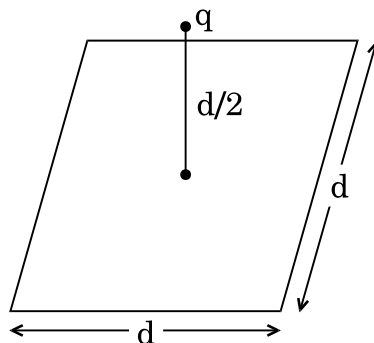


- (a) Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.
- (b) Obtain the mirror formula and write the expression for the linear magnification.
- (c) Explain two advantages of a reflecting telescope over a refracting telescope.

**OR**

- (a) Define a wavefront. Using Huygens' principle, verify the laws of reflection at a plane surface.
- (b) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band ? Explain.
- (c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the obstacle. Explain why.

26. (a) विद्युत् फ्लक्स की परिभाषा दीजिए । क्या यह सदिश राशि है अथवा अदिश ?  
आरेख में दर्शाए अनुसार कोई बिन्दु आवेश  $q$  भुजा  $d$  के किसी वर्ग के केन्द्र के ठीक ऊपर दूरी  $d/2$  पर स्थित है । गाउस के नियम का उपयोग करके इस वर्ग से गुज़रने वाले विद्युत् फ्लक्स के लिए व्यंजक प्राप्त कीजिए ।



- (b) अब यदि इस बिन्दु आवेश को इस वर्ग के केन्द्र से 'd' दूरी पर ले जाएँ तथा वर्ग की भुजा को दुगुना कर दें, तो व्याख्या कीजिए कि विद्युत् फ्लक्स किस प्रकार प्रभावित होगा ।

5

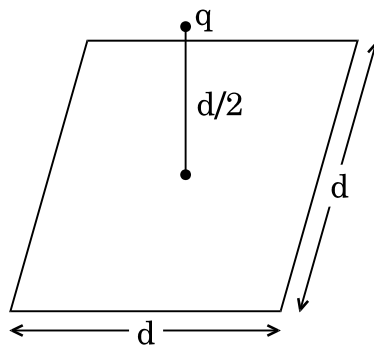
अथवा

- (a) गाउस के नियम का उपयोग करके आवेश घनत्व  $\lambda$  C/m की किसी सीधी एकसमान आवेशित अनन्त रेखा के कारण विद्युत्-क्षेत्र ( $\vec{E}$ ) के लिए व्यंजक व्युत्पन्न कीजिए ।
- (b) आवेश रेखा से लम्बवत् दूरी  $r$  के साथ  $E$  के विचरण को दर्शाने के लिए ग्राफ़ खींचिए ।
- (c) लम्बवत् दूरी  $r_1$  से  $r_2$  तक ( $r_2 > r_1$ ) आवेश  $q$  को ले जाने में किया गया कार्य ज्ञात कीजिए ।

5

- (a) Define electric flux. Is it a scalar or a vector quantity ?

A point charge  $q$  is at a distance of  $d/2$  directly above the centre of a square of side  $d$ , as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.

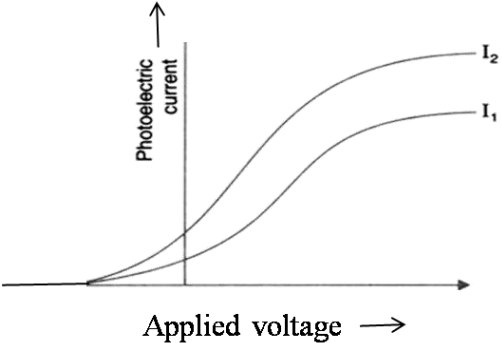


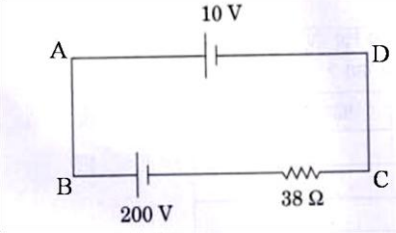
- (b) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

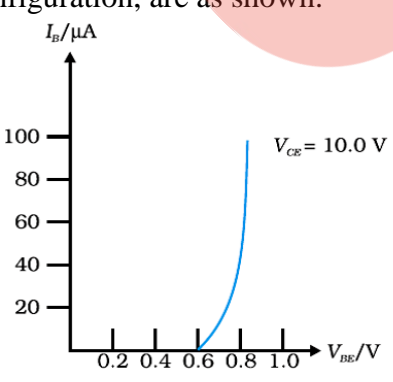
**OR**

- (a) Use Gauss' law to derive the expression for the electric field ( $\vec{E}$ ) due to a straight uniformly charged infinite line of charge density  $\lambda$  C/m.
- (b) Draw a graph to show the variation of  $E$  with perpendicular distance  $r$  from the line of charge.
- (c) Find the work done in bringing a charge  $q$  from perpendicular distance  $r_1$  to  $r_2$  ( $r_2 > r_1$ ).

**MARKING SCHEME**

Q.NO.	Expected Answer/Value Points	Marks	Total Marks						
1	Sky wave propagation	1	1						
2	Daughter nucleus	1	1						
3	(a) Ultra violet rays (b) Ultra violet rays / Laser	½ ½	1						
4	 <p>The graph <math>I_2</math> corresponds to radiation of higher intensity [Note: Deduct this ½ mark if the student does not show the two graphs starting from the same point.] (Also accept if the student just puts some indicative marks, or words, (like tick, cross, higher intensity) on the graph itself.)</p>	½ ½	1						
5	Electron (No explanation need to be given. If a student only writes the formula for frequency of charged particle (or $\nu_c \propto \frac{q}{m}$ ) award ½ mark)	1	1						
<b>SECTION B</b>									
6	<table border="1" style="width: 100%;"> <tr> <td>Formula for modulation index</td> <td>1 mark</td> </tr> <tr> <td>Finding the peak value of the modulating signal</td> <td>1 mark</td> </tr> </table> <p>We have  <math display="block">\mu = \frac{A_m}{A_c}</math>                     Here <math>\mu = 60\% = \frac{3}{5}</math>  <math display="block">\therefore A_m = \mu A_c = \frac{3}{5} \times 15V = 9V</math></p>	Formula for modulation index	1 mark	Finding the peak value of the modulating signal	1 mark	1 ½ ½	2		
Formula for modulation index	1 mark								
Finding the peak value of the modulating signal	1 mark								
7	<table border="1" style="width: 100%;"> <tr> <td>Calculating the energy of the incident photon</td> <td>1 mark</td> </tr> <tr> <td>Identifying the metals</td> <td>½ mark</td> </tr> <tr> <td>Reason</td> <td>½ mark</td> </tr> </table> <p>The energy of a photon of incident radiation is given by  <math display="block">E = \frac{hc}{\lambda}</math> <math display="block">\therefore E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{(412.5 \times 10^{-9}) \times (1.6 \times 10^{-19})} eV</math></p>	Calculating the energy of the incident photon	1 mark	Identifying the metals	½ mark	Reason	½ mark	½	
Calculating the energy of the incident photon	1 mark								
Identifying the metals	½ mark								
Reason	½ mark								

