Class: XII
SESSION : 2022-2023
CBSE SAMPLE QUESTION PAPER (THEORY)
SUBJECT: PHYSICS

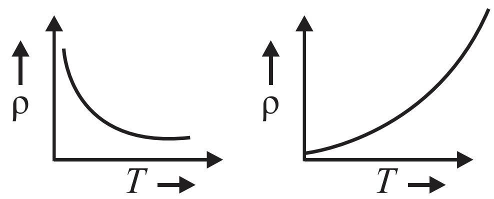
Maximum Marks: 70 Marks **Time Allowed**: 3 hours.

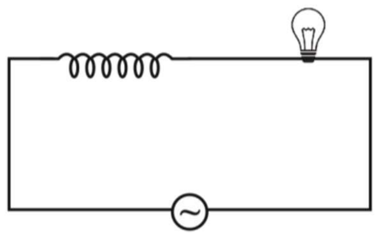
General Instructions:

(1) There are 35 questions in all. All questions are compulsory
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
(3) Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
(4) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

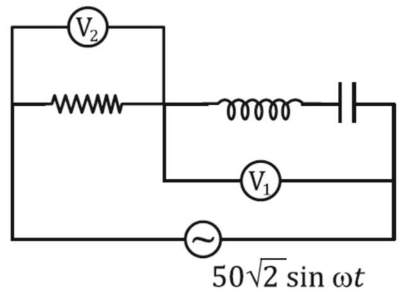
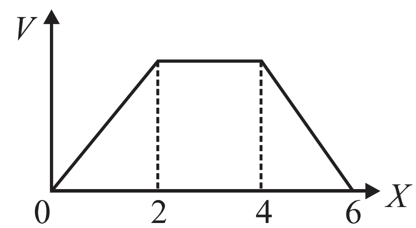
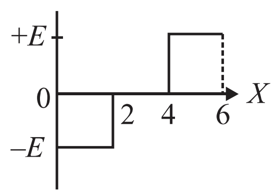
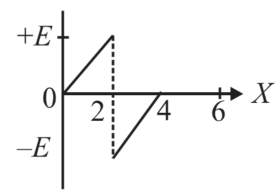
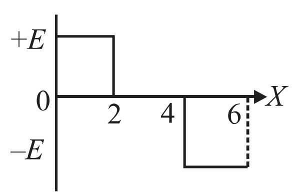
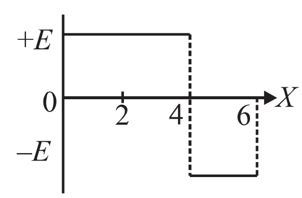
SECTION A

Q. NO.		MARKS
1	**According to Coulomb's law, which is the correct relation for the following figure?**  (i) $q_1 q_2 > 0$ (ii) $q_1 q_2 < 0$ (iii) $q_1 q_2 = 0$ (iv) $1 > q_1 / q_2 > 0$	1
2	**The electric potential on the axis of an electric dipole at a distance 'r from it's centre is V. Then the potential at a point at the same distance on its equatorial line will be** (i) 2V (ii) -V (iii) V/2 (iv) Zero	1

3	**The temperature (T) dependence of resistivity of materials A and material B is represented by fig (i) and fig (ii) respectively. Identify material A and material B.**  fig. (i) fig. (ii) (i) material A is copper and material B is germanium (ii) material A is germanium and material B is copper (iii) material A is nichrome and material B is germanium (iv) material A is copper and material B is nichrome	1
4	**Two concentric and coplanar circular loops P and Q have their radii in the ratio 2:3. Loop Q carries a current 9 A in the anticlockwise direction. For the magnetic field to be zero at the common centre, loop P must carry** (i) 3A in clockwise direction (ii) 9A in clockwise direction (iii) 6 A in anti-clockwise direction (iv) 6 A in the clockwise direction.	1
5	**A long straight wire of circular cross section of radius a carries a steady current I. The current is uniformly distributed across its cross section. The ratio of the magnitudes of magnetic field at a point distant a/2 above the surface of wire to that at a point distant a/2 below its surface is** (i) 4 :1 (ii) 1:1 (iii) 4: 3 (iv) 3 :4	1
6	**If the magnetizing field on a ferromagnetic material is increased, its permeability** (i) decreases (ii) increases (iii) remains unchanged (iv) first decreases and then increases	1

7	**An iron cored coil is connected in series with an electric bulb with an AC source as shown in figure. When iron piece is taken out of the coil, the brightness of the bulb will**  **(i)** decrease (ii) increase (iii) remain unaffected (iv) fluctuate	1
8	**Which of the following statement is NOT true about the properties of electromagnetic waves?** (I) These waves do not require any material medium for their propagation (ii) Both electric and magnetic field vectors attain the maxima and minima at the same time (iii) The energy in electromagnetic wave is divided equally between electric and magnetic fields (iv) Both electric and magnetic field vectors are parallel to each other	1
9	A rectangular, a square, a circular and an elliptical loop, all in the (x-y) plane, are moving out of a uniform magnetic field with a constant velocity $\vec{v} = v\hat{i}$.The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for (i) any of the four loops (ii) the circular and elliptical loops (iii) the rectangular, circular and elliptical loops (iv) only the elliptical loops	1

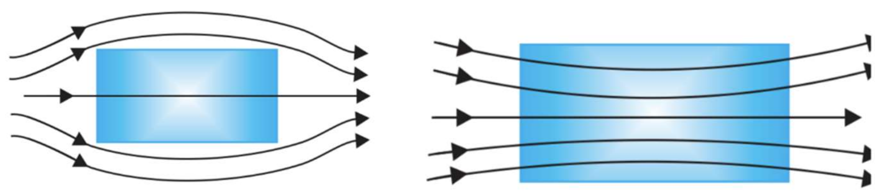
10	**In a Young's double slit experiment, the path difference at a certain point on the screen between two interfering waves is $\frac{1}{8}$th of the wavelength. The ratio of intensity at this point to that at the centre of a bright fringe is close to** (i) 0.80 (ii) 0.74 (iii) 0.94 (iv) 0.85	1
11	**The work function for a metal surface is 4.14 eV. The threshold wavelength for this metal surface is:** (i) 4125 Å (ii) 2062.5 Å (iii) 3000 Å (iv) 6000 Å	1
12	**The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. The radius of the n =3 orbit is** (i) 1.01×10^{-10}m (ii) 1.59×10^{-10}m (iii) 2.12×10^{-10}m (iv) 4.77×10^{-10}m	1
13	**Which of the following statements about nuclear forces is not true?** **(i)** The nuclear force between two nucleons falls rapidly to zero as their distance is more than a few femtometres. **(ii)** The nuclear force is much weaker than the Coulomb force. **(iii)** The force is attractive for distances larger than 0.8 fm and repulsive if they are separated by distances less than 0.8 fm. **(iv)** The nuclear force between neutron-neutron, proton-neutron and proton-proton is approximately the same.	1
14	**If the reading of the voltmeter V_1 is 40 V, then the reading of voltmeter V_2 is**	1

