Sample Question Paper-5

PHYSICS

Class-12th

SOLVED

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

Read the following instructions carefully and follow them:

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

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

(iii) In Section A: Question number 1 to 16 are Multiple Choice (MCQ) type questions carrying 1 mark each.

(iv) In Section B: Question number 17 to 21 are Very Short Answer (VSA) type questions carrying 2 marks each.

(v) In Section C: Question number 22 to 28 are Short Answer (SA) type questions carrying 3 marks each.

(vi) In Section D: Question number 29 and 30 are Case-Based questions carrying 4 marks each.

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

(viii) There is no overall choice. However, an internal choice has been provided in one question in Section-B, one question in Section-C, one question in each CBQ in Section-D and all three questions in Section-E.

(ix) Use of calculators is NOT allowed.

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

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

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

$\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

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

$\frac{1}{4\pi_0} = 9 \times 10^9$ N m^{2}C^{-2}

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

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

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

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

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

Section-A

[16 × 1 = 16 marks]

1. An infinite long straight wire having a charge density λ is kept along y'y axis in X-Y plane. The Coulomb force on a point charge q at a point $P(x, 0)$ will be

(A) attractive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$ **(B)** repulsive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$ **(C)** attractive and $\frac{q\lambda}{\pi\varepsilon_0 x}$ **(D)** repulsive and $\frac{q\lambda}{\pi\varepsilon_0 x}$ [A]

2. An electric dipole of dipole moment $\vec{p}$ is kept in a uniform electric field $\vec{E}$. The amount of work done to rotate it from the position of stable equilibrium to that of unstable equilibrium will be

(A) $2\,pE$ **(B)** $-2\,pE$ **(C)** pE **(D)** zero [Ap]

3. Given below are two charged subatomic particles P and Q, that are accelerated through same potential difference V.

Here, Masses: $m_P = m_Q$

Charges: $\frac{1}{2} q_P = q_Q$

Which of the two sub atomic particles will have longer de Broglie wavelength?

(A) Particle P, because it has the greater momentum

(B) Particle Q, because it has the greater momentum

(C) Particle P, because it has the smaller momentum

(D) Particle Q, because it has the smaller momentum [Ap]

4. Each of the statements below are based on the properties of electron orbits in a hydrogen atom. Identify a statement that correctly satisfies the Bohr's model of an atom.

(A) The angular momentum of the orbiting electron is $\frac{3h}{\pi}$.

(B) The potential energy of the electron in any stable orbit is positive.

(C) The radius of the second electron orbit is $2a_o$, where a_o is Bohr's radius.

(D) An amount of energy = –3.4 eV given to an electron in its second orbit will let it escape the atom. A

5. Which of the following statements is INCORRECT for a magnetic dipole?

(A) A freely suspended magnetic dipole in a uniform magnetic field always turns to align parallel to the external magnetic field.

(B) A magnetic dipole that is free to move in a non-uniform magnetic field can slide as well as rotate.

(C) The torque required to hold a freely suspended magnetic dipole is maximum when the dipole is perpendicular to the direction of the external magnetic field.

(D) A small angular displacement given to a magnetic dipole result in a simple harmonic motion about its original position, irrespective of its orientation in a uniform magnetic field. A

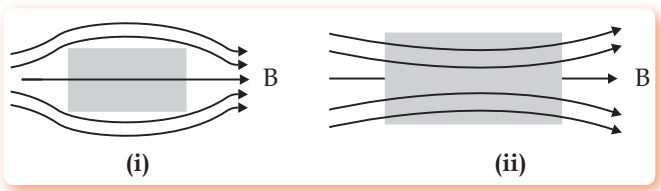
6.

	Column I (Concepts)		Column II (Explanation)
1.	Photoelectric Effect	**P.**	Matter behaves both as waves and particles
2.	De-Broglie Hypothesis	**Q.**	Emission of electrons when light falls on metal surfaces
3.	Einstein's Equation	**R.**	Independent of intensity
4.	Threshold Frequency	**S.**	Relates energy of photon to frequency

Correct match of Column I with Column II is:

(A) 1-Q, 2-P, 3-S, 4-R **(B)** 1-P, 2-Q, 3-R, 4-S **(C)** 1-P, 2-R, 3-Q, 4-S **(D)** 1-S, 2-Q, 3-R, 4-P U

7. Two blocks of different materials are placed in a uniform magnetic field B. The magnetic field lines passing through the two blocks are represented as follows. : Identify the suitable values of relative permeability μ_r and magnetic susceptibility χ for the materials I and II.



A

(A) For I : $\mu_r > 1, \chi < 0$, For II : $\mu_r < 1, \chi > 0$ **(B)** For I : $\mu_r < 1, \chi = 0$, For II : $\mu_r > 1, \chi = 0$

(C) For I : $\mu_r = 0, \chi = 1$, For II : $\mu_r = 1, \chi = 0$ **(D)** For I : $\mu_r < 1, \chi < 0$, For II : $\mu_r > 1, \chi > 0$

8. O_2 molecule consists of two oxygen atoms. In the molecule, nuclear force between the nuclei of the two atoms

(A) is not important because nuclear forces are short-ranged.

(B) is as important as electrostatic force for binding the two atoms.

(C) cancels the repulsive electrostatic force between the nuclei.

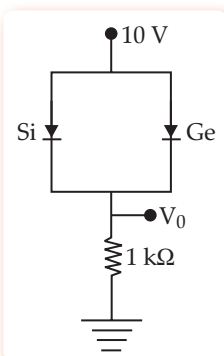
(D) is not important because oxygen nucleus have equal number of neutrons and protons. A

9. In an *ON* state, the individual Silicon and Germanium diodes, allow a voltage drop of 0.7 V and 0.3 V respectively across them. In the circuit shown, the Si and the Ge diode, are connected in a parallel combination to a voltage source of 10V. AI Ap

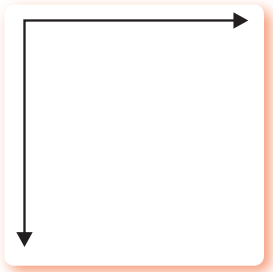
What is the voltage V_o for the circuit network?

(A) 0 volt **(B)** 9.3 volt

(C) 9.7 volt **(D)** 10 volt



10. The diagram below shows the electric field (E) and magnetic field (B) components of an electromagnetic wave at a certain time and location. What is the direction of propagation of the em wave? U



(A) perpendicular to E and B and out of the plane of the paper
(B) perpendicular to E and B and into the plane of the paper
(C) parallel and in the same direction as E
(D) parallel and in the same direction as B

11. An LCR series circuit is connected to an ac supply of ω=100rad/s. Given the values as R = 100-ohm, L = 500mH, C = 5μF, study the following statements carefully.