	<p><math>\cong 3.01\text{eV}</math> Hence, only Na and K will show photoelectric emission [<b>Note:</b> Award this <math>\frac{1}{2}</math> mark even if the student writes the name of <u>only one</u> of these metals] <b>Reason:</b> The energy of the incident photon is more than the work function of only these two metals.</p>	<p><math>\frac{1}{2}</math> <math>\frac{1}{2}</math> <math>\frac{1}{2}</math></p>	<p>2</p>
<p>8</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>Writing the equation <span style="float: right;">1 mark</span> Finding the current <span style="float: right;">1 mark</span></p> </div> <p>By Kirchoff's law, we have, for the loop ABCD,  <math>+200 - 38i - 10 = 0</math>  <math>\therefore i = \frac{190}{38} \text{A} = 5\text{A}</math></p>  <p style="text-align: center;"><b>Alternatively:</b></p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>Finding the Net emf <span style="float: right;">1 mark</span> Stating that <math>I = \frac{V}{R}</math> <span style="float: right;"><math>\frac{1}{2}</math> mark</span> Calculating I <span style="float: right;"><math>\frac{1}{2}</math> mark</span></p> </div> <p>The two cells being in 'opposition',  <math>\therefore \text{net emf} = (200 - 10)\text{V} = 190\text{V}</math>          Now <math>I = \frac{V}{R}</math>  <math>\therefore I = \frac{190\text{V}}{38\Omega} = 5\text{A}</math>  <b>[Note:</b> Some students may use the formulae <math>\frac{\epsilon}{r} = \frac{\epsilon_1}{r_1} + \frac{\epsilon_2}{r_2}</math>, and  <math display="block">r = \frac{(r_1 r_2)}{(r_1 + r_2)}</math></p> <p>For two cells connected in parallel          They may then say that <math>r = 0</math>;  <math>\epsilon</math> is indeterminate and hence          I is also indeterminate          Award full marks(2) to students giving this line of reasoning.]  <p style="text-align: center;"><b>OR</b></p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>Stating the formula <span style="float: right;">1mark</span> Calculating <math>r</math> <span style="float: right;">1mark</span></p> </div> <p>We have <math>r = \left(\frac{l_1}{l_2} - 1\right)R = \left(\frac{l_1 - l_2}{l_2}\right)R</math>  <math>\therefore r = \left(\frac{350 - 300}{300}\right) \times 9\Omega</math>  <math>= \frac{50}{300} \times 9\Omega = 1.5\Omega</math></p> </p>	<p>1 1  1 <math>\frac{1}{2}</math> <math>\frac{1}{2}</math>  1 <math>\frac{1}{2}</math> <math>\frac{1}{2}</math></p>	<p>2 2  2  2</p>

<p><b>9</b></p>	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">a) Reason for calling IF rays as heat rays</td> <td style="width: 50%;">1 mark</td> </tr> <tr> <td>b) Explanation for transport of momentum</td> <td>1 mark</td> </tr> </table> <p>a) Infrared rays are readily absorbed by the (water) molecules in most of the substances and hence increases their thermal motion. (If the student just writes that “infrared ray produce heating effects”, award ½ mark only)</p> <p>b) Electromagnetic waves can set (and sustain) charges in motion. Hence, they are said to transport momentum. (Also accept the following: Electromagnetic waves are known to exert ‘radiation pressure’. This pressure is due to the force associated with rate of change of momentum. Hence, EM waves transport momentum)</p>	a) Reason for calling IF rays as heat rays	1 mark	b) Explanation for transport of momentum	1 mark	<p><b>1</b></p> <p><b>1</b></p>	<p><b>2</b></p>				
a) Reason for calling IF rays as heat rays	1 mark										
b) Explanation for transport of momentum	1 mark										
<p><b>10</b></p>	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">Formula</td> <td style="width: 50%;">½ mark</td> </tr> <tr> <td>Stating that currents are equal</td> <td>½ mark</td> </tr> <tr> <td>Ratio of powers</td> <td>1mark</td> </tr> </table> <p>Power = <math>I^2R</math> The current, in the two bulbs, is the same as they are connected in series.</p> $\therefore \frac{P_1}{P_2} = \frac{I^2R_1}{I^2R_2} = \frac{R_1}{R_2}$ $= \frac{1}{2}$	Formula	½ mark	Stating that currents are equal	½ mark	Ratio of powers	1mark	<p>½</p> <p>½</p> <p>½</p> <p>½</p>	<p><b>2</b></p>		
Formula	½ mark										
Stating that currents are equal	½ mark										
Ratio of powers	1mark										
<b>SECTION C</b>											
<p><b>11</b></p>	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">Input and Output characteristics</td> <td style="width: 50%;">1+1marks</td> </tr> <tr> <td>Determination of</td> <td></td> </tr> <tr> <td>    a) Input resistance</td> <td>½ mark</td> </tr> <tr> <td>    b) Current amplification factor</td> <td>½ mark</td> </tr> </table> <p>The input and output characteristics, of a <i>n-p-n</i> transistor, in its CE configuration, are as shown.</p>  <p><u>Input resistance</u></p> $r_i = \left( \frac{\Delta V_{BE}}{\Delta I_B} \right)_{V_{CE}}$	Input and Output characteristics	1+1marks	Determination of		a) Input resistance	½ mark	b) Current amplification factor	½ mark	<p><b>1</b></p> <p>½</p>	
Input and Output characteristics	1+1marks										
Determination of											
a) Input resistance	½ mark										
b) Current amplification factor	½ mark										



(a)

b) The circuit symbol, and the truth table, for the NAND gate, are given below.

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

$\frac{1}{2} + \frac{1}{2}$

**3**

**13**

a) Drawing the plot 1 mark  
 Explaining the process of Nuclear fission and Nuclear fusion  $\frac{1}{2} + \frac{1}{2}$  marks

b) Finding the required time 1 mark

a) The plot of (B.E / nucleon) verses mass number is as shown.