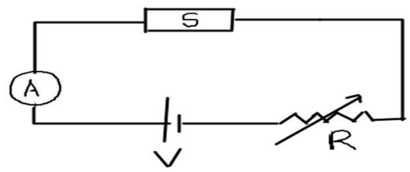
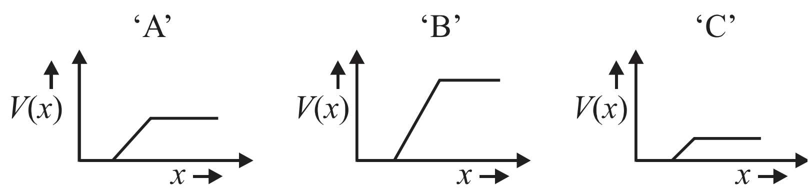
	 (i) 30 V (ii) 58 V (iii) 29 V (iv) 15 V	
15	**The electric potential V as a function of distance X is shown in the figure.**  **The graph of the magnitude of electric field intensity E as a function of X is**	1
	(i)  **(ii)** 	
	(iii)  **(iv)** 	
16	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.** **a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of A**	1

	c) A is true but R is false **d) A is false and R is also false** **ASSERTION(A):** The electrical conductivity of a semiconductor increases on doping. **REASON:** Doping always increases the number of electrons in the semiconductor.	
17	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.** **a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of A** **c) A is true but R is false** **d) A is false and R is also false** **ASSERTION:** In an interference pattern observed in Young's double slit experiment, if the separation (d) between coherent sources as well as the distance (D) of the screen from the coherent sources both are reduced to $1/3^{rd}$, then new fringe width remains the same. **REASON:** Fringe width is proportional to (d/D).	1
18	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.** **a) Both A and R are true and R is the correct explanation of A** **b Both A and R are true and R is NOT the correct explanation of A** **c) A is true but R is false** **d) A is false and R is also false** **Assertion(A)** : The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies. **Reason(R)** :	1

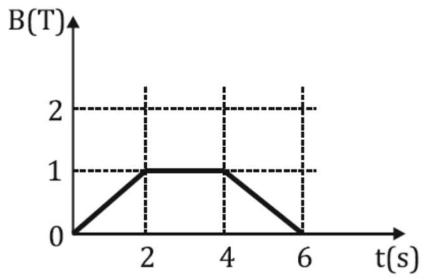
	The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.	

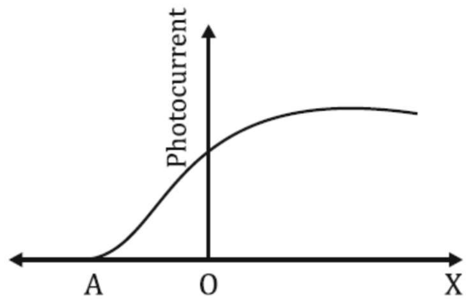
SECTION B

19	Electromagnetic waves with wavelength (i) λ_1 is suitable for radar systems used in aircraft navigation. (ii) λ_2 is used to kill germs in water purifiers. (iii) λ_3 is used to improve visibility in runways during fog and mist conditions. Identify and name the part of the electromagnetic spectrum to which these radiations belong.Also arrange these wavelengths in ascending order of their magnitude.	2
20	A uniform magnetic field gets modified as shown in figure when two specimens A and B are placed in it.  (a) (b) (i)Identify the specimen A and B. **(**ii) How is the magnetic susceptibility of specimen A different from that of speci**me**n B**?**	2
21	What is the nuclear radius of ^{125}Fe ,if that of ^{27} Al is 3.6 fermi?. **OR** The short wavelength limit for the Lyman series of the hydrogen spectrum is 913.4 **A⁰**. Calculate the short wavelength limit for the Balmer series of the hydrogen spectrum.	2
22	A biconvex lens made of a transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Justify your answer.	2

23	The figure shows a piece of pure semiconductor S in series with a variable resistor R and a source of constant voltage V. Should the value of R be increased or decreased to keep the reading of the ammeter constant, when semiconductor S is heated? Justify your answer  **OR** The graph of potential barrier versus width of depletion region for an unbiased diode is shown in graph A. In comparison to A ,graphs B and C are obtained after biasing the diode in different ways .Identify the type of biasing in B and C and justify your answer. 	2
24	A narrow slit is illuminated by a parallel beam of monochromatic light of wavelength λ equal to 6000 Å and the angular width of the central maximum in the resulting diffraction pattern is measured. When the slit is next illuminated by light of wavelength λ', the angular width decreases by 30%. Calculate the value of the wavelength λ'.	2
25	Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude 17.7×10^{-22} C/m^2. What is electric field intensity E: (a) in the outer region of the first plate, and (b) between the plates?	

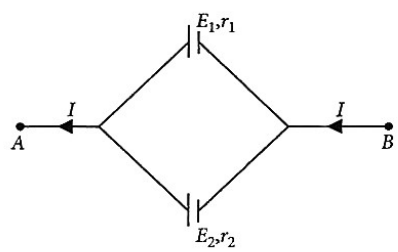
SECTION C

26	Two long straight parallel conductors carrying currents I_1 and I_2 are separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field produced by one exerts an attractive force on the other. Obtain the expression for this force and hence define 1 ampere.	3
27.	The magnetic field through a circular loop of wire, 12cm in radius and 8.5Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the current induced in the loop and plot a graph showing induced current as a function of time. 	3
28	An a.c. source generating a voltage $\varepsilon = \varepsilon_0 \sin \omega t$ is connected to a capacitor of capacitance C. Find the expression for the current I flowing through it. Plot a graph of ε and I versus ωt to show that the current is ahead of the voltage by π/2. **OR** An ac voltage $V = V_0 \sin \omega t$ is applied across a pure inductor of inductance *L*. Find an expression for the current *i*, flowing in the circuit and show mathematically that the current flowing through it lags behind the applied voltage by a phase angle of $\frac{\pi}{2}$. Also draw graphs of *V* and *i* versus ωt for the circuit.	3
29	Radiation of frequency 10^{15} Hz is incident on three photosensitive surfaces A, B and C. Following observations are recorded: **Surface A**: no photoemission occurs **Surface B**: photoemission occurs but the photoelectrons have zero kinetic energy.	3

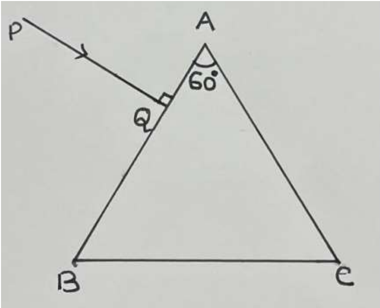
	Surface C: photo emission occurs and photoelectrons have some kinetic energy. Using Einstein's photo-electric equation, explain the three observations. **OR** **The graph shows the variation of photocurrent for a photosensitive metal**  (a)What does X and A on the horizontal axis represent? (b)Draw this graph for three different values of frequencies of incident radiation υ_1, υ_2 and υ_3 ($\upsilon_3 > \upsilon_2 > \upsilon_1$) for the same intensity. (c) Draw this graph for three different values of intensities of incident radiation I_1, I_2 and I_3 ($I_3 > I_2 > I_1$) having the same frequency.	
30	The ground state energy of hydrogen atom is -13.6 eV. The photon emitted during the transition of electron from n=3 to n=1 state, is incident on a photosensitive material of unknown work function .The photoelectrons are emitted from the material with the maximum kinetic energy of 9eV.Calculate the threshold wavelength of the material used.	3

SECTION D

31	(a)Draw equipotential surfaces for (i)an electric dipole and (ii) two identical positive charges placed near each other. (b) In a parallel plate capacitor with air between the plates, each plate has an area of 6 x $10^{-3}m^2$ and the separation between the plates is 3 mm. (i) Calculate the capacitance of the capacitor. (ii) If the capacitor is connected to 100V supply, what would be the the charge on each plate? (iii) How would charge on the plate be affected if a 3 mm thick mica sheet of k=6 is inserted between the plates while the voltage supply remains connected ?.	5