I. The given circuit **(LCR)** is dominantly capacitive
II. The instantaneous current in the circuit leads V_{max}.
III. If ω greater than $200\sqrt{10}$ rad/s, the circuit becomes dominantly inductive
IV. The LCR circuit can be made capacitive or inductive by simply changing the angular frequency of the input *ac* supply, keeping the voltage V_{max} constant.

Identify the correct option.
(A) Only statement IV is correct
(B) Only statements I and II are correct
(C) Only statements I and III are correct
(D) All statements are correct Ap

12. Two H atoms in the ground state collide in elastically. The maximum amount by which their combined kinetic energy is reduced, is
(A) 10.20 eV **(B)** 20.40 eV **(C)** 13.6 eV **(D)** 27.2 eV Ap

Direction: In the following questions, a statements of Assertion (A) is following by a statement of Reason (R). Mark the correction choice as:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

13. **Assertion (A):** The curve between the binding energy per nucleon versus mass number droops at high mass numbers (A > 170) as well as at low mass numbers (A < 30).
Reason (R): Nuclei with middle mass numbers (30 < A < 170) have higher binding energy per nucleon. U

14. **Assertion (A):** At very high temperature, extrinsic semiconductor behaves like an intrinsic semiconductor.
Reason (R): As temperature increases, more and more covalent bond of semiconductor rupture. More and more charge carriers become available. E

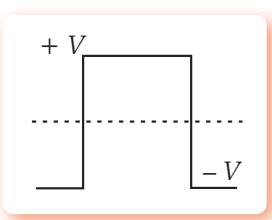
15. **Assertion (A):** When electrons drift in a conductor, it does not mean that all free electrons in the conductor are moving in the same direction.
Reason (R): The drift velocity is superposed over large random velocities of electrons. E

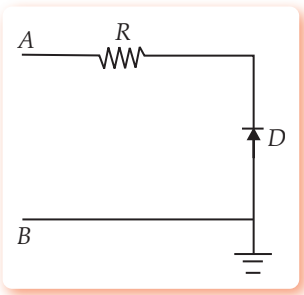
16. **Assertion (A):** Interference pattern has all maxima that are equally bright and bands are large in number in comparison to the diffraction pattern that has maxima of decreasing intensity and fewer in number.
Reason (R): Interference is the result of the superposition of the waves from two different wavefronts whereas diffraction is the result of the superposition of the wavelets from different points of the same wavefront. E

Section-B

[5 × 2 = 10 marks]

17. In the circuit containing an ideal p-n diode D and a resistor R is given an input square wave as shown. AI





(i) What is the shape of the output waveform across diode D?

(ii) Give an explanation for your answer in **(i)** Ap

18. The ratio of de Broglie wavelengths of a proton and a deuteron accelerated by potential V_P and V_d respectively, $\left(\frac{\lambda_p}{\lambda_d}\right)$ is $\frac{1}{2}$. Find $\frac{V_P}{V_d}$. Ap

19. The critical angle for the total internal reflection of diamond in air is 24°. State whether the two statements given here are correct or incorrect. Give a reason for your answer.

(i) The critical angle for total internal reflection of diamond is more than 24° when surrounded by water.

(ii) The sparkle of the diamond increases remarkably when placed in water. A

20. Find the temperature at which the resistance of a conductor increases by 25% of its value at 27°C. The temperature coefficient of resistance of the conductor is 2.0×10^{-4} °C^{-1}. Ap

21. Estimate the number of dark fringes on the either side of the central maximum that can be produced by diffraction set up with slit of width 5×10^{-6} m and incident light of wavelength 600 nm. Ap

OR

Fringe width of the interference pattern on the screen in a double slit experiment is β. Determine the fringe width if the whole apparatus is immersed in a liquid of refractive index $n = \frac{6}{5}$. Ap

Section-C

[7 × 3 = 21 marks]

22. **(a)** A glass container contains hydrogen atoms with all its atoms in their ground states. The container is irradiated with electromagnetic waves containing wavelengths corresponding to Lyman, Balmer and Paschen series. The electromagnetic waves exiting the glass container are found to have certain strong absorption spectral lines. Identify one or more series to which these absorption spectral lines would correspond to. Explain. Assume that once an electron absorbs a photon and jumps to a higher level, it does not absorb more photons to jump to even higher levels.

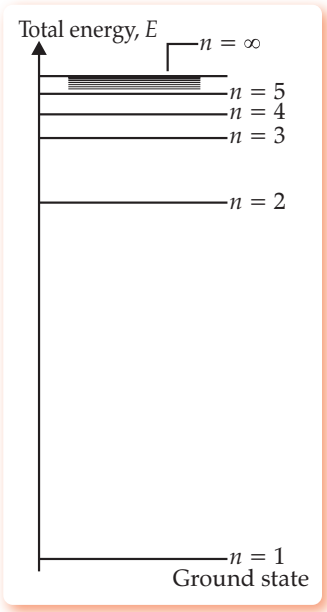
(b) An electron in its orbit undergoes transitions across the energy levels either by absorbing or emitting the photons. A given hydrogen atom is in third excited state.

Determine the final quantum number and the energy of the photon,

(i) when a photon with shortest wavelength is emitted

(ii) when a photon with longest wavelength is absorbed

Ap



23. A 200μF parallel plate capacitor having plate separation of 5 mm is charged by a 100 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 5 mm and dielectric constant 10 is introduced between the plates. Explain with reason, how the **(i)** capacitance, **(ii)** electric field between the plates, **(iii)** energy density of the capacitor will change? Ap

24. **(i)** How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased?

(ii) Find the flux of a uniform electric field $E = 5 \times 10^3$ N/C held through a square of 10 cm on a side with a plane parallel to the YZ-plane. What would be the flux across the same square if the plane intersected the X-axis at a 30° angle? U&Ap

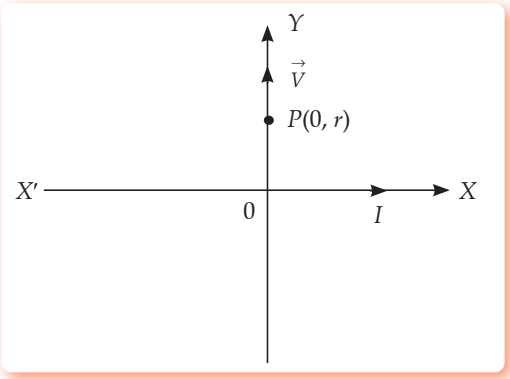
25. Define Nuclear fission. Find the electrical potential energy of the two identical nuclei formed just after the fission of a $^{250}_{100}X$ nucleus. ($R_0 = 1.28 \times 10^{-15}$). R&Ap

26. **(i)** Draw V-I characteristics of a p-n Junction diode.

(ii) Differentiate between the threshold voltage and the breakdown voltage for a diode.