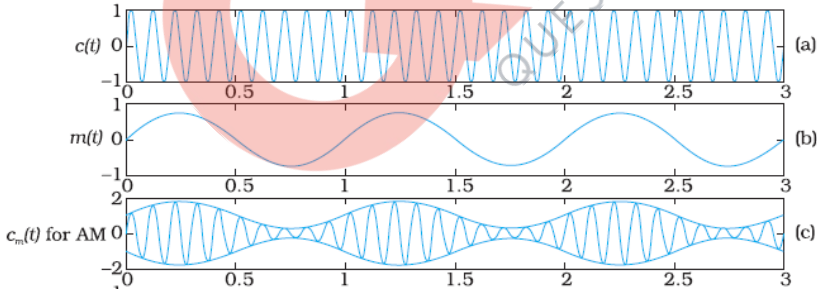
[Note : Also accept the diagram that just shows the general shape of the graph.]

From the plot we note that

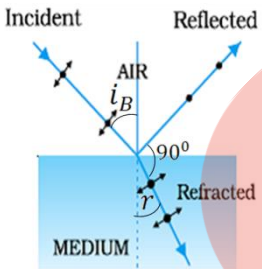
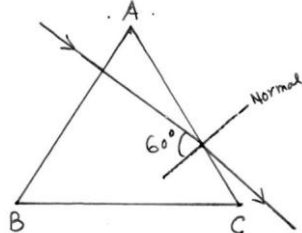
i) During nuclear fission  
 A heavy nucleus in the larger mass region ( $A > 200$ ) breaks into two

$\frac{1}{2}$

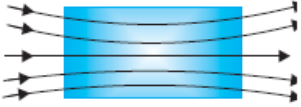


	<p>middle level nuclei, resulting in an increase in B.E/ nucleon. This results in a release of energy.</p> <p>ii) <u>During nuclear fusion</u></p> <p>Light nuclei in the lower mass region (<math>A &lt; 20</math>) fuse to form a nucleus having higher B.E / nucleon. Hence Energy gets released.</p> <p>[Alternatively: As per the plot: During nuclear fission as well as nuclear fusion, the final value of B.E/ nucleon is more than its initial value. Hence energy gets released in both these processes. ]</p> <p>b) We have</p> $3.125\% = \frac{3.125}{100} = \frac{1}{32} = \frac{1}{2^5}$ <p>Half life = 10 years  <math>\therefore</math> Required time = <math>5 \times 10</math> years          = 50 Years</p>	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	<p align="center"><b>3</b></p>
<p align="center"><b>14</b></p>	<div style="border: 1px solid black; padding: 5px;"> <p>a) Stating the three reasons <span style="float: right;"><math>\frac{1}{2} + \frac{1}{2} + \frac{1}{2}</math> mark</span></p> <p>b) Graphical representation of the audio signal, carrier wave and the amplitude modulated wave <span style="float: right;"><math>\frac{1}{2} + \frac{1}{2} + \frac{1}{2}</math> mark</span></p> </div> <p>a) The required three reasons are :</p> <p>(i) A reasonable length of the transmission antenna.          (ii) Increase in effective power radiated by the antenna.          (iii) Reduction in the possibility of ‘mix-up’ of different signals.</p> <p>b) The required graphical representation is as shown below</p>  <p>The figure shows three vertically stacked graphs sharing a common x-axis representing time from 0 to 3 seconds. Graph (a) shows a high-frequency carrier wave <math>c(t)</math> oscillating between -1 and 1. Graph (b) shows a lower-frequency modulating signal <math>m(t)</math> oscillating between -1 and 1. Graph (c) shows the resulting amplitude modulated wave <math>c_m(t)</math> for AM, which is a high-frequency wave whose amplitude varies according to the modulating signal <math>m(t)</math>.</p>	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	<p align="center"><b>3</b></p>
<p align="center"><b>15</b></p>	<div style="border: 1px solid black; padding: 5px;"> <p>a) Finding the (modified) ratio of the maximum and minimum intensities <span style="float: right;">2 marks</span></p> <p>b) Fringes obtained with white light <span style="float: right;">1mark</span></p> </div> <p>a) After the introduction of the glass sheet (say, on the second slit), we have</p> $\frac{I_2}{I_1} = 50\% = \frac{1}{2}$ <p><math>\therefore</math> Ratio of the amplitudes</p>		

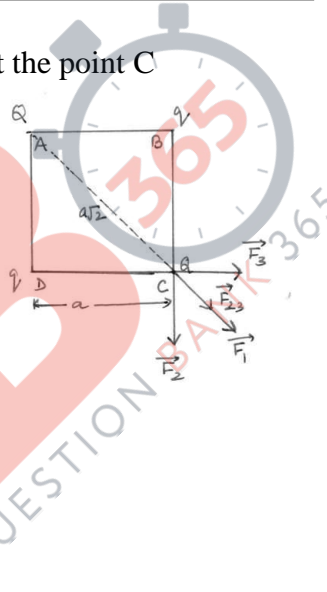
	$= \frac{a_2}{a_1} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$ <p>Hence <math>\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2</math></p> $= \left(\frac{1+\frac{1}{\sqrt{2}}}{1-\frac{1}{\sqrt{2}}}\right)^2$ $= \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2$ <p>(<math>\approx 34</math>)</p> <p>b) The central fringe remains white. No clear fringe pattern is seen after a few (coloured) fringes on either side of the central fringe.</p> <p>[Note : For part (a) of this question, The student may (i) Just draw the diagram for the Young's double slit experiment. Or (ii) Just state that the introduction of the glass sheet would introduce an additional phase difference and the position of the central fringe would shift.</p> <p>For all such answers, the student may be awarded the full (2) marks for this part of this question.]</p>	<p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p> <p align="center"><b>1</b></p>									
<p><b>16</b></p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">a) Statement of Bohr's postulate</td> <td style="text-align: right; padding: 5px;">1 mark</td> </tr> <tr> <td style="padding: 5px;">Explanation in terms of de Broglie hypothesis</td> <td style="text-align: right; padding: 5px;">1/2 mark</td> </tr> <tr> <td style="padding: 5px;">b) Finding the energy in the <math>n = 4</math> level</td> <td style="text-align: right; padding: 5px;">1 mark</td> </tr> <tr> <td style="padding: 5px;">Estimating the frequency of the photon</td> <td style="text-align: right; padding: 5px;">1/2 mark</td> </tr> </table> <p>a) Bohr's postulate, for stable orbits, states "The electron, in an atom, revolves around the nucleus only in those orbits for which its angular momentum is an integral multiple of <math>\frac{h}{2\pi}</math> (<math>h = \text{Planck's constant}</math>),"</p> <p>[Also accept <math>mvr = n \cdot \frac{h}{2\pi}</math> (<math>n = 1,2,3, \dots</math>)</p> <p>As per de Broglie's hypothesis</p> $\lambda = \frac{h}{p} = \frac{h}{mv}$ <p>For a stable orbit, we must have circumference of the orbit = <math>n\lambda</math> (<math>n = 1,2,3, \dots</math>)</p> $\therefore 2\pi r = n \cdot mv$ <p>or <math>mvr = \frac{nh}{2\pi}</math></p> <p>Thus de-Broglie showed that formation of stationary pattern for intergral 'n' gives rise to stability of the atom.</p> <p>This is nothing but the Bohr's postulate</p>	a) Statement of Bohr's postulate	1 mark	Explanation in terms of de Broglie hypothesis	1/2 mark	b) Finding the energy in the $n = 4$ level	1 mark	Estimating the frequency of the photon	1/2 mark	<p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p>	
a) Statement of Bohr's postulate	1 mark										
Explanation in terms of de Broglie hypothesis	1/2 mark										
b) Finding the energy in the $n = 4$ level	1 mark										
Estimating the frequency of the photon	1/2 mark										