	OR (a)Three charges –q, Q and –q are placed at equal distances on a straight line. If the potential energy of the system of these charges is zero, then what is the ratio Q:q? (b)(i) Obtain the expression for the electric field intensity due to a uniformly charged spherical shell of radius R at a point distant r from the centre of the shell outside it. (ii) Draw a graph showing the variation of electric field intensity E with r, for r > R and r < R.	
32	(a) Explain the term drift velocity of electrons in a conductor .Hence obtain the expression for the current through a conductor in terms of drift velocity. (b) Two cells of emfs E_1 and E_2 and internal resistances $r_1$and r_2 respectively are connected in parallel as shown in the figure. Deduce the expression for the (i) equivalent emf of the combination (ii) equivalent internal resistance of the combination (iii) potential difference between the points *A* and *B*.  **OR** (a) State the two Kirchhoff's rules used in the analysis of electric circuits and explain them. (b) Derive the equation of the balanced state in a Wheatstone bridge using Kirchhoff's laws.	5
33	a) Draw the graph showing intensity distribution of fringes with phase angle due to diffraction through a single slit. What is the width of the central maximum in comparison to that of a secondary maximum? b) A ray PQ is incident normally on the face AB of a	5

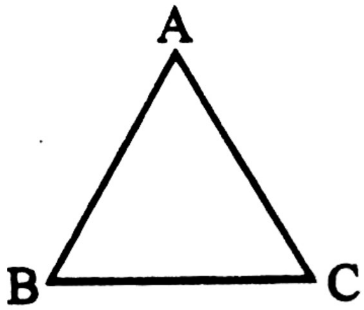
triangular prism of refracting angle 60^0 as shown in figure. The prism is made of a transparent material of refractive index $\frac{2}{\sqrt{3}}$. Trace the path of the ray as it passes through the prism. Calculate the angle of emergence and the angle of deviation.



OR

a) Write two points of difference between an interference pattern and a diffraction pattern.

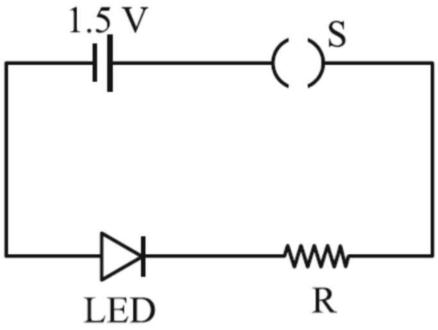
b) (i) A ray of light incident on face AB of an equilateral glass prism, shows minimum deviation of 30°. Calculate the speed of light through the prism.



(ii) Find the angle of incidence at face AB so that the emergent ray grazes along the face AC.

SECTION E

34	**Case Study :** ***Read the following paragraph and answer the questions.*** A number of optical devices and instruments have been designed and developed such as periscope, binoculars, microscopes and telescopes utilising the reflecting and refracting properties of mirrors, lenses and prisms. Most of them are in common use. Our knowledge about the formation of images by the mirrors and lenses is the basic requirement for understanding the working of these devices. (i) Why the image formed at infinity is often considered most suitable for viewing. Explain (ii) In modern microscopes multicomponent lenses are used for both the objective and the eyepiece. Why? (iii) Write two points of difference between a compound microscope and an astronomical telescope **OR** (iii) Write two distinct advantages of a reflecting type telescope over a refracting type telescope.
35	**Case study: Light emitting diode.** **Read the following paragraph and answer the questions** **LED** is a heavily doped P-N junction which under forward bias emits spontaneous radiation. When it is forward biased, due to recombination of holes and electrons at the junction, energy is released in the form of photons. In the case of Si and Ge diode, the energy released in recombination lies in the infrared region. LEDs that can emit red, yellow, orange, green and blue light are commercially available. The semiconductor used for fabrication of visible LEDs must at least have a band gap of 1.8 eV. The compound semiconductor Gallium Arsenide – Phosphide is used for making LEDs of different colours.

	 LEDs of different kinds **(i)**. Why are LEDs made of compound semiconductor and not of elemental semiconductors? **(ii)** What should be the order of bandgap of an LED, if it is required to emit light in the visible range? **(iii)** A student connects the blue coloured LED as shown in the figure. The LED did not glow when switch S is closed. Explain why ?  **OR** (iii) Draw V-I characteristic of a p-n junction diode in (i) forward bias and (ii) reverse bias

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MARKING SCHEME
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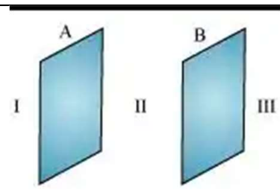
Q.no		Marks
	SECTION A	
1	(ii) $q_1q_2<0$	1
2	(iv) zero	1
3	(ii) material A is germanium and material B is copper	1
4	(iv) 6A in the clockwise direction	1
5	(iii) 4:3	1
6	(i) decreases	1
7	(ii) increase	1
8	(iv) Both electric and magnetic field vectors are parallel to each other.	1
9	(ii) the circular and elliptical loops	1
10	(iv) 0.85	1
11	(iii) 3000 Å	1
12	(iv) 4.77×10^{-10}m	1
13	(ii) The nuclear force is much weaker than the Coulomb force .	1
14	(i) 30 V	1
15	(i)	1
16	c) A is true but R is false	1
17	c) A is true but R is false	1
18	a) Both A and R are true and R is the correct explanation of A	1
	SECTION B	
19	λ_1 -Microwave λ_2 - ultraviolet λ_3- infrared Ascending order - $\lambda_2<\lambda_3<\lambda_1$	½ ½ ½ ½
20	A - diamagnetic B- paramagnetic The magnetic susceptibility of A is small negative and that of B is small positive.	½ ½ ½ ½
21	From the relation $R = R_0A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus $R_{Fe}/R_{Al} = (A_{Fe}/A_{Al})^{1/3}$ $= (125/27)^{1/3}$ $R_{Fe} = 5/3\ R_{Al}$ $=5/3 \times 3.6$ $= 6$ fermi **OR** Given short wavelength limit of Lyman series	½ ½ ½ ½

	$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right)$$ $$\frac{1}{913.4\ \text{Å}} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right)$$	½
	$\lambda_L = \frac{1}{R} = 913.4$ Å	½
	For the short wavelength limit of Balmer series $n_1=2,\ n_2 = \infty$ $$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right)$$	½
	$\lambda_B = \frac{4}{R} = 4 \times 913.4$ Å = 3653.6 Å	½
22	$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$	½
	$$\frac{1}{f} = \left(\frac{\mu_m}{\mu_w} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$	½
	$$\frac{\mu_m}{\mu_w} = \frac{1.25}{1.33}$$ $$\frac{\mu_m}{\mu_w} = 0.98$$	½
	The value of (μ – 1) is negative and 'f' will be negative. So it will behave like diverging lens.	½
23	To keep the reading of ammeter constant value of R should be **increased**	1
	as with the increase in temperature of a semiconductor, its resistance **decreases** and current tends to increase.	1
	OR	
	B - reverse biased	½
	In the case of reverse biased diode the potential barrier becomes higher as the battery further raises the potential of the n side.	½
	C -forward biased	½
	Due to forward bias connection the potential of P side is raised and hence the height of the potential barrier decreases.	½
24	Angular width $2\varphi = 2\lambda/d$ Given $\lambda = 6000$ Å	½
	In Case of new λ (assumed λ' here), angular width decreases by 30%	½
	New angular width = 0.70 (2 φ) $2\lambda'/d = 0.70 \times (2\lambda/d)$	½
	∴λ'= 4200 Å	½