(iii) Write the property of a junction diode which makes it suitable for rectification of ac voltages. U&C

27. An infinite straight conductor is kept along $X'X$ axis and carries a current as I. A charge q at point $P(0, r)$ starts moving with velocity $\vec{v} = v_0 \hat{j}$ shown in figure. Find the direction and magnitude of force initially experienced by the charge. A|I



Ap

28. Lens Q when placed in contact with a converging lens P of focal length = 20 cm makes a combination that behaves as a converging lens system of focal length 30 cm.

Lens Q when placed in contact with another lens R makes a combination that behaves as a diverging lens system of focal length 10 cm.

Identify the nature of lens Q and R and determine their focal lengths. A&Ap

OR

(i) **Give reason:** A radiation of wavelength $\lambda < \lambda_{threshold}$ incident on a metal sphere placed on an insulated stand results in the emission of photoelectrons for some time and then stops.

(ii) In the photoelectric experiment apparatus containing the collector and the emitter plate, a saturated photoelectron current is observed. If an external electric field is applied in the direction opposite to the motion of the photoelectrons, what is the change observed in each of the following? Give reasons.

(a) The saturation value of the photocurrent

(b) The kinetic energy of the photoelectrons striking the collector plate Ap

Section-D

[2 × 4 = 8 marks]

29. **Bottle Dynamo:** A bottle dynamo is a small generator to generate electricity to power the bicycle light.

Is is not a dynamo. Dynamo generates d.c. but a bottle dynamo generates a.c. Newer models are now available with a rectifier. The available d.c. can power the light and small electronic gadgets. This is also known as sidewall generator since, it operates using a roller placed on the sidewall of bicycle tyre. When the bicycle is in motion, the dynamo roller is engaged and electricity is generated as the tyre spins the roller. When engaged, a dynamo requires the bicycle rider to exert more effort to maintain a given speed than would otherwise be necessary when the dynamo is not present or disengaged.

Bottle dynamos can be completely disengaged during day time when cycle light is not in use. In wet conditions, the roller on a bottle dynamo can slip against the surface of the tyre, which interrupts the electricity generated. This cause the lights to go out intermittently. U&R

(i) Why bottle dynamo is not a dynamo ?

(A) It generates a.c. only **(B)** It generates d.c. only

(C) It looks like a bottle **(D)** It requires no fuel to operate

(ii) Can you recharge the battery of your mobile phone with the help of bottle dynamo ?

(A) Yes **(B)** No

(C) Yes, when a rectifier is used **(D)** Yes, when a transformer is used

(iii) Bottle generator generates electricity

(A) when fuel is poured in the bottle. **(B)** when cycle is in motion.

(C) when it is mounted properly. **(D)** when wind blows.

OR

Bulb of bicycle light glows

(A) with a.c. supply only. **(B)** with d.c. supply only.

(C) with both a.c. and d.c. supply. **(D)** only when a.c. supply is rectified.

(iv) Which one of the following is not an advantages of newer model of bottle dynamo ?

(A) Works intermittently when it roller slips on tyre **(B)** Small electronic gadgets can be charged

(C) Can be easily disengaged during day time **(D)** Requires no fuel

30. A compound microscope consists of two converging lenses. One of them, of smaller aperture and smaller focal length is called objective and the other of slightly larger aperture and slightly larger focal length is called eye-piece. Both the lenses are fitted in a tube with an arrangement to vary the distance between them. A tiny object is placed in front of the objective at a distance slightly greater than its focal length. The objective produces the image of the object which acts as an object for the eye-piece. The eye piece, in turn produces the final magnified image.

(i) In a compound microscope the images formed by the objective and the eye-piece are respectively.

(A) virtual, real **(B)** real, virtual **(C)** virtual, virtual **(D)** real, real U&R

(ii) The magnification due to a compound microscope does not depend upon

(A) the aperture of the objective and the eye-piece **(B)** the focal length of the objective and the eye-piece

(C) the length of the tube **(D)** the colour of the light used A

(iii) Which of the following is not correct in the context of a compound microscope?

(A) Both the lenses are of short focal lengths.

(B) The magnifying power increases by decreasing the focal lengths of the two lenses.

(C) The distance between the two lenses is more than $(f_o + f_e)$.

(D) The microscope can be used as a telescope by interchanging the two lenses. U&R

(iv) A compound microscope consists of an objective of 10X and an eye-piece of 20X. The magnification due to the microscope would be

(A) 2 **(B)** 10 **(C)** 30 **(D)** 200 Ap

OR

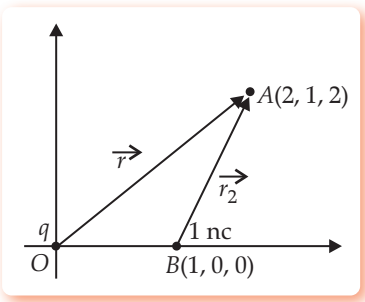
The focal lengths of objective and eye-piece of a compound microscope are 1.2 cm and 3.0 cm respectively. The object is placed at a distance of 1.25 cm from the objective. If the final image is formed at infinity, the magnifying power of the microscope would be

(A) 100 **(B)** 150 **(C)** 200 **(D)** 250 Ap

Section-E

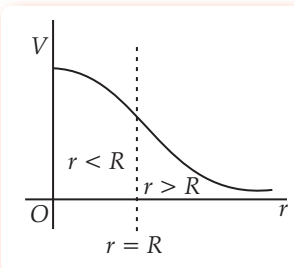
[3 × 5 = 15 marks]

31. **(i)** An unknown charge q is placed at the origin and another charge of 1 nano-coloumb is placed at position B(1,0,0). The x-component of the electric field due to these two charges at position $A(2,1,2)$ is zero. Determine charge q. A I



Ap

(ii) A given solid sphere of radius R made of an insulating material carries a charge q distributed uniformly throughout its volume. The potential due to this charge distribution as a function of distance r from the center of the sphere is given as:



(a) At which location with respect to the sphere, is the potential V maximum in this case?

(b) In case the above sphere is made up of a conducting material instead of an insulating material, what would be your answer for part (a)? How is the charge q distributed across a charged conducting sphere?

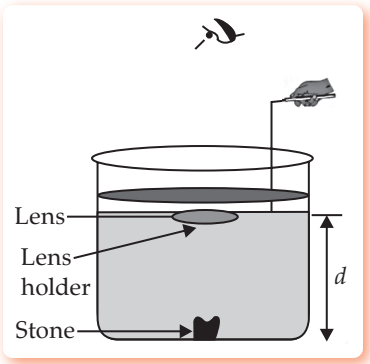
OR

A parallel plate capacitor of capacitance C is charged to a potential V by a battery. Q is the charge stored on the capacitor. Without disconnecting the battery, the plates of the capacitor are pulled apart to a larger distance of separation. What changes will occur in each of the following quantities? Will they increase, decrease or remain the same? Give an explanation in each case.