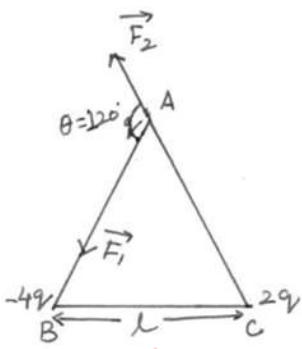
	<p>b) Energy in the <math>n = 4</math> level <math>= \frac{-E_0}{4^2} = -\frac{E_0}{16}</math>  <math>\therefore</math> Energy required to take the electron from the ground state, to the <math>n = 4</math> level <math>= \left(-\frac{E_0}{16}\right) - (-E_0)</math>  <math>= \frac{-1+16}{16}</math>  <math>= \frac{15}{16} E_0</math>  <math>= \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19} \text{J}</math>                  Let the frequency of the photon be <math>\nu</math>, we have  <math>h\nu = \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19}</math>  <math>\therefore \nu = \frac{15 \times 13.6 \times 1.6 \times 10^{-19}}{16 \times 6.63 \times 10^{-34}} \text{ Hz}</math>  <math>\approx 3.1 \times 10^{15} \text{ Hz}</math>                  (Also accept <math>3 \times 10^{15} \text{ Hz}</math>)</p>	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	<p align="center"><b>3</b></p>
<p align="center"><b>17</b></p>	<p>a) Diagram <span style="float:right">1/2 mark</span>                  Polarisation by reflection <span style="float:right">1 mark</span>                  b) Justification <span style="float:right">1 mark</span>                  Writing yes/no <span style="float:right">1/2 mark</span></p> <p>a) The diagram, showing polarisation by reflection is as shown.                  [Here the reflected and refracted rays are at right angle to each other.]</p>  <p><math>\therefore r = \left(\frac{\pi}{2} - i_B\right)</math>  <math>\therefore \mu = \left(\frac{\sin i_B}{\sin r} = \tan i_B\right)</math>                  Thus light gets totally polarised by reflection when it is incident at an angle <math>i_B</math> (Brewster's angle), where <math>i_B = \tan^{-1} \mu</math></p> <p>a) The angle of incidence, of the ray, on striking the face AC is <math>i = 60^\circ</math> (as from figure)                  Also, relative refractive index of glass, with respect to the surrounding water, is  <math>\mu_r = \frac{3/2}{4/3} = \frac{9}{8}</math>                  Also <math>\sin i = \sin 60^\circ = \frac{\sqrt{3}}{2} = \frac{1.732}{2}</math>  <math>= 0.866</math>                  For total internal reflection, the required critical angle, in this case, is given by</p> 	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	

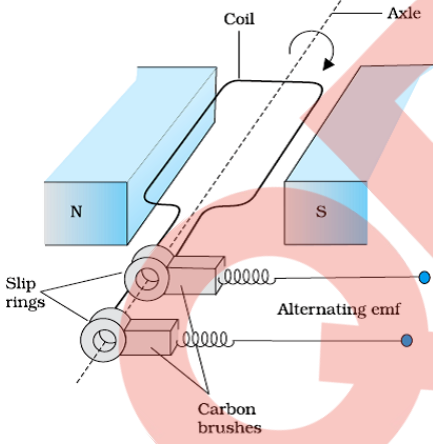
	$\sin i_c = \frac{1}{\mu} = \frac{8}{9} \approx 0.89$ $\therefore i < i_c$ <p>Hence the ray would not suffer total internal reflection on striking the face AC</p> <p>[The student may just write the two conditions needed for total internal reflection without analysis of the given case.</p> <p>The student may be awarded ( 1/2 + 1/2 ) mark in such a case.]</p>	<p align="center">1/2</p> <p align="center">1/2</p>	<p align="center"><b>3</b></p>								
<p align="center"><b>18</b></p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">Lens maker's formula</td> <td align="right" style="padding: 5px;">1/2 mark</td> </tr> <tr> <td style="padding: 5px;">Formula for 'combination of lenses'</td> <td align="right" style="padding: 5px;">1/2 mark</td> </tr> <tr> <td style="padding: 5px;">Obtaining the expression for <math>\mu</math></td> <td align="right" style="padding: 5px;">2 marks</td> </tr> </table> <p>Let <math>\mu_l</math> denote the refractive index of the liquid. When the image of the needle coincides with the lens itself ; its distance from the lens, equals the relevant focal length.</p> <p>With liquid layer present, the given set up, is equivalent to a combination of the given (convex) lens and a concavo plane / plano concave 'liquid lens'.</p> <p>We have <math>\frac{1}{f} = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)</math></p> <p>and <math>\frac{1}{f} = \left( \frac{1}{f_1} + \frac{1}{f_2} \right)</math></p> <p>as per the given data, we then have</p> $\frac{1}{f_2} = \frac{1}{y} = (1.5 - 1) \left( \frac{1}{R} - \frac{1}{(-R)} \right)$ $= \frac{1}{R}$ $\therefore \frac{1}{x} = (\mu_l - 1) \left( -\frac{1}{R} \right) + \frac{1}{y} = \frac{-\mu_l}{y} + \frac{2}{y}$ $\therefore \frac{\mu_l}{y} = \frac{2}{y} - \frac{1}{x} = \left( \frac{2x - y}{xy} \right)$ <p>or <math>\mu_l = \left( \frac{2x - y}{x} \right)</math></p>	Lens maker's formula	1/2 mark	Formula for 'combination of lenses'	1/2 mark	Obtaining the expression for $\mu$	2 marks	<p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p>	<p align="center"><b>3</b></p>		
Lens maker's formula	1/2 mark										
Formula for 'combination of lenses'	1/2 mark										
Obtaining the expression for $\mu$	2 marks										
<p align="center"><b>19</b></p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">a) Expression for Ampere's circuital law</td> <td align="right" style="padding: 5px;">1/2 mark</td> </tr> <tr> <td style="padding: 5px;">Derivation of magnetic field inside the ring</td> <td align="right" style="padding: 5px;">1 mark</td> </tr> <tr> <td style="padding: 5px;">b) Identification of the material</td> <td align="right" style="padding: 5px;">1/2 mark</td> </tr> <tr> <td style="padding: 5px;">Drawing the modification of the field pattern</td> <td align="right" style="padding: 5px;">1 mark</td> </tr> </table> <p>a) From Ampere's circuital law, we have,</p> $\oint \vec{B} \cdot d\vec{l} = \mu_o \mu_r I_{enclosed} \quad (i)$ <p>For the field inside the ring, we can write</p> $\oint \vec{B} \cdot d\vec{l} = \oint B dl = B \cdot 2\pi r$ <p>(r = radius of the ring)</p> <p>Also, <math>I_{enclosed} = (2\pi r n) I</math> using equation (i)</p> $\therefore B \cdot 2\pi r = \mu_o \mu_r \cdot (n \cdot 2\pi r) I$ $\therefore B = \mu_o \mu_r n I$	a) Expression for Ampere's circuital law	1/2 mark	Derivation of magnetic field inside the ring	1 mark	b) Identification of the material	1/2 mark	Drawing the modification of the field pattern	1 mark	<p align="center">1/2</p> <p align="center">1/2</p> <p align="center">1/2</p>	
a) Expression for Ampere's circuital law	1/2 mark										
Derivation of magnetic field inside the ring	1 mark										
b) Identification of the material	1/2 mark										
Drawing the modification of the field pattern	1 mark										