25	 Surface charge density of plate A = +17.7 × 10^{-22} C/m^2 Surface charge density of plate B = -17.7 × 10^{-22} C/m^2 (a) In the outer region of plate I, electric field intensity E is zero. (b)Electric field intensity E in between the plates is given by relation $$E = \frac{\sigma}{\in_0}$$ Where, $\in_0$ = Permittivity of free space = 8.85 x10^{-12} N^{-1} C^2 m^{-2} $$\therefore E = \frac{17.7\ x\ 10^{-22}}{8.85\ x\ 10^{-1}}$$ Therefore, electric field between the plates is 2.0 x 10^{-10} N/C	 ½ ½ ½ ½
	SECTION C	
26	Diagram Derivation The ampere is the value of that steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would exert on each of these conductors a force equal to 2 × 10^{-7}newtons per metre of length.	½ 1 ½ 1
27	Area of the circular loop = πr^2 $= 3.14 \times (0.12)^2\ m^2 = 4.5 \times 10^{-2}\ m^2$ $$E = -\frac{d\varphi}{dt} = -\frac{d}{dt}(BA) = -A\frac{dB}{dt} = -A\ .\ \frac{B_2 - B_1}{t_2 - t_1}$$ For $0 < t < 2s$ $$E_1 = -4.5 \times 10^{-2} \times \left\{\frac{1-0}{2-0}\right\} = -2.25 \times 10^{-2}\ V$$ $$\therefore\quad I_1 = \frac{E_1}{R} = \frac{-2.25 \times 10^{-2}}{8.5}\ A = -2.6 \times 10^{-3}\ A = -2.6\ mA$$ For $2s < t < 4s$, $$E_2 = -4.5 \times 10^{-2} \times \left\{\frac{1-1}{4-2}\right\} = 0$$ $$\therefore\quad I_2 = \frac{E_2}{R} = 0$$ For $4s < t < 6s$, $$I_3 = -\frac{4.5 \times 10^{-2}}{8.5} \times \left\{\frac{0-1}{6-4}\right\} A = 2.6\ mA$$	 ½ ½ ½ ½

<table>
<tr><td></td><td>
<table>
<tr><td></td><td>0<t<2s</td><td>2<t<4s</td><td>4<t<6s</td></tr>
<tr><td>E(V)</td><td>-0.023</td><td>0</td><td>+0.023</td></tr>
<tr><td>I(mA)</td><td>-2.6</td><td>0</td><td>+2.6</td></tr>
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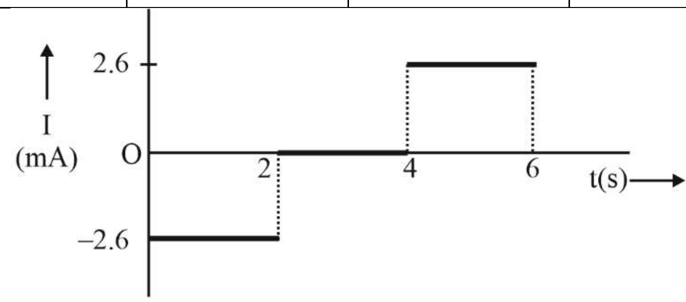
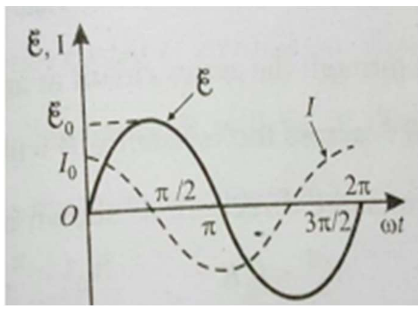
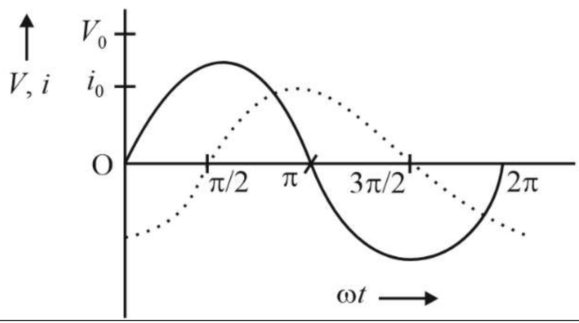


</td><td>1</td></tr>
<tr><td>28</td><td>Derivation


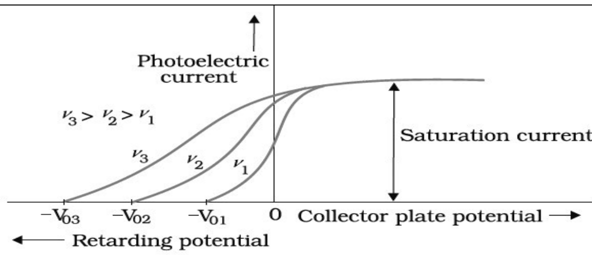
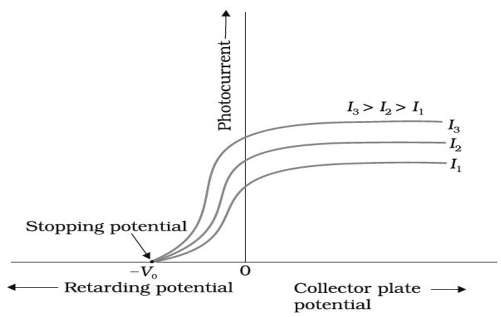
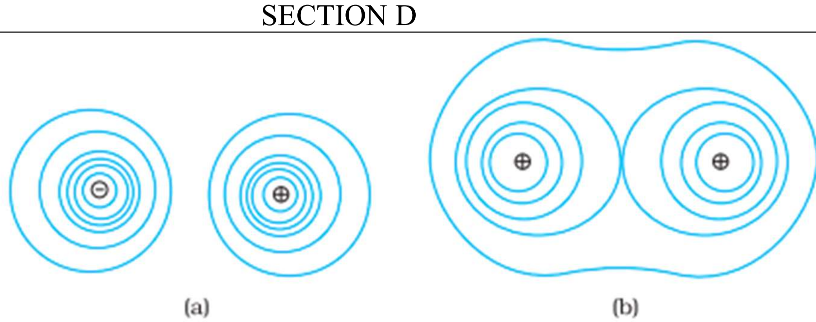
OR
Derivation


</td><td>2
1
2
1</td></tr>
<tr><td>29

a)</td><td>From the observations made (parts A and B) on the basis of Einstein's photoelectric equation, we can draw following conclusions:

For surface A, the threshold frequency is more than 10^{15} HZ, hence no photoemission is possible.
For surface B the threshold frequency is equal to the frequency of given radiation. Thus, photo-emission takes place but kinetic energy of photoelectrons is zero.
For surface C, the threshold frequency is less than 10^{15} Hz. So photoemission occurs and photoelectrons have some kinetic energy

OR
A - cut off or stopping potential
X - anode potential</td><td>1
1
1
½
½</td></tr>
</table>

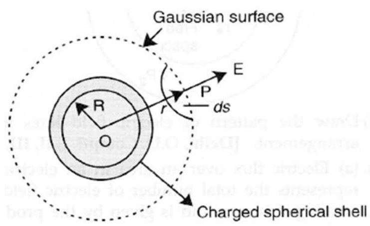
b)	 **FIGURE** Variation of photoelectric current with collector plate potential for different frequencies of incident radiation.	1
c)	 **FIGURE** Variation of photocurrent with collector plate potential for different intensity of incident radiation.	1
30	For a transition from n=3 to n =1 state, the energy of the emitted photon, hν = E_2 –E_1 = 13.6 $[\frac{1}{1^2} - \frac{1}{3^2}]$ eV = 12.1 eV. From Einstein's photoelectric equation, hν = K_{max} + W_0 $\therefore W_0 = h\nu - K_{max} \quad = 12.1 - 9 = 3.1\ eV$ Threshold wavelength, $\lambda_{th} = \frac{hc}{W_0} = \frac{6.62x10^{-34}x3x10^8}{3.1x1.6x10^{-19}}$ = 4x10^{-7} m	1 ½ ½ 1
	SECTION D	
31(a) **(b)** **(a)**	 **FIGURE 2.11** Some equipotential surfaces for (a) a dipole, (b) two identical positive charges. Here, A =6 x 10^{-3} m^2, d =3mm=3x10^{-3}m (i) Capacitance, C=ϵ_0A/d = (8.85x10^{-12} x 6x10^{-3}/3x10^{-3}) = 17.7x10^{-12} F (ii) Charge, Q = CV =17.7 x10^{-12}x100=17.7x10^{-10}C (iii) New charge Q'= KQ=6x17.7 x10^{-10} =1.062 x 10^{-8} C **OR** Diagram	1 + 1 1 1 1 1/2

$$\frac{K(-q)Q}{x} + \frac{kQ(-q)}{x} + \frac{k(-q)(-q)}{2x} = 0$$ 1

$$\frac{-2kqQ}{x} + \frac{kq^2}{2x} = 0 \text{ or } \frac{kq^2}{2x} = \frac{2kqQ}{x}$$

$$q = 4Q \quad \text{or} \quad \frac{Q}{q} = \frac{1}{4}$$ ½

(b) Electric field due to a uniformly charged thin spherical shell:



½

(i) When point P lies outside the spherical shell: Suppose that we have calculate field at the point P at a distance r (r>R) from its centre. Draw Gaussian surface through point P so as to enclose the charged spherical shell. Gaussian surface is a spherical surface of radius r and centre O.