(i) Capacitance **(ii)** Charge **(iii)** Potential difference **(iv)** Electric field

(v) Energy stored in the capacitor Ap

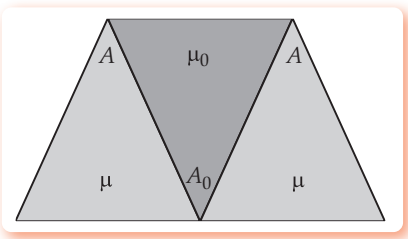
32. **(i)** In reference to the picture given here, a convex lens of focal length f(in air), is immersed in the water to view a small black stone that is placed at the bottom of the container is at a depth d from the lens. AI



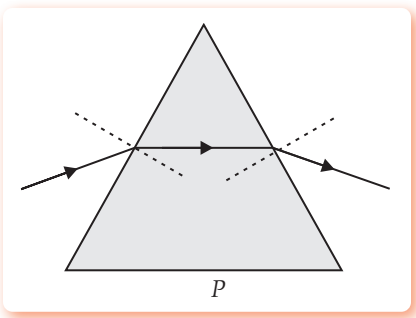
Will the stone in the water be visible as seen from above, for $d = f$ or $d < f$ or $d > f$? Give reason for your answer.

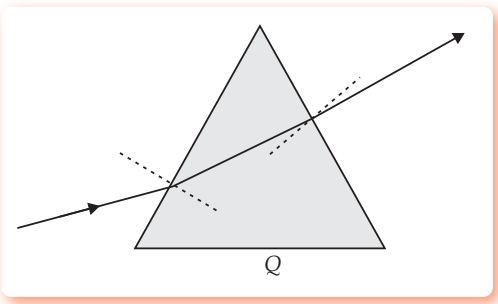
(ii) In the given combination of three triangular prisms, a ray of light enters the first prism on the left and exits from prism on the right after refraction. Consider the angles of the prisms to be small and the ratio $\frac{A_0}{A} = 2$.

Prove that for a net deviation produced in the light ray to be zero, $\mu = \mu_0$ in the given combination.



(iii) A glass prism of absolute refractive index of 1.52 is surrounded by a medium. The emergent rays are bent either upwards or downwards.





Select the suitable surrounding mediums from the given table of refractive indices here for each of the above refractions through the prisms P and Q. Give reason for the choice of the mediums.

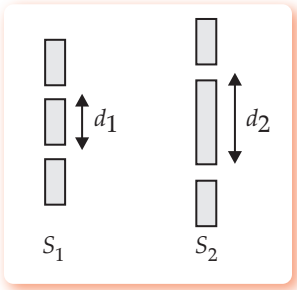
Medium	Refractive Index
Benzene	1.50
Carbon disulphide	1.63
Ethyl alcohol	1.36
Aqueous sodium chloride	1.54

Ap&E

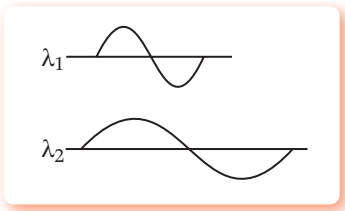
OR

(i) The interference pattern due to light shows bright and dark regions that appear similar to the antinodes and nodes of a standing-wave pattern on a string. While both the patterns are based on the superposition principle, give one major point of difference between the standing waves pattern and the interference pattern.

(ii) Given two sets of slits S_1 and S_2.



Also given are two possible incident light wavelengths λ_1 and λ_2.



Ap

State with reason for what combination of the slits and wavelengths will the interference pattern be:

(a) most spread out **(b)** least spread out?

(iii) Determine the value of y at which the intensity of the fringe reduced to half the intensity of the central maxima formed at point O.

33. (i) State the principle of working of a transformer.

(ii) Define efficiency of a transformer.

(iii) State any two factors that reduce the efficiency of a transformer.

(iv) Calculate the current drawn by the primary of a 90% efficient transformer which steps down 220 V to 22 V, if the output resistance is 440 Ω. R&Ap

OR

(i) Derive the expression for the current flowing in an ideal capacitor and its reactance when connected to an *ac* source of voltage $V = V_0 \sin \omega t$.

(ii) Draw its phasor diagram.

(iii) If resistance is added in series to capacitor what changes will occur in the current flowing in the circuit and phase angle between voltage and current. Ap&E

■■■

ANSWERS

Sample Question Paper-5

PHYSICS

Section-A

1. **Option (B) is correct.**

Explanation: $F = qE = q\left(\frac{2k\lambda}{x}\right)$

$= 2q\times\left(\frac{1}{4\pi\varepsilon_0}\frac{\lambda}{x}\right)$

$= \frac{q\lambda}{2\pi\varepsilon_0 x}$ and repulsive

2. **Option (A) is correct.**

Explanation: For stable equilibrium

$\theta = 0°$

$\Rightarrow \quad U = -\vec{P}\cdot\vec{E} = -PE$

For unstable equilibrium

$\theta = 180°$

$\Rightarrow \quad U = -\vec{P}\cdot\vec{E} = +PE$

So,

$\Delta U = +2PE$

3. **Option (D) is correct.**

Explanation: $\lambda = \frac{h}{\sqrt{2\text{ km}}}$

K_P = Kinetic energy of $P = q_P V$

K_Q = Kinetic energy of $Q = q_Q V = \frac{1}{\lambda^2} q_P V$

So, $K_Q < K_P$

So, $\lambda_Q > \lambda_P$

4. **Option (A) is correct.**

Explanation: From Bohr's postulates,

Angular momentum of the orbiting electron is integral multiple of $\frac{h}{2\pi}$.

If $n = 6$, then angular momentum of the orbiting electron is

$$6\times\frac{h}{2\pi} = \frac{3h}{\pi}$$

5. **Option (D) is correct.**

Explanation: The simple harmonic motion of a magnetic dipole in a uniform magnetic field only occurs when the dipole is initially displaced perpendicular to the field direction. If the dipole is initially displaced parallel to the field, it will not oscillate but will simply remain in its new position.

6. **Option (A) is correct.**

7. **Option (D) is correct.**

Explanation: Material I is diamagnetic substance.

Material II is paramagnetic substance.

For diamagnetic substance, $\mu_r < 1$ and $\chi < 0$.

For paramagnetic substance, $\mu_r > 1$ and $\chi > 0$.

8. **Option (A) is correct.**

Explanation: The nuclear forces are too much stronger. Only attractive force as compared to electrostatic repulsive force and nuclear force decreases to zero on increasing distance.

So, in case of oxygen molecule, the distance between atoms of oxygen is larger as compared to the distances between nucleons in a nucleus. So that, the force between the nuclei of two oxygen atoms is not important as nuclear forces are short-ranged forces.

9. **Option (C) is correct.**

Explanation: Easier path for current will be through Ge diode since the voltage drop is lower than that of Si diode. Hence, the whole current will flow through Ge diode and the potential V_0 will be

$V_0 = 10 - 0.3 = 9.7\text{V}$

10. **Option (A) is correct.**

Explanation: Direction of propagation of *em* wave is the direction of $\vec{E}\times\vec{B}$ and in the outward direction of the plane of paper.