	<p>[Award these <math>(\frac{1}{2} + \frac{1}{2})</math> marks even if the result is written without giving the derivation]</p> <p>b) The material is paramagnetic. The field pattern gets modified as shown in the figure below.</p> 	<p><math>\frac{1}{2}</math></p> <p><b>1</b></p>	<p><b>3</b></p>
<p><b>20</b></p>	<div style="border: 1px solid black; padding: 5px;"> <p>a) Formula and Calculation of work done in the two cases (1+ 1) marks</p> <p>b) Calculation of torque in case (ii) 1 mark</p> </div> <p><b>(a)</b> Work done = <math>mB(\cos\theta_1 - \cos\theta_2)</math> (i) <math>\theta_1 = 60^\circ, \theta_2 = 90^\circ</math> ∴ work done = <math>mB(\cos 60^\circ - \cos 90^\circ)</math> <math>= mB(\frac{1}{2} - 0) = \frac{1}{2} mB</math> <math>= \frac{1}{2} \times 6 \times 0.44 \text{ J} = 1.32 \text{ J}</math> (ii) <math>\theta_1 = 60^\circ, \theta_2 = 180^\circ</math> ∴ work done = <math>mB(\cos 60^\circ - \cos 180^\circ)</math> <math>= mB(\frac{1}{2} - (-1)) = \frac{3}{2} mB</math> <math>= \frac{3}{2} \times 6 \times 0.44 \text{ J} = 3.96 \text{ J}</math> [Also accept calculations done through changes in potential energy.] <b>(b)</b> Torque = <math> \vec{m} \times \vec{B}  = mB \sin\theta</math> For <math>\theta = 180^\circ</math>, we have Torque = <math>6 \times 0.44 \sin 180^\circ = 0</math> [If the student straight away writes that the torque is zero since magnetic moment and magnetic field are anti parallel in this orientation, award full 1 mark]</p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	<p><b>3</b></p>
<p><b>21</b></p>	<div style="border: 1px solid black; padding: 5px;"> <p>a) Definition and SI unit of conductivity <math>\frac{1}{2} + \frac{1}{2}</math> marks</p> <p>b) Derivation of the expression for conductivity 1 <math>\frac{1}{2}</math> marks Relation between current density and electric field <math>\frac{1}{2}</math> mark</p> </div> <p>a) The conductivity of a material equals the reciprocal of the resistance of its wire of unit length and unit area of cross section. <b>[Alternatively:</b> The conductivity (<math>\sigma</math>) of a material is the reciprocal of its resistivity (<math>\rho</math>) (Also accept <math>\sigma = \frac{1}{\rho}</math>) Its SI unit is <math>(\frac{1}{ohm\text{-metre}}) / ohm^{-1}m^{-1} / (mho m^{-1}) / siemen m^{-1}</math> b) The acceleration, <math>\vec{a} = -\frac{e}{m} \vec{E}</math></p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	