Let $\vec{E}$ be the electric field at point P, then the electric flux through area element of area $\overrightarrow{ds}$ is given by

$$d\varphi = \vec{E}.\overrightarrow{ds}$$ ½

Since $\overrightarrow{ds}$ is also along normal to the surface

$$d\varphi = E\, dS$$

∴ Total electric flux through the Gaussian surface is given by

$$\varphi = \oint Eds = E \oint ds$$

$$\text{Now, } \oint ds = 4\pi r^2 \quad ...(i)$$

$$= Ex4\pi r^2$$

Since the charge enclosed by the Gaussian surface is q, according to the Gauss's theorem,

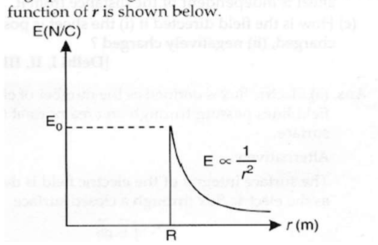
$$\varphi = \frac{q}{\epsilon_0} ....(ii)$$ ½

From equation (i) and (ii) we obtain

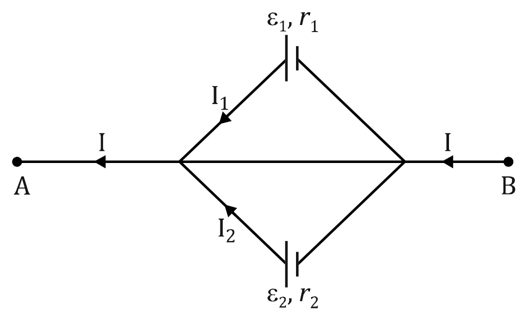
$$E \text{ x } 4\pi r^2 = \frac{q}{\epsilon_0}$$

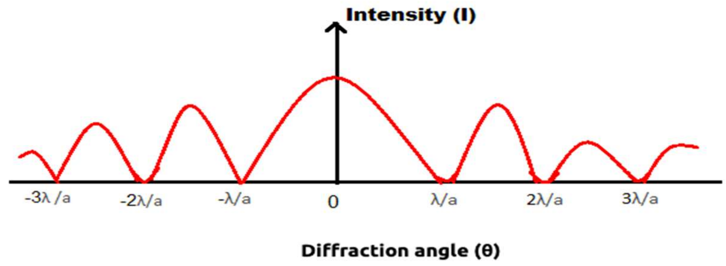
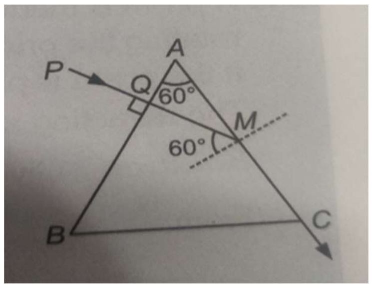
$$E = \frac{1}{4\pi\epsilon_0} . \frac{q}{r^2} \quad (\text{for } r>R)$$ ½

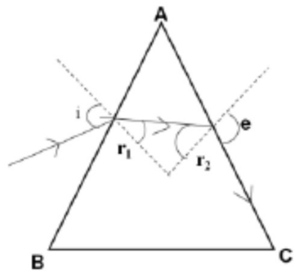
(ii) A graph showing the variation of electric field as a function of r is shown below.



1

32(a)	Drift velocity: It is the average velocity acquired by the free electrons superimposed over the random motion in the direction opposite to electric field and along the length of the metallic conductor.	½
	Derivation $I = neAV_d$	1½
(b)	Here, $I = I_1 + I_2$ ...(*i*) Let V = Potential difference between A and B. For cell ε_1 Then, $V = \varepsilon_1 - I_1 r_1 \Rightarrow I_1 = \frac{\varepsilon_1 - V}{r_1}$  Similarly, for cell ε_2 $I_2 = \frac{\varepsilon_2 - V}{r_2}$ Putting these values in equation (*i*) $I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$ or $I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$ or $V = \left(\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}\right) - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$ ...(*ii*) Comparting the above equation with the equivalent circuit of emf 'ε_{eq}' and internal resistance 'r_{eq}' then, $V = \varepsilon_{eq} - Ir_{eq}$ ...(*iii*) Then (*i*) $\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$ (*ii*) $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$ (*iii*) The potential difference between A and B $V = \varepsilon_{eq} - Ir_{eq}$	3
	OR	
(a)	Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of currents leaving the junction	1
	Loop rule: The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero	1
(b)	Derivation	3

33(a)	 Width of central maximum is twice that of any secondary maximum	1 1
(b)	 Given : $\angle A = 60^0$, $\angle i = 0^0$ At M : Sin C $= \frac{1}{\mu} = \frac{\sqrt{3}}{2} = \sin 60^0$ $\therefore$ $C = 60^0$ So the ray PM after refraction from the face AC grazes along AC. $\therefore \angle e = 90^0$ From $\angle i + \angle e = \angle A + \angle \delta$ Or $0^0 + 90^0 = 60^0 + \angle\delta$ $\therefore \delta = 90^0 - 60^0 = 30^0$	1 1 1
	OR	
(a)	(i) The interference pattern has a number of equally spaced bright and dark bands. The diffraction pattern has a central bright maximum which is twice as wide as the other maxima. The intensity falls as we go to successive maxima away from the centre, on either side. (ii) We calculate the interference pattern by superposing two waves originating from the two narrow slits. The diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit.	1 1
(b)	**(i)** $\mu = \frac{sin\left(\frac{A+\delta_m}{2}\right)}{sin\left(\frac{A}{2}\right)} = \frac{sin\left(\frac{60+30}{2}\right)}{sin\left(\frac{60^o}{2}\right)} = \sqrt{2}$ Also $\mu = \frac{c}{\upsilon} \Rightarrow \upsilon = \frac{3\times10^8}{\sqrt{2}} m/s$	1½

	(ii) At face AC, let the angle of incidence be r_2. For grazing ray, $e = 90^o$ $\Rightarrow \mu = \frac{1}{sin\ r_2} \quad \Rightarrow r_2 = sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^o$ Let angle of refraction at face AB be r_1. Now $r_1 + r_2 = A$ $\therefore\ r_1 = A - r_2 = 60^o - 45^o = 15^o$ Let angle of incidence at this face be i $\mu = \frac{sin\ i}{sin\ r_1} \quad \Rightarrow \sqrt{2} = \frac{sin\ i}{sin 15^o}$ $\therefore i = sin^{-1}\left(\sqrt{2}\ .\ sin\,15^o\right) = 21.5^0$  	1½
	SECTION E	
34(i)	When the image is formed at infinity, we can see it with minimum strain in the ciliary muscles of the eye.	1
(ii)	The multi-component lenses are used for both objective and the eyepiece to improve image quality by minimising various optical aberrations in lenses.	1
(iii)	(a)The compound microscope is used to observe minute nearby objects whereas the telescope is used to observe distant objects.	1
	(b) In compound microscope the focal length of the objective is lesser than that of the eyepiece whereas in telescope the focal length of the objective is larger than that of the eyepiece.	1
	OR	
(iii)	(a) The image formed by reflecting type telescope is brighter than that formed by refracting telescope.	1
	(b) The image formed by the reflecting type telescope is more magnified than that formed by the refracting type telescope.	1
35(i)	LEDs are made up of compound semiconductors and not by the elemental conductor because the band gap in the elemental conductor has a value that can detect the light of a wavelength which lies in the infrared (IR) region.	1
(ii)	1.8 eV to 3 eV	1
(iii)	LED is reversed biased that is why it is not glowing.	2
	OR	
	V-I Characteristic curves of pn junction diode in forward biasing and reverse biasing.	1+ 1