11. **Option (D) is correct.**

Explanation: The given *LCR* circuit is dominantly capacitive due to the large capacitive reactance compared to the inductive reactance. This means the current leads the voltage. Increasing the angular frequency **(ω)** will increase the inductive reactance, eventually making the circuit dominantly inductive. By adjusting ω, we can control whether the circuit is capacitive or inductive, without changing the voltage amplitude.

Therefore, all statements are correct.

12. **Option (A) is correct.**

Explanation: Total energy of two H-atom in ground state $= 2(-13.6) = -27.2$ eV.

The maximum amount by which their combined kinetic energy is reduced when any one H-atom goes into first excited state after the inelastic collision, that is, the total energy of two H-atom after inelastic collision :

$$E = \frac{13.6}{n^2} + 13.6$$

$$= \frac{13.6}{2^2} + 13.6 \quad [\text{For excited state } (n = 2)]$$

$$= 3.4 + 13.6 = 17.0 \text{ eV}$$

So that the loss in kinetic energy due to inelastic collision will be,

$$= 27.2 - 17.0 = 10.2 \text{ eV}$$

13. **Option (A) is correct.**

Explanation: From the *BE* per nucleon vs. mass number graph it is observed that the *BE* is maximum for Fe-56. *BE* decreases before and after this. So the assertion is true.

It is also observed that nucleons having $30 < A < 170$ are in the middle range and *BE* is higher compared to nucleons having $A < 30$ and nucleons having $A > 170$. So, the reason is also true and explains the assertion.

14. **Option (A) is correct.**

Explanation: As temperature increases, more and more covalent bonds of semiconductor rupture. More free electrons and equal number of free holes become available for carrying electricity.

Number of free intrinsic charge carriers becomes so high that the number of free charges available from dopants becomes negligible.

So, the situation becomes such that number of free electrons is almost equal to the number of free holes. This is the situation of intrinsic semiconductor.

So, the assertion and reason both are true and the reason explains the assertion.

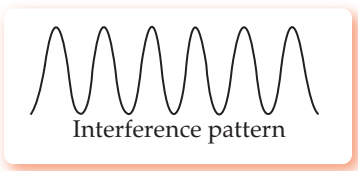
15. **Option (A) is correct.**

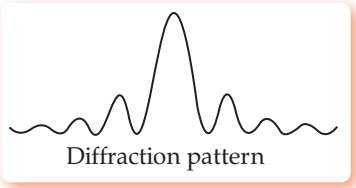
Explanation: When electrons drift in a conductor, it doesn't mean that all free electrons in the conductor are moving in the same direction. this is because the drift velocity, which constitutes the net flow of electrons, is superposed over large random velocities of electrons within the conductor.

16. **Option (B) is correct.**

Explanation: Interference is the result of the superposition of the waves from two different wavefronts. Diffraction is the result of the superposition of the wavelets from different points of the same wavefront.

Interference pattern has all maxima of equally brightness and bands are large in number in comparison to the diffraction pattern which has maxima of decreasing intensity and fewer in number.


Interference pattern

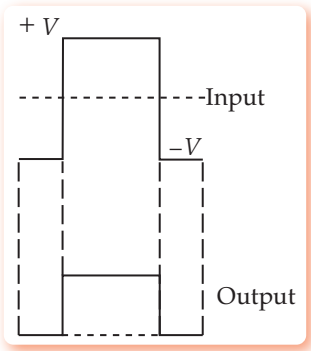

Diffraction pattern

Hence, the assertion and reason both are true but reason does not explain the assertion.

Section-B

17. For –V portion of the input square wave the diode will be forward biased, Current will flow through the diode. No potential drop across the diode will be available.

For +V portion of the input square wave the diode will be reverse biased, Current will not flow through the diode. Total potential will drop across the diode.



Commonly Made Error

- Students often treat diode as a resistor. When current flows through the diode, then consider a voltage drop and when no current flows through the diode they consider no voltage drop.

Answering Tip

- But in this problem, diode is considered to be an ideal diode. So, when the diode is forward biased it exhibits zero resistance. So, there will be no voltage drop. When the diode is reverse biased it exhibits infinite resistance. Hence, there will be no voltage drop.

18. De-Broglie wavelength is given by

$$\lambda = \frac{h}{\sqrt{2meV}}$$

now $$\frac{\lambda_p}{\lambda_d} = \frac{h}{\sqrt{2m_p q_p V_p}} \times \frac{\sqrt{2m_d q_d V_d}}{h}$$

$$\Rightarrow \quad \frac{\lambda_p}{\lambda_d} = \sqrt{\frac{m_p q_d V_d}{m_p q_p V_p}}$$

Squaring both sides

$$\Rightarrow \quad \frac{1}{4} = \frac{m_d q_d V_d}{m_p q_p V_p}$$

$$\Rightarrow \quad \frac{1}{4} = \frac{2m_p \times e \times V_d}{m_p \times e \times V_p}$$

$$\Rightarrow \quad 2\frac{V_d}{V_p} = \frac{1}{4}$$

$$\Rightarrow \quad V_P = 8V_d$$

$$\Rightarrow \quad \frac{V_p}{V_d} = 8$$

19. **(i)** When the diamond is in air,

$$\text{Sin } C = \frac{\propto_{\text{air}}}{\propto_{\text{glass}}}$$

i.e., $$\sin 24° = \frac{\propto_{\text{air}}}{\propto_{\text{glass}}}$$

When the diamond is in water,

$$\text{Sin } C' = \frac{\propto_{\text{water}}}{\propto_{\text{glass}}}$$

Since $\mu_{\text{water}} > \mu_{\text{air}}$

So, $\text{Sin } C' > \sin 24°$

$\therefore \quad C' > 24°$

So, statement is correct.

(ii) Sparkling of diamond depends on the critical angle. Lower the critical angle higher the sparkling. So, in water sparkling of diamond will decrease. So, this statement is wrong.

20. $R_{27} = R$ (say)

$$R_T = R + \frac{25}{100} R = 1.25\, R$$

$$T_1 = 27 + 273 = 300 \text{ K}$$

From the relation $R_T = R_{27}\,[1 + \alpha\,(T_2 - 300)]$,

we have $1.25R = R[1 + 2 \times 10^{-4}\,(T_2 - 300)]$

$\Rightarrow 1 + 2 \times 10^{-4}\,(T_2 - 300) = 1.25$

$\Rightarrow \quad 2 \times 10^{-4}\,(T_2 - 300) = 0.25$

$$\Rightarrow \quad T_2 - 300 = \frac{0.25}{(2\times 10^{-4})} = 1250$$

$$\Rightarrow \quad T_2 = 1250 + 300$$

$$= 1550 \text{ K}$$

21. For dark fringe,

$$\sin\theta = \frac{m\lambda}{a}$$

For maximum number of dark fringes,

$$\sin\theta = 1$$

So, $$\frac{m\lambda}{a} = 1$$

Or, $$m = \frac{a}{\lambda}$$

Or, $$m = \frac{5\times 10^{-6}}{600\times 10^{-9}}$$

Or, $$m = 8.3$$

So, number of dark fringes = 8

OR

As $$\beta = \left(\frac{D}{d}\right)\lambda$$

When immersed in a liquid, D and d remain constant.