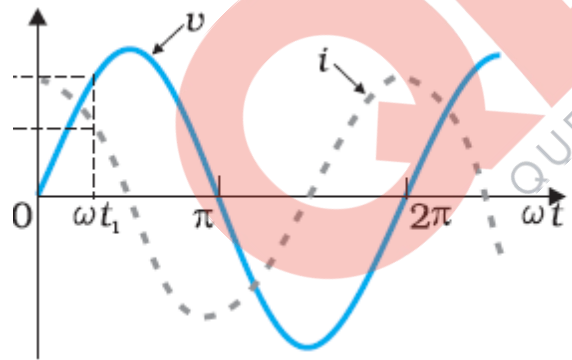
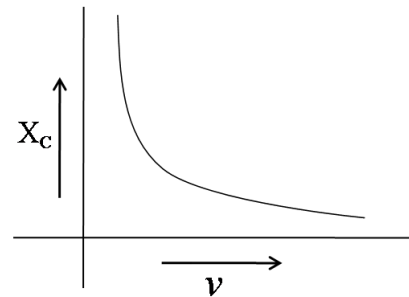
	<p>The average drift velocity, <math>v_d</math>, is given by</p> $v_d = -\frac{eE}{m}\tau$ <p>(<math>\tau</math> = average time between collisions/ relaxation time)          If <math>n</math> is the number of free electrons per unit volume, the current <math>I</math> is given by</p> $I = neA v_d $ $= \frac{e^2 A}{m} \tau n  E $ <p>But <math>I =  j A</math> (<math>j</math>= current density)          We, therefore, get</p> $ j  = \frac{ne^2}{m} \tau  E , \text{ The term } \frac{ne^2}{m} \tau \text{ is conductivity. } \therefore \sigma = \frac{ne^2\tau}{m}$ $\Rightarrow J = \sigma E$	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	<p align="center"><b>3</b></p>
<p><b>22</b></p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>a) Finding the resultant force on a charge <math>Q</math>      2 marks</p> <p>b) Potential Energy of the system                      1 mark</p> </div> <p>a) Let us find the force on the charge <math>Q</math> at the point C</p> <p>Force due to the other charge <math>Q</math></p> $F_1 = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{(a\sqrt{2})^2} = \frac{1}{4\pi\epsilon_0} \left(\frac{Q^2}{2a^2}\right) \text{ (along AC)}$ <p>Force due to the charge <math>q</math> (at B), <math>F_2</math></p> $= \frac{1}{4\pi\epsilon_0} \frac{qQ}{a^2} \text{ along BC}$ <p>Force due to the charge <math>q</math> (at D), <math>F_3</math></p> $= \frac{1}{4\pi\epsilon_0} \frac{qQ}{a^2} \text{ along DC}$ <p>Resultant of these two equal forces</p> $F_{23} = \frac{1}{4\pi\epsilon_0} \frac{qQ(\sqrt{2})}{a^2} \text{ (along AC)}$ <p><math>\therefore</math> Net force on charge <math>Q</math> ( at point C)</p> $F = F_1 + F_{23} = \frac{1}{4\pi\epsilon_0} \frac{Q}{a^2} \left[\frac{Q}{2} + \sqrt{2}q\right]$ <p>This force is directed along AC          ( For the charge <math>Q</math>, at the point A, the force will have the same magnitude but will be directed along CA)          [Note : Don't deduct marks if the student does not write the direction of the net force , <math>F</math>]</p> <p>b) Potential energy of the system</p> $= \frac{1}{4\pi\epsilon_0} \left[4 \frac{qQ}{a} + \frac{q^2}{a\sqrt{2}} + \frac{Q^2}{a\sqrt{2}}\right]$ $= \frac{1}{4\pi\epsilon_0 a} \left[4qQ + \frac{q^2}{\sqrt{2}} + \frac{Q^2}{\sqrt{2}}\right]$ <p align="center"><b>OR</b></p>	<p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p> <p align="center"><math>\frac{1}{2}</math></p>	<p align="center"><b>3</b></p>

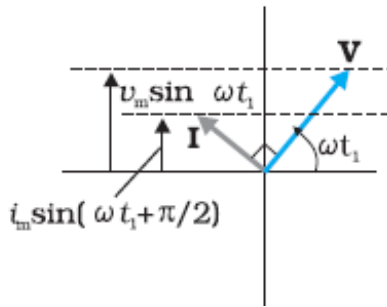


	<p>a) Finding the magnitude of the resultant force on charge <math>q</math> 2 marks                  b) Finding the work done 1 mark</p> <p>b) Force on charge <math>q</math> due to the charge <math>4q</math>  <math>F_1 = \frac{1}{4\pi\epsilon_0} \left( \frac{4q^2}{l^2} \right)</math>, along AB                  Force on the charge <math>q</math>, due to the charge <math>2q</math>  <math>F_2 = \frac{1}{4\pi\epsilon_0} \left( \frac{2q^2}{l^2} \right)</math>, along CA                  The forces <math>F_1</math> and <math>F_2</math> are inclined to each other at an angle of <math>120^\circ</math></p>  <p>Hence, resultant electric force on charge <math>q</math></p> $F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$ $= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120^\circ}$ $= \sqrt{F_1^2 + F_2^2 - F_1F_2}$ $= \left( \frac{1}{4\pi\epsilon_0} \frac{q^2}{l^2} \right) \sqrt{16 + 4 - 8}$ $= \frac{1}{4\pi\epsilon_0} \left( \frac{2\sqrt{3} q^2}{l^2} \right)$ <p>(b) Net P.E. of the system</p> $= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l} [-4 + 2 - 8]$ $= \frac{(-10) q^2}{4\pi\epsilon_0 l}$ <p><math>\therefore</math> Work done <math>= \frac{10 q^2}{4\pi\epsilon_0 l} = \frac{5q^2}{2\pi\epsilon_0 l}</math></p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	<p>3</p>
<p>23</p>	<p>a) Name of device <math>\frac{1}{2}</math> mark                  One cause for power dissipation <math>\frac{1}{2}</math> mark                  b) Reduction of power loss in long distance transmission 1 mark                  c) Two values each displayed by teacher and Geeta <math>(\frac{1}{2} \times 4 = 2)</math> marks</p> <p>a) Transformer <math>\frac{1}{2}</math>                  Cause of power dissipation                  i) Joule heating in the windings.                  ii) Leakage of magnetic flux between the coils.                  iii) Production of eddy currents in the core.                  iv) Energy loss due to hysteresis.                  [Any one / any other correct reason of power loss] <math>\frac{1}{2}</math>                  b) ac voltage can be stepped up to high value, which reduces the</p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	

	<p>current in the line during transmission, hence the power loss(<math>I^2R</math>) is reduced considerably while such stepping up is not possible for direct current.</p> <p>[Also accept if the student explains this through a relevant example.]</p> <p>c) Teacher : Concerned, caring, ready to share knowledge .                  Geeta : Inquisitive, scientific temper, Good listener, keen learner (any other two values for the teacher and Geeta)</p>	<p align="center"><b>1</b></p> <p><math>\frac{1}{2} + \frac{1}{2}</math>  <math>\frac{1}{2} + \frac{1}{2}</math></p>	<p align="center"><b>4</b></p>
<p><b>24</b></p>	<p>a) Principle of ac generator <span style="float:right">1/2 mark</span>                  working <span style="float:right">1/2 mark</span>                  Labeled diagram <span style="float:right">1 mark</span>                  Derivation of the expression for induced emf <span style="float:right">1 1/2 mark</span>                  b) Calculation of potential difference <span style="float:right">1 1/2 mark</span></p> <p>a) The AC Generator works on the principle of electromagnetic induction.                  when the magnetic flux through a coil changes, an emf is induced in it.                  As the coil rotates in magnetic field the effective area of the loop, (i.e. <math>A \cos \theta</math>) exposed to the magnetic field keeps on changing, hence magnetic flux changes and an emf is induced.</p> <div style="text-align: center;">  </div> <p>When a coil is rotated with a constant angular speed '<math>\omega</math>', the angle '<math>\theta</math>' between the magnetic field vector <math>\vec{B}</math> and the area vector <math>\vec{A}</math>, of the coil at any instant '<math>t</math>' equals <math>\omega t</math>; (assuming <math>\theta = 0^\circ</math> at <math>t=0</math>)                  As a result, the effective area of the coil exposed to the magnetic field changes with time ; The flux at any instant '<math>t</math>' is given by</p> $\phi_B = NBA \cos \theta = NBA \cos \omega t$ <p><math>\therefore</math> The induced emf <math>e = - N \frac{d\phi}{dt}</math> <span style="float:right">1/2</span></p> $= -NBA \frac{d}{dt} (\cos \omega t)$ $e = NBA \omega \sin \omega t$ <p>b) Potential difference developed between the ends of the wings                  'e' = <math>Blv</math> <span style="float:right">1/2</span></p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p align="center"><b>1</b></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	