CLASS : XII

SESSION: 2023-24

CBSE SAMPLE QUESTION PAPER

SUBJECT: PHYSICS (THEORY)

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

General Instructions:

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
(5) 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. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary
   i. $c = 3 \times 10^8$ m/s
   ii. $m_e = 9.1 \times 10^{-31}$ kg
   iii. $e = 1.6 \times 10^{-19}$ C
   iv. $\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$
   v. $h = 6.63 \times 10^{-34}$ Js
   vi. $\varepsilon_0 = 8.854 \times 10^{-12}\ C^2N^{-1}m^{-2}$
   vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. Which of the following is not the property of an equipotential surface?
(a) They do not cross each other.
(b) The work done in carrying a charge from one point to another on an equipotential surface is zero.
(c) For a uniform electric field, they are concentric spheres.
(d) They can be imaginary spheres.

2. An electric dipole placed in an electric field of intensity 2×10^5 N/C at an angle of 30° experiences a torque equal to 4 Nm. The charge on the dipole of dipole length 2 cm is
(a) 7 μC (b) 8 mC (c) 2 mC (d) 5 mC

3. A metallic plate exposed to white light emits electrons. For which of the following colours of light, the stopping potential will be maximum?

(a) Blue (b) Yellow (c) Red (d) Violet

4. When alpha particles are sent through a thin gold foil, most of them go straight through the foil, because

(a) alpha particles are positively charged

(b) the mass of an alpha particle is more than the mass of an electron

(c) most of the part of an atom is empty space

(d) alpha particles move with high velocity

5. An electron is moving along positive x-axis in a magnetic field which is parallel to the positive y-axis. In what direction will the magnetic force be acting on the electron?

(a) Along -x axis (b) Along -z axis

(c) Along +z axis (d) Along -y axis

6. The relative permeability of a substance X is slightly less than unity and that of substance Y is slightly more than unity, then

(a) X is paramagnetic and Y is ferromagnetic

(b) X is diamagnetic and Y is ferromagnetic

(c) X and Y both are paramagnetic

(d) X is diamagnetic and Y is paramagnetic

7. An ammeter of resistance 0.81 ohm reads up to 1 A. The value of the required shunt to increase the range to 10 A is

(a) 0.9 ohm (b) 0.09 ohm (c) 0.03 ohm (d) 0.3 ohm

8. An electron with angular momentum L moving around the nucleus has a magnetic moment given by

(a) e L/ 2m (b) e L/3m (c) e L /4m (d) e L / m

9. The large scale transmission of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up because of

(a) reduction of current (b) reduction of current and voltage both

(c) power loss is cut down (d) a and c both

10. The diagram below shows the electric field (**E**) and magnetic field (**B)** components of an electromagnetic wave at a certain time and location.

The direction of the propagation of the electromagnetic wave is

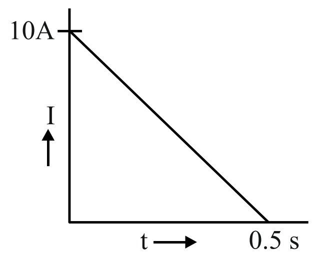
(a) perpendicular to **E** and **B** and out of plane of the paper

(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. In a coil of resistance 100 Ω a current is induced by changing the magnetic flux through it. The variation of current with time is as shown in the figure. The magnitude of change in flux through coil is



(a) 200 Wb (b) 275 Wb (c) 225 Wb (d) 250 Wb

12. The energy of an electron in n^th orbit of hydrogen atom is E_n= - 13.6/$n^2 eV$.The negative sign of energy indicates that
(a) electron is free to move.
(b) electron is bound to the nucleus.
(c) kinetic energy of electron is equal to potential energy of electron.
(d) atom is radiating energy.

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.

b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

c) If Assertion is true but Reason is false.

d) If both Assertion and Reason are false.

13. **Assertion** (A): For the radiation of a frequency greater than the threshold frequency, photoelectric current is proportional to the intensity of the radiation.

Reason (R) : Greater the number of energy quanta available, greater is the number of electrons absorbing the energy quanta and greater is number of electrons coming out of the metal.

14. **Assertion (A)** : Putting p type semiconductor slab directly in physical contact with n type semiconductor slab cannot form the pn junction.

Reason (R) : The roughness at contact will be much more than inter atomic crystal spacing and continuous flow of charge carriers is not possible.

15. **Assertion (A) :** An electron has a higher potential energy when it is at a location associated with a negative value of potential and has a lower potential energy when at a location associated with a positive potential.

Reason (R) : Electrons move from a region of higher potential to a region of lower potential.

16. **Assertion (A) :** Propagation of light through an optical fibre is due to total internal reflection taking place at the core-cladding interface.

Reason (R): Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

SECTION-B

17. (a) Name the device which utilizes unilateral action of a pn diode to convert ac into dc.
(b) Draw the circuit diagram of full wave rectifier.

18. The wavelength λ of a photon and the de Broglie wavelength of an electron of mass m have the same value. Show that the energy of the photon is 2λmc/h times the kinetic energy of the electron, where c and h have their usual meanings.

19. A ray of monochromatic light passes through an equilateral glass prism in such a way that the angle of incidence is equal to the angle of emergence and each of these angles is 3/4 times the angle of the prism. Determine the angle of deviation and the refractive index of the glass prism.

20. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C and the temperature coefficient of resistance of nichrome is $1.70 \times 10^{-4}\ °C^{-1}$?

21. Show that the least possible distance between an object and its real image in a convex lens is 4f, where f is the focal length of the lens.

OR

In an astronomical telescope in normal adjustment a straight black line of length L is drawn on the objective lens. The eyepiece forms a real image of this line whose length is l. What is the angular magnification of the telescope?

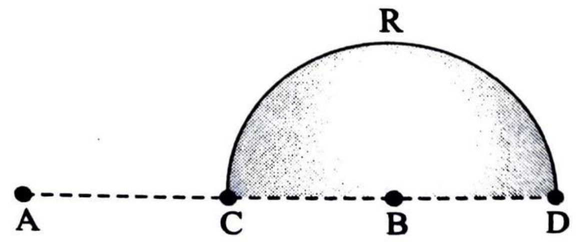
SECTION-C

22. A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of ${}^{63}_{29}Cu$ atoms (of mass 62.92960 u).
Given m_p = 1.007825u and m_n = 1.008665u.

OR

Draw the graph showing the variation of binding energy per nucleon with mass number. Write two inferences which can be drawn from this graph.

23. Charges ($+q$) and ($-q$) are placed at the points A and B respectively which are a distance 2L apart. C is the midpoint between A and B. What is the work done in moving a charge +Q along the semicircle CRD.



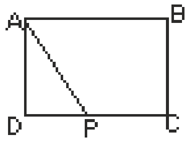
24. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV.

a. What is the kinetic energy of the electron in this state?