The wavelength of the light from the source changes to λ' as the frequency f of the light remains constant, speed of light and its wavelength change in the liquid.

$$\lambda' = \frac{v}{f\lambda} = \frac{c}{f}$$

So, $$\frac{\beta'}{\beta} = \frac{\lambda'}{\lambda} = \frac{v}{c} = \frac{1}{n}$$

Hence, $$\beta' = \frac{\beta}{n} = \frac{5\beta}{6}$$

Section-C

22. **(a)** As there are no electrons present in $n = 2$ or above in the ground state of hydrogen atom, the electron in the ground state gets excited only when it absorbs electromagnetic radiation of wavelength corresponding to Lyman series. The absorbed wavelengths will appear as absorption spectral lines in the exciting em radiation.

(b) **(i)** When a photon is emitted with the shortest possible wavelength, it has the largest possible energy. The largest possible energy is released when the electron jumps from the initial state ($n_i = 4$) to the ground state ($n_f = 1$). So, the final quantum number is $n_f = 1$

Energy of the photon emitted

$$= E_f - E_i = -13.6\left(\frac{1}{4^2} - \frac{1}{3^2}\right) = 12.75 \text{ eV}$$

(ii) When a photon is absorbed by the hydrogen atom, the electron jumps to a higher energy state. The photon has the longest possible wavelength when its energy is the smallest. The smallest possible energy change in the hydrogen atom arises when the electron jumps from the initial state $n_i = 4$ to the immediate next possible higher state, that is, $n_f = 5$.

Energy of the photon absorbed

$$= E_f - E_i = -13.6\left(\frac{1}{5^2} - \frac{1}{4^2}\right) = 0.31 \text{ eV}$$

23. **Given:** Capacitance of the capacitor, $C = 200\mu\text{F}$

Potential of dc source, $V = 100$ V

Let 'A' be the area of the plate and 'd' be the separation between the plates,

The capacitance of the capacitor is given as,

$$C = \frac{(\varepsilon_0 A)}{d}$$

Or, $$\varepsilon_0 A = Cd \qquad \ldots(i)$$

When the capacitor remains connected with the dc source, then there will be no change in potential difference.

(i) Now, according the problem

Separation between the plates = $2d$

Thickness of dielectric slab, $t = 5$ mm
$= 5.0 \times 10^{-3}$ m
Dielectric constant, $K = 10$
New capacitance of the capacitor

$$C = \frac{A\varepsilon_0}{(d'-t)+\frac{t}{K}}$$

Here, $d' = 2d$ and $t = d$

$$C' = \frac{A\varepsilon_0}{(2d-d)+\frac{d}{K}} = \frac{A\varepsilon_0}{d\left(1+\frac{1}{K}\right)}$$

$$= \frac{Cd}{d\left(1+\frac{1}{K}\right)} = \frac{CK}{K+1}$$

$$= \frac{10\times 200\mu F}{(10+1)}$$

$$= 182\mu F$$

Hence, new capacitance of the capacitor will decrease.

(ii) Since, there is no change in the potential difference, Hence, there would not be any change in electric field. It will be $\frac{100}{(5.5\times10^{-3})} = 18182$ V/m.

(iii) The Energy will decrease because

$$E = \frac{1}{2}CV^2$$

Or, $E \propto C$ [V is constant]

(iv) Since, the capacitance decreases, the energy density will also decrease.

24. (i) Electric flux remains unaffected.

(ii) The given value of electric field intensity is $|E| = 5 \times 10^3$ N/C.

The length of one side of the square is 10 cm or 0.1 m. So, the area of the square will be 0.01 m^2.

The square's plane is parallel to the YZ-plane. So, there is no angle between the unit vector normal to the plane and the electric field, $\theta = 0°$.

Substitute $|E| = 5 \times 10^3$, $A = 0.01$, and $\theta = 0°$ into the flux through the plane $\phi = |E|A\cos\theta$,

$\phi = 5 \times 10^3\ (0.01)\cos 0°$
$= 5 \times 10^3\ (0.01)$
$= 50$ N-m^2/C

Therefore, the flux when the square's plane is parallel to the YZ-plane is 50 N-m^2/C.

When the plane makes a 30° angle with the x axis then, $\theta = 60°$.

Substitute $|E| = 5 \times 10^3$, $A = 0.01$ and $\theta = 60°$ into the flux through the plane $\phi = |E|A\cos\theta$,

$\phi = 5 \times 10^3\ (0.01)\cos 60°$
$= 5 \times 10^3\ (0.01)(0.5)$
$= 25$ N-m^2/C

Therefore, the flux when the square's plane is intersected the X-axis at a 30° angle is 25 Nm^2/C

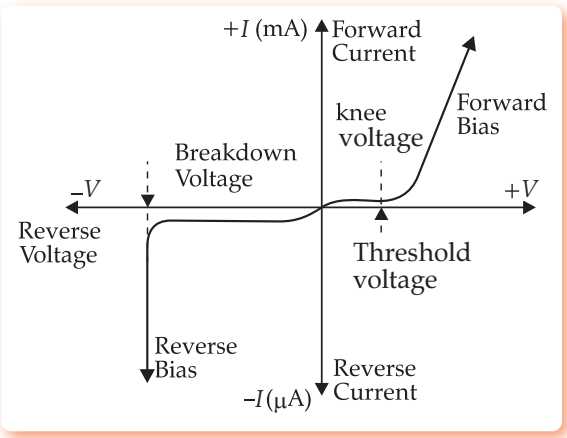
25. Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei producing a large amount of energy.

$$U = \frac{K(50e)(50e)}{2R}$$

$$= \frac{(9\times10^9\times50\times1.6\times10^{-16}\times50\times1.6\times10^{-16})}{\{2\times1.28\times10^{-15}\times(125)^{1/3}\}}$$

$$= 4.5 \times 10^{-11}\ \text{J}$$

26. (i) ***V-I* characteristics of *p-n* Junction diode:**



(ii)

Threshold voltage	Breakdown voltage
The forward voltage at which the current through the *p-n* junction starts increasing rapidly is known as threshold voltage.	Reverse voltage at which the *p-n* junction breakdown occurs is called as breakdown voltage.
The magnitude of this voltage is lower than the breakdown voltage.	The magnitude of this voltage is higher than the threshold voltage.

(iii) The property of junction diode which makes it suitable for rectification:

It exhibits high resistance when reverse biased and low resistance when forward biased.