	<p>Given Velocity <math>v = 900 \text{ km/hour}</math>  <math>= 250 \text{ m/s}</math>                  Wing span (<math>l</math>) = 20 m</p> <p>Vertical component of Earth's magnetic field  <math>B_V = B_H \tan \delta</math>  <math>= 5 \times 10^{-4} (\tan 30^\circ) \text{ tesla}</math></p> <p><math>\therefore</math> Potential difference  <math>= 5 \times 10^{-4} (\tan 30^\circ) \times 20 \times 250</math>  <math>= \frac{5 \times 20 \times 250 \times 10^{-4}}{\sqrt{3}} \text{ V}</math>  <math>= 1.44 \text{ volt}</math></p> <p style="text-align: center;"><b>Or</b></p>	<p style="text-align: center;"><math>\frac{1}{2}</math></p> <p style="text-align: center;"><math>\frac{1}{2}</math></p>	<p style="text-align: center;"><b>5</b></p>
	<p>a) Identification of the device X <span style="float: right;"><math>\frac{1}{2}</math></span>                  Expression for reactance <span style="float: right;"><math>\frac{1}{2}</math></span></p> <p>b) Graphs of voltage and current with time <span style="float: right;"><math>1+1</math></span></p> <p>c) Variation of reactance with frequency (Graphical variation) <span style="float: right;"><math>\frac{1}{2}</math></span></p> <p>d) Phasor Diagram <span style="float: right;"><math>\frac{1}{2}</math></span></p>	<p style="text-align: center;"><math>\frac{1}{2}</math></p> <p style="text-align: center;"><math>\frac{1}{2}</math></p>	
	<p>a) X : capacitor                  Reactance <math>X_c = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}</math></p> <p>b)</p> 	<p style="text-align: center;"><math>\frac{1}{2}</math></p> <p style="text-align: center;"><math>\frac{1}{2}</math></p>	<p style="text-align: center;"><math>\frac{1}{2} + \frac{1}{2}</math></p>
	<p>c) Reactance of the capacitor varies in inverse proportion to the frequency i.e. , <math>X_c \propto \frac{1}{\nu}</math></p> 	<p style="text-align: center;"><b>1</b></p> <p style="text-align: center;"><b>1</b></p>	



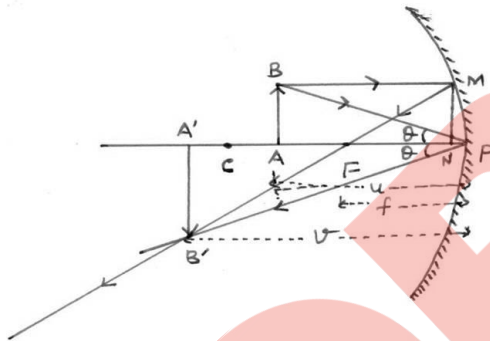
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5

25

- (a) Ray diagram to show the required image formation 1 mark
- (b) Derivation of mirror formula 2 1/2 marks  
Expression for linear magnification 1/2 mark
- (c) Two advantages of a reflecting telescope over a refracting telescope 1/2+1/2 marks

a)



1

- (b) In the above figure  
 $\Delta BAP$  and  $\Delta B'A'P$  are similar  
 $\Rightarrow \frac{BA}{B'A'} = \frac{PA}{PA'}$  (i)  
 Similarly,  $\Delta MNF$  and  $\Delta B'A'F$  are similar  
 $\Rightarrow \frac{MN}{B'A'} = \frac{NF}{FA'}$  (ii)  
 As  $MN = BA$   
 $NF \approx PF$   
 $FA' = PA' - PF$   
 $\therefore$  equation (ii) takes the following form  
 $\frac{BA}{B'A'} = \frac{PF}{PA' - PF}$  (iii)

1/2

Using equation (i) and (iii)