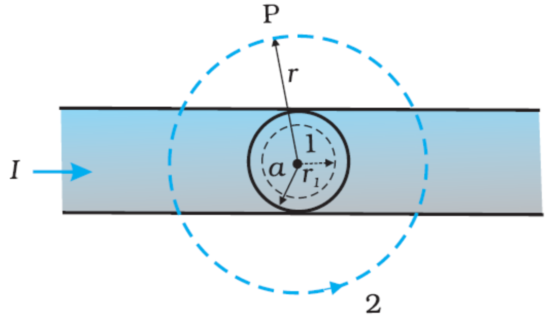
b. What is the potential energy of the electron in this state?

c. Which of the answers above would change if the choice of the zero of potential energy is changed?

25. A wire of uniform cross-section and resistance 4 ohm is bent in the shape of square ABCD. Point A is connected to a point P on DC by a wire AP of resistance 1 ohm. When a potential difference is applied between A and C, the points B and P are seen to be at the same potential. What is the resistance of the part DP?



26. The given figure shows a long straight wire of a circular cross-section (radius a) carrying steady current I. The current I is uniformly distributed across this cross-section. Calculate the magnetic field in the region $r < a$ and $r > a$.



27. Identify the part of the electromagnetic spectrum which:

a) produces heating effect,
b) is absorbed by the ozone layer in the atmosphere,
c) is used for studying crystal structure.

Write any one method of the production of each of the above radiations.

28. a. Define mutual inductance and write its SI unit.

b. Two circular loops, one of small radius *r* and other of larger radius R, such that R >> *r*, are placed coaxially with centres coinciding. Obtain the mutual inductance of the arrangement.

OR

Two long straight parallel current carrying conductors are kept 'a' distant apart in air. The direction of current in both the conductors is same. Find the magnitude of force per unit length and direction of the force between them. Hence define one ampere.

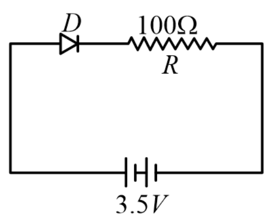
SECTION-D

Case Study Based Questions

29. **Read the following paragraph and answer the questions that follow.**

A semiconductor diode is basically a pn junction with metallic contacts provided at the ends for the application of an external voltage. It is a two terminal device. When an external voltage is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal, it is said to be forward biased. When an external voltage is applied across the diode such that n-side is positive and p-side is negative, it is said to be reverse biased. An ideal diode is one whose resistance in forward biasing is zero and the resistance is infinite in reverse biasing. When the diode is forward biased, it is found that beyond forward voltage called knee voltage, the conductivity is very high. When the biasing voltage is more than the knee voltage the potential barrier is overcome and the current increases rapidly with increase in forward voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

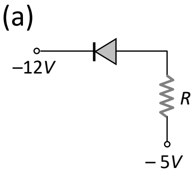
i. In the given figure, a diode *D* is connected to an external resistance $R = 100\ \Omega$ and an emf of 3.5 *V*. If the barrier potential developed across the diode is 0.5 *V*, the current in the circuit will be:



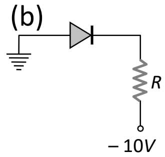
(a) 40 mA (b) 20 mA (c) 35 mA (d) 30 mA

ii. In which of the following figures, the pn diode is reverse biased?

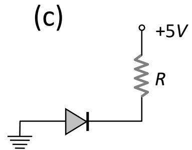
(a)



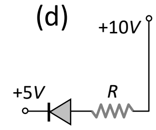
(b)



(c)



(d)



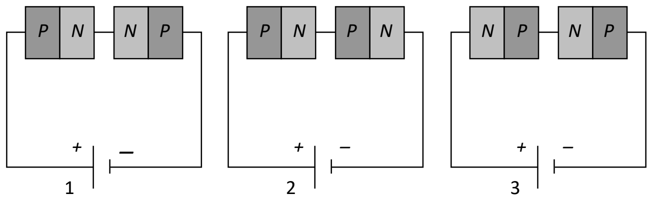
iii. Based on the V-I characteristics of the diode, we can classify diode as

(a) bilateral device (b) ohmic device

(c) non-ohmic device (d) passive element

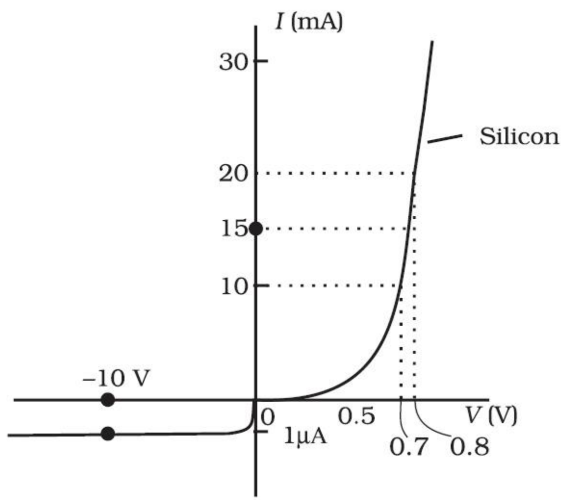
OR

Two identical *PN* junctions can be connected in series by three different methods as shown in the figure. If the potential difference in the junctions is the same, then the correct connections will be



(a) in the circuits (1) and (2)
(b) in the circuits (2) and (3)
(c) in the circuits (1) and (3)
(d) only in the circuit (1)

iv.



The V-I characteristic of a diode is shown in the figure. The ratio of the resistance of the diode at I = 15 mA to the resistance at V = -10 V is
(a) 100 (b) 10^6 (c) 10 (d) 10^{-6}

30. Read the following paragraph and answer the questions that follow.

Types of Lenses and their combination

A convex or converging lens is thicker at the centre than at the edges. It converges a beam of light on refraction through it. It has a real focus. Convex lens is of three types: Double convex lens, Plano convex lens and Concavo-convex lens.

Concave lens is thinner at the centre than at the edges. It diverges a beam of light on refraction through it. It has a virtual focus. Concave lenses are of three types: Double concave lens, Plano concave lens and Convexo-concave lens.

When two thin lenses of focal lengths f_1 and f_2 are placed in contact with each other along their common principal axis, then the two lens system is regarded as a single lens of focal length *f* and

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

If several thin lenses of focal length f_1, f_2, ... f_n are placed in contact, then the effective focal length of the combination is given by

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

and in terms of power, we can write

$$P = P_1 + P_2 + ... + P_n$$

The value of focal length and power of a lens must be used with proper sign consideration.

i. Two thin lenses are kept coaxially in contact with each other and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be

(a) -26.7cm (b) 60cm (c) 80cm (d) 30cm

ii. A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a

(a) converging lens
(b) diverging lens
(c) mirror
(d) thin plane sheet of glass

iii. Lens generally used in magnifying glass is

(a) single concave lens
(b) single convex lens
(c) combination of convex lens of lower power and concave lens of lower focal length
(d) Planoconcave lens

iv. The magnification of an image by a convex lens is positive only when the object is placed

(a) at its focus F
(b) between F and 2F
(c) at 2F
(d) between F and optical centre

OR

A convex lens of 20 cm focal length forms a real image which is three times magnified. The distance of the object from the lens is

(a) 13.33 cm (b) 14 cm (c) 26.66 cm (d) 25 cm

SECTION-E

31. i. Draw a ray diagram for the formation of image of a point object by a thin double convex lens having radii of curvature R_1 and R_2. Hence derive lens maker's formula.

ii A converging lens has a focal length of 10 cm in air. It is made of a material of refractive index 1.6. If it is immersed in a liquid of refractive index 1.3, find its new focal length.

OR

i. Define a wavefront. How is it different from a ray?