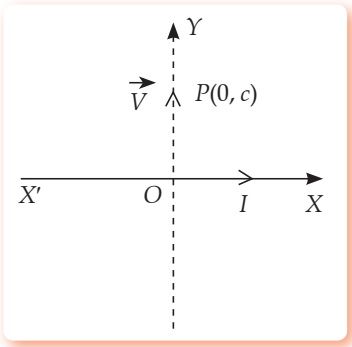
Commonly Made Error

- It is observed that while drawing the *V-I* curve of *p-n* junction, students mark negative *Y*-axis as –*I*(mA). But this is wrong.

Answering Tip

- Positive *y*-axis should be marked as *I*(mA) and negative *y*-axis should be marked as –*I*(μA). Sometimes it is marked as –*I*(μA or *n*A).

27.

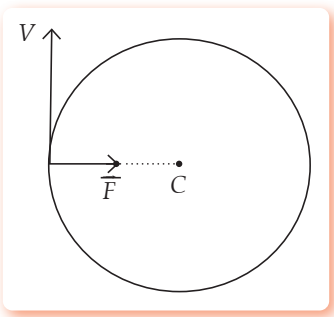


The magnetic field

$$B = \frac{\mu_0 I}{2\pi r} \text{ (outward)}$$

Velocity is in the upward direction.

So, the motion of the particle will be in the X-Y plane.



$$\text{Force} = qvB$$

$$\vec{F} = qv\frac{\mu_0 I}{2\pi r}\hat{i}$$

28. ***P* and *Q* combination:**

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{30} = \frac{1}{20} + \frac{1}{f_2}$$

Calculating $f_2 = -60$ cm

i.e., Lens Q is a diverging lens.

***Q* and *R* combination:**

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{-10} = \frac{1}{-60} + \frac{1}{f_2}$$

Calculating $f_2 = -12$ cm

i.e., Lens R is also a diverging lens.

OR

(i) The incident wavelength lower than the threshold value results in the emission of photoelectrons from the valence band. Once all the valence electrons in the valence band of the metal sphere are emitted, the photoemission stops as the incident radiations doesn't supply sufficient energy to eject the electrons from the inner shells of the metal atoms.

(ii) **(a)** The saturation value of the photo current remains constant. The rate at which the photoelectrons emitted per unit time remains unchanged.

(b) The kinetic energy of the photoelectrons increases due to electrostatic force experienced by the electric field applied in the direction opposite to their motion towards the collector plate.

Section-D

29. **(i) Option (A) is correct.**

Explanation: Dynamo generates *d.c.*. But bottle dynamo generates *a.c.*. So, it is not a dynamo in that sense. But, it generates electricity for bicycle light.

(ii) Option (C) is correct.

Explanation: Newer models of bottle generators are now available with a rectifier. *d.c.* available from such bottle generator can be used directly for charging mobile phone. Otherwise with the old models, a rectifier is to be attached to convert *a.c.* to *d.c.*.

(iii) Option (B) is correct.

Explanation: Bottle generator is also known as sidewall generator since, it operates using a roller placed on the sidewall of bicycle tyre. When the bicycle is in motion, the dynamo roller is engaged and electricity is generated as the tyre spins the roller.

OR

Option (C) is correct.

Explanation: Normal lamps work with both *a.c.* and *d.c.*. So, bottle generators of older model or newer model can be directly used for bicycle lamp.

(iv) Option (A) is correct.

Explanation: In wet conditions, the roller on a bottle dynamo (old model or new model) can slip against the surface of the tyre, which interrupts the electricity generated. This causes the lights to go out intermittently. This is not an advantage.

30. **(i) Option (B) is correct.**

Explanation: Objective lens produces a real image which is positioned between the focus and the optical centre of eyepiece lens. So, eyepiece lens produces a virtual image.

(ii) Option (A) is correct.

Explanation: Magnification when image is formed at the near point of distinct vision is $\frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$.

Magnification when image is formed at infinity is $\frac{L}{f_o}\frac{D}{f_e}$.

No expression contains the aperture terms. So, magnification does not depend on aperture of the objective and the eyepiece.

(iii) Option (D) is correct.

Explanation: Both the lens of microscope are of short focal lengths and hence the microscope

cannot be used as a telescope by interchanging the two lenses. Objective of telescope is of large focal length.

(iv) Option (D) is correct.

Explanation: 10X lens and 20X lens means their magnifications are 10 and 20 respectively. So, the magnification of the microscope is $10 \times 20 = 200$.

OR

Option (C) is correct.

Explanation: Applying lens formula for objective lens,

$$\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_0}$$

Or, $$\frac{1}{v_o} + \frac{1}{1.25} = \frac{1}{1.2}$$

$$\therefore \quad v_0 = 30 \text{ cm}$$

$$\text{Magnification} = \frac{v_o}{u_o}\frac{D}{f_e} = \frac{30}{1.25} \times \frac{25}{3} = 200$$

Section-E

31. (i) Position vectors

$\vec{r_1} = (2-0)\hat{i} + (1-0)\hat{j} + (2-0)\hat{k} = 2\hat{i} + 1\hat{j} + 2\hat{k}$

Here magnitude of

$\vec{r_1} = \sqrt{2^2 + 1^2 + 2^2} = 3$

$\vec{r_2} = (2-1)\hat{i} + (1-0)\hat{j} + (2-0)\hat{k} = 1\hat{i} + 1\hat{j} + 2\hat{k}$

Here magnitude of

$\vec{r_2} = \sqrt{1^2 + 1^2 + 2^2} = \sqrt{6}$

Given in the problem is $E_x = 0$

So, $$k\left[\frac{2q}{3^3} + \frac{10^{-9}}{6^{\frac{3}{2}}}\right] = 0$$

Solving for q,

$$\frac{2q}{3^3} = \frac{-10^{-9}}{6^{\frac{3}{2}}}$$

$$q \approx -0.9 \times 10^{-9} \text{ C} = -0.9 \text{ nC}$$

(ii) (a) At the center of the sphere.

(b) Potential is constant, same and maximum across the volume of the sphere of conducting material.

Charges are distributed only on the surface of the conducting sphere. The charge inside the surface of the conducting sphere is always zero.

OR

(i) Capacitance decreases.

Capacitance is inversely proportional to the distance of separation.

(ii) Charge decreases. From $Q = CV$, C decreases and V remains the same, so Q decreases.

(iii) Potential difference remains the same. As the capacitor is connected to the battery, the potential V of the capacitor will remain the same as that of the battery.

(iv) Electric field decreases.

E due to a plane sheet of charge $= \frac{\sigma}{\epsilon_0}$ is independent of the distance from the sheet. But charge density σ on the plate decreases, so E decreases.

Alternatively, As $$E = \frac{V}{d} = \frac{Q}{Cd} = \frac{Q}{\epsilon_0 A}$$

Since, Q decreases, E also decreases.