$$\frac{PA}{PA'} = \frac{PF}{PA' - PF}$$

1/2

For the given figure, as per the sign convention,

$PA = -u$

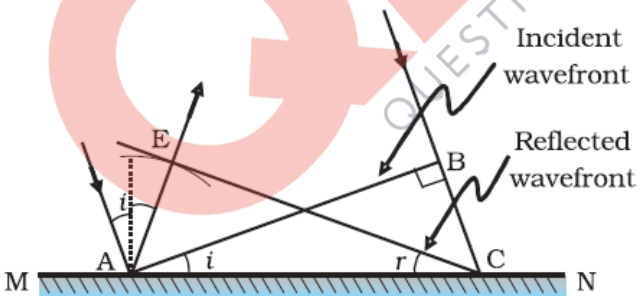
$PA' = -v$

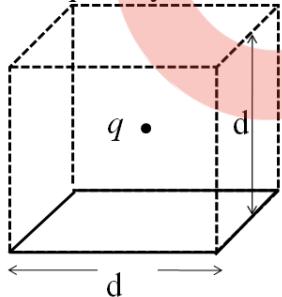
$PF = -f$

$$\Rightarrow \frac{-u}{-v} = \frac{-f}{-v - (-f)}$$

$$\frac{u}{v} = \frac{f}{v - f}$$

1/2

<p><math>uv - uf = vf</math> Dividing each term by <math>uvf</math>, we get</p> $\frac{1}{f} - \frac{1}{v} = \frac{1}{u}$ $\Rightarrow \frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ <p>Linear magnification = <math>-\frac{v}{u}</math>, (alternatively <math>m = \frac{h_i}{h_o}</math>)</p> <p>c) Advantages of reflecting telescope over refracting telescope</p> <ul style="list-style-type: none"> <li>(i) Mechanical support is easier</li> <li>(ii) Magnifying power is large</li> <li>(iii) Resolving power is large</li> <li>(iv) Spherical aberration is reduced</li> <li>(v) Free from chromatic aberration</li> </ul> <p>(any two)</p>	<p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2} + \frac{1}{2}</math></p>	<p>5</p>
<p style="text-align: center;"><b>OR</b></p> <div style="border: 1px solid black; padding: 5px;"> <p>(a) Definition of wave front <span style="float: right;">1/2 mark</span> Verification of laws of reflection <span style="float: right;">2 marks</span></p> <p>(b) Explanation of the effect on the size and intensity of central maxima <span style="float: right;">1+1marks</span></p> <p>(c) Explanation of the bright spot in the shadow of the obstacle <span style="float: right;">1/2 mark</span></p> </div>		
<p>(a) The wave front may be defined as a surface of constant phase. (Alternatively: The wave front is the loci of all points that are in the same phase)</p> <div style="text-align: center;">  </div> <p>Let speed of the wave in the medium be '<math>v</math>' Let the time taken by the wave front, to advance from point B to point C is '<math>\tau</math>' Hence <math>BC = v\tau</math> Let CE represent the reflected wave front Distance <math>AE = v\tau = BC</math> <math>\Delta AEC</math> and <math>\Delta ABC</math> are congruent <math>\therefore \angle BAC = \angle ECA</math></p> <p><math>\Rightarrow \angle i = \angle r</math></p> <p>(b) Size of central maxima reduces to half,</p>	<p><math>\frac{1}{2}</math></p> <p>1</p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	

	<p>(∵ Size of central maxima = <math>\frac{2\lambda D}{a}</math>)</p> <p>Intensity increases. This is because the amount of light, entering the slit, has increased and the area, over which it falls, decreases. (Also accept if the student just writes that the intensity becomes four fold)</p> <p>(c) This is because of diffraction of light. [Alternatively: Light gets diffracted by the tiny circular obstacle and reaches the centre of the shadow of the obstacle.] [Alternatively: There is a maxima, at the centre of the obstacle, in the diffraction pattern produced by it.]</p>	<p>1/2 1/2 1/2 1/2</p>	<p>5</p>
<p>26</p>	<p>a) Definition of electric flux 1 mark Stating scalar/ vector 1/2 mark Gauss's Theorem 1/2 mark Derivation of the expression for electric flux 1 marks b) Explanation of change in electric flux 2 marks</p> <p>a) Electric flux through a given surface is defined as the dot product of electric field and area vector over that surface. Alternatively <math>\phi = \int_s \vec{E} \cdot \vec{dS}</math></p> <p>Also accept Electric flux, through a surface equals the surface integral of the electric field over that surface.</p> <p>It is a scalar quantity</p>  <p>Constructing a cube of side 'd' so that charge 'q' gets placed within of this cube (Gaussian surface)</p> <p>According to Gauss 's law the Electric flux <math>\phi = \frac{\text{Charge enclosed}}{\epsilon_0}</math> <math>= \frac{q}{\epsilon_0}</math></p> <p>This is the total flux through all the six faces of the cube. Hence electric flux through the square <math>\frac{1}{6} \times \frac{q}{\epsilon_0} = \frac{q}{6\epsilon_0}</math></p> <p>b) If the charge is moved to a distance d and the side of the square is</p>	<p>1 1/2 1/2 1/2</p>	

doubled the cube will be constructed to have a side  $2d$  but the total charge enclosed in it will remain the same. Hence the total flux through the cube and therefore the flux through the square will remain the same as before.

1+1

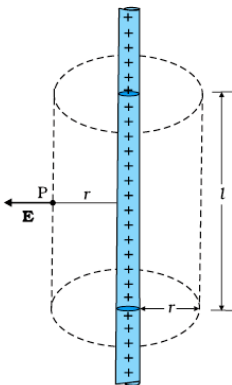
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[Deduct 1 mark if the student just writes No change /not affected without giving any explanation.]

OR

- |   |         |
|---|---------|
| a) Derivation of the expression for electric field $\vec{E}$  | 3 marks |
| b) Graph to show the required variation of the electric field | 1 mark  |
| c) Calculation of work done                                   | 1 mark  |

a)



To calculate the electric field, imagine a cylindrical Gaussian surface, since the field is everywhere radial, flux through two ends of the cylindrical Gaussian surface is zero.

1/2

At cylindrical part of the surface electric field  $\vec{E}$  is normal to the surface at every point and its magnitude is constant.

1/2

Therefore flux through the Gaussian surface.

= Flux through the curved cylindrical part of the surface.

$$= E \times 2\pi r l \quad \text{-----(i)}$$

1/2

Applying Gauss's Law

$$\text{Flux } \phi = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

Total charge enclosed

$$= \text{Linear charge density} \times l$$

$$= \lambda l$$

$$\therefore \phi = \frac{\lambda l}{\epsilon_0} \quad \text{-----(ii)}$$

1/2

Using Equations (i) & ii

$$E \times 2\pi r l = \frac{\lambda l}{\epsilon_0}$$

$$\Rightarrow E = \frac{\lambda}{2\pi\epsilon_0 r}$$

1/2

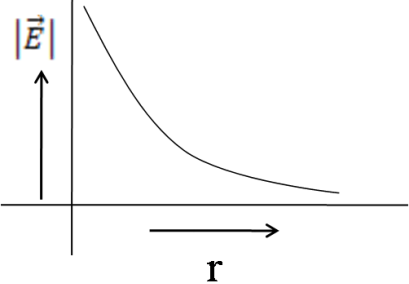
In vector notation

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r} \hat{n}$$

1/2

(where  $\hat{n}$  is a unit vector normal to the line charge)

b) The required graph is as shown:

	 <p>a) Work done in moving the charge 'q'. Through a small displacement 'dr'</p> $dW = \vec{F} \cdot \vec{dr}$ $dW = q\vec{E} \cdot \vec{dr}$ $= qEdr\cos 0$ $dW = q \times \frac{\lambda}{2\pi\epsilon_0 r} dr$ <p>Work done in moving the given charge from <math>r_1</math> to <math>r_2 (r_2 &gt; r_1)</math></p> $W = \int_{r_1}^{r_2} dW = \int_{r_1}^{r_2} \frac{\lambda q dr}{2\pi\epsilon_0 r}$ $W = \frac{\lambda q}{2\pi\epsilon_0} [\log_e r_2 - \log_e r_1]$ $W = \frac{\lambda q}{2\pi\epsilon_0} \left[ \log_e \frac{r_2}{r_1} \right]$	<p><b>1</b></p> <p><math>\frac{1}{2}</math></p> <p><math>\frac{1}{2}</math></p>	<p><b>5</b></p>
--	---	---	-----------------