(v) Energy stored in the capacitor decreases.

Energy stored is proportional to both Q and V. Charge Q decreases but potential V is constant.

32. (i) Focal length of the lens is more in water than in the air, $f_{water} > f_{air}$

Image of the stone is visible from above, only if it is placed at distance less than focal length of the lens in the water.

Since, $f_{water} > f_{air}$, for the stone to be visible when seen from the above, if the distance $d < f_{water}$ and $d < f_{air}$.

(ii) Given $\frac{A_0}{A} = 2$ and deviation produced by each prism

$$\delta = (\mu - 1)A$$

$$\delta_{net} = \delta - \delta_o + \delta$$

$$= 2\delta - \delta_o$$

For $$\delta_{net} = 0,\ 2\delta = \delta_o$$

$$2(\mu - 1)A = (\mu_o - 1)A_o$$

As $$\frac{A_o}{A} = 2$$

So, $$2(\mu - 1) = (\mu_o - 1).2$$

$$(\mu - 1) = (\mu_o - 1)$$

$$\mu = \mu_o$$

(iii) For downward refraction as in P, the surrounding medium should have a refractive index less than that of the prism.

So the medium surrounding the prism can be that of Benzene and Ethyl alcohol.

And for the upward refraction as in Q, the surrounding medium should have a refractive index more than that of the prism.

So, the medium surrounding the prism can be that of Carbon disulphide and Aqueous sodium chloride.

OR

(i) (1) Waves on a string propagate in only one dimension while the light-wave interference pattern exists in three dimensions;

(2) The standing-wave pattern represents no net energy flow, while there is a net energy flow from the slits to the screen in an interference pattern. (any one point)

(ii) (a) S_1 and λ_2

Most spread-out fringes imply greater fringe width.

Since, fringe width, $\beta = \frac{\lambda D}{d}$

For greater β, higher λ and small d is required.

So slits S_1 and wavelength λ_2 will produce fringe pattern that is most spread out.

(b) S_2 and λ_1

Least spread-out fringes imply smaller fringe width.

Since, fringe width, $\beta = \frac{\lambda D}{d}$

For smaller β, lower λ and greater d is required.

So slits S_2 and wavelength λ_1 will produce a fringe pattern that is most spread out.

(iii) The intensity of a given fringe where the phase difference between the two incoming waves r_1 and r_2 is ϕ, is given as,

$$I = 4I_o \frac{\cos^2\phi}{2}$$

Intensity at central maxima = maximum = $4I_o$

As given at P, Intensity = half of that at central maximum = $2I_o$

$$2I_o = 4I_o \frac{\cos^2\phi}{2}$$

$$\frac{1}{2} = \frac{\cos^2\phi}{2}$$

Calculating, the phase difference, $\phi = \frac{\pi}{2}$

As we know the relation between path difference δ and the phase difference ϕ,

$$\phi = \left(\frac{2\pi}{\lambda}\right).\delta$$

$$\frac{\neq}{2} = \left(\frac{2\pi}{\lambda}\right).\delta$$

So, path difference, $\delta = \frac{\lambda}{4} = d\frac{y}{D}$

….. from equation (3)

So, the intensity of the fringe at $y = \frac{\lambda D}{4d}$, will be half of that at the central maximum.

33. **(i)** Mutual induction **1**

(ii) The efficiency of a transformer equals the ratio of the output power to the input power. **1**

Alternatively:

$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}}$$

$$\text{Efficiency} = \frac{V_s I_s}{V_p I_p}$$

(iii) (a) Eddy current loss

(b) joule heat loss

(c) hysteresis loss ½+½

(d) magnetic flux leakage loss **(Any two)**

(iv) We have

$$\frac{V_s I_s}{V_p I_p} = 90\% = 0.9$$

$$\therefore \quad \frac{22 I_s}{220 I_p} = 0.9$$

$$\text{Or,} \quad \frac{I_s}{I_p} = \frac{0.9}{0.1} = 9$$

$$\therefore \quad I_p = \frac{I_s}{9} = \frac{\left(\frac{22}{440}\right)}{9}\text{A}$$

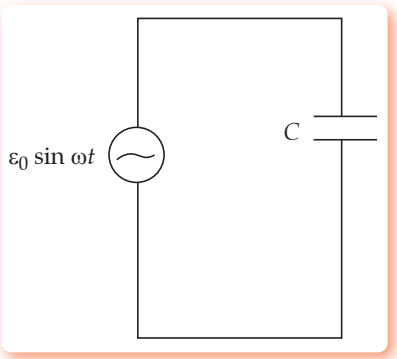
$$= \frac{1}{180}\text{A}$$

$$= 0.0056\text{ A} \quad \textbf{2}$$

[Marking Scheme, 2018]

OR

(i)



At any moment charge on the capacitor is $q = C\varepsilon = C\varepsilon_0 \sin \omega t$ Current in the circuit,

$$I = \frac{dq}{dt} = \frac{d}{dt} C\varepsilon_0 \sin \omega t$$

$$= \omega C \varepsilon_0 \cos \omega t$$

$$= \frac{\varepsilon_0}{\frac{1}{\omega C}} \sin\left(\omega t + \frac{\pi}{2}\right)$$

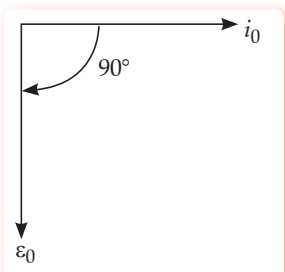
$$= \frac{\varepsilon_0}{X_C} \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= \frac{\varepsilon_0}{Z} \sin\left(\omega t + \frac{\pi}{2}\right)$$

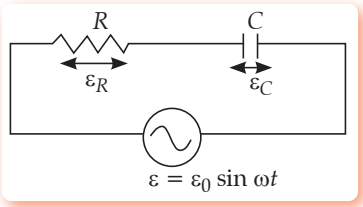
$$= I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

So, the current is ahead of the voltage by $\frac{\square}{2}$.

(ii) Phasor diagram:



(iii) A resistor is now connected with the capacitor in series:



Peak voltage drop across R is I_0R

Peak voltage drop across C is $I_0 X_C$.

Voltage a cross R is in phase with the current.

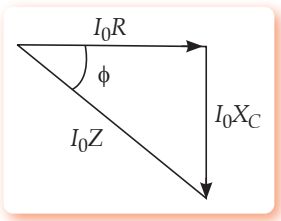
Voltage across C lags the current by 90°.

So, the voltage drops across R and across C are not in phase. They are out of phase by 90°.

So, $$\varepsilon_0 = \sqrt{(I_0R)^2 + (I_0X_C)^2}$$

$\therefore$ $$I_0 = \frac{V_0}{\sqrt{R^2 + X_C^2}}$$

The phase angle by which the current leads the applied voltage is



Phase Angle $= \phi = \tan^{-1} \frac{X_C}{R}$

■■■