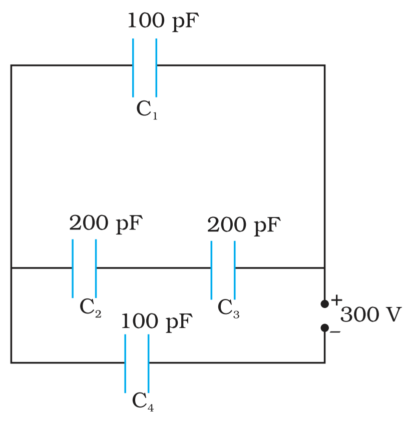
ii. Using Huygens's construction of secondary wavelets draw a diagram showing the passage of a plane wavefront from a denser to a rarer medium. Using it verify Snell's law.

iii. In a double slit experiment using light of wavelength 600nm and the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.

iv. Write two differences between interference pattern and diffraction pattern.

32. i. Derive an expression for the capacitance of a parallel plate capacitor with air present between the two plates.

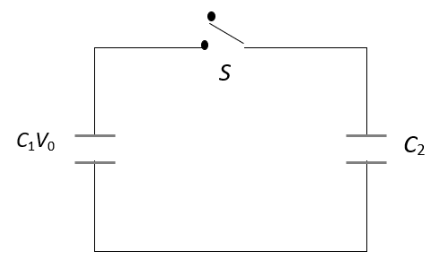
ii. Obtain the equivalent capacitance of the network shown in figure. For a 300 V supply, determine the charge on each capacitor.



OR

i. A dielectric slab of thickness 't' is kept between the plates of a parallel plate capacitor with plate separation 'd' ($t < d$). Derive the expression for the capacitance of the capacitor.

ii. A capacitor of capacity C_1 is charged to the potential of V_o. On disconnecting with the battery, it is connected with an uncharged capacitor of capacity C_2 as shown in the adjoining figure. Find the ratio of energies before and after the connection of switch S.



33.a. Draw graphs showing the variations of inductive reactance and capacitive reactance with frequency of applied ac source.

b. Draw the phasor diagram for a series LRC circuit connected to an AC source.

c. When an alternating voltage of 220V is applied across a device X, a current of 0.25A flows which lags behind the applied voltage in phase by π/2 radian. If the same voltage is applied across another device Y, the same current flows but now it is in phase with the applied voltage.
(i) Name the devices X and Y.
(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

OR

a. A series LCR circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit.

b. Plot a graph to show the variation of current with frequency of the ac source, explaining the nature of its variation for two different resistances R_1 and R_2 ($R_1 < R_2$) at resonance.

Class: XII Session 2023-24

SUBJECT: PHYSICS(THEORY)

MARKING SCHEME

SECTION A

A1: c **1M**

A2: c $q = \tau/[(2a) \, E \sin\theta] = \frac{4}{2\times10^{-2}\times 2 \times 10^5 \sin 30°}$ **1M**

$= 2 \times 10^{-3}$ C = 2 mC

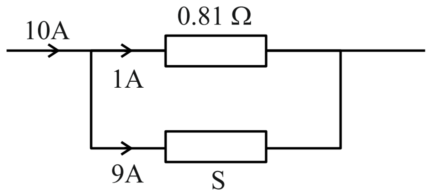
A3: d Higher the frequency, greater is the stopping potential **1M**

A4: c **1M**

A5: b **1M**

A6: d **1M**

A7: b **1M**



9 x S = 1 × 0.81

$S = \frac{0.81}{9} = 0.09\ \Omega$

A8: a **1M**

A9: d **1M**

A10: a **1M**

A11: d $e = \frac{\Delta\Phi}{\Delta t}, I = \frac{1}{R}\frac{\Delta\Phi}{\Delta t}$ **1M**

$I\,\Delta t = \frac{\Delta\Phi}{R}$ = Area under $I - t$ graph, R = 100 ohm

$\therefore \quad \Delta\Phi = 100 \times \frac{1}{2} \times 10 \times 0.5 = 250$ Wb.

A12: b **1M**

A13: a **1M**

A14: a **1M**

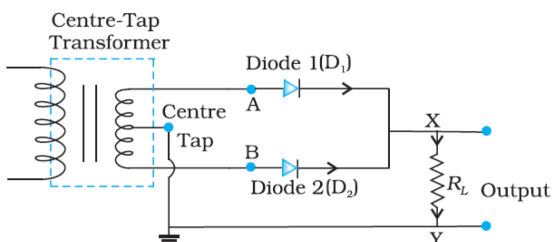
A15: c **1M**

Q16: c **1M**

SECTION B

A17: (a) Rectifier **1M**

(b) Circuit diagram of full wave rectifier **1M**



(a)

A18: As $\lambda = h / mv$, $v = h / m\lambda$ -----------------(i) 1/2M

Energy of photon $E = hc / \lambda$ 1/2M

& Kinetic energy of electron $K = 1/2\ mv^2 = ½\ mh^2 / m^2 \lambda^2$ --------------(ii) 1/2M

Simplifying equation i & ii we get $E / K = 2\lambda mc / h$ 1/2M

A19: Here angle of prism A = 60°, angle of incidence *i* = angle of emergence *e* and under this condition angle of deviation is minimum

$\therefore\ i = e = \frac{3}{4} A = \frac{3}{4} \times 60° = 45°$ and $i + e = A + D$,

hence $D_m = 2i - A = 2 \times 45° - 60° = 30°$ 1M

∴ Refractive index of glass prism

$$n = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60°+30°}{2}\right)}{\sin\left(\frac{60°}{2}\right)} = \frac{\sin 45°}{\sin 30°} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2}.$$ 1M

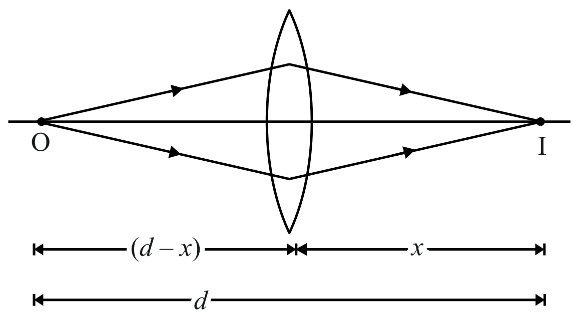
A20:Given: V=230 V, I_0= 3.2A, I=2.8A, T_0 =27 ^{0}C, $\alpha = 1.70 \times 10^{-4}\ °C^{-1}$.

Using equation $R = R_0 (1 + \alpha \Delta T)$ ½ M

i.e $V / I = \{V / I_0\} [1 + \alpha \Delta T]$ ½ M

and solving $\Delta T = 840$, i.e. $T = 840 + 27 = 867\ ^0C$ 1M

A21: Let *d* be the least distance between object and image for a real image formation.



½ M

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $\frac{1}{f} = \frac{1}{x} + \frac{1}{d-x} = \frac{d}{x(d-x)}$ ½ M

$fd = xd - x^2$, $x^2 - dx + fd = 0$, $x = \frac{d \pm \sqrt{d^2 - 4fd}}{2}$ ½ M

For real roots of *x*, $d^2 - 4fd \geq 0$ ½ M

$d \geq 4f$.

OR

Let f_o and f_e be the focal length of the objective and eyepiece respectively.

For normal adjustment the distance from objective to eyepiece is $f_o + f_e$.

Taking the line on the objective as object and eyepiece as lens

$u = -(f_o + f_e)$ and $f = f_e$

$\frac{1}{v} - \frac{1}{[-\{fo + fe\}]} = \frac{1}{fe} \Rightarrow v = \left(\frac{f_o + f_e}{f_o}\right) f_e$ 1M

Linear magnification (eyepiece) = $\frac{v}{u} = \frac{Image\ size}{Object\ size} = \frac{f_e}{f_o} = \frac{l}{L}$ ½ M

∴ Angular magnification of telescope

M = $\frac{f_0}{f_e} = \frac{L}{l}$ ½ M

SECTION C

A22: Number of atoms in 3 gram of Cu coin = $(6.023 \times 10^{23} \times 3) / 63 = 2.86 \times 10^{22}$ ½ M

Each atom has 29 Protons & 34 Neutrons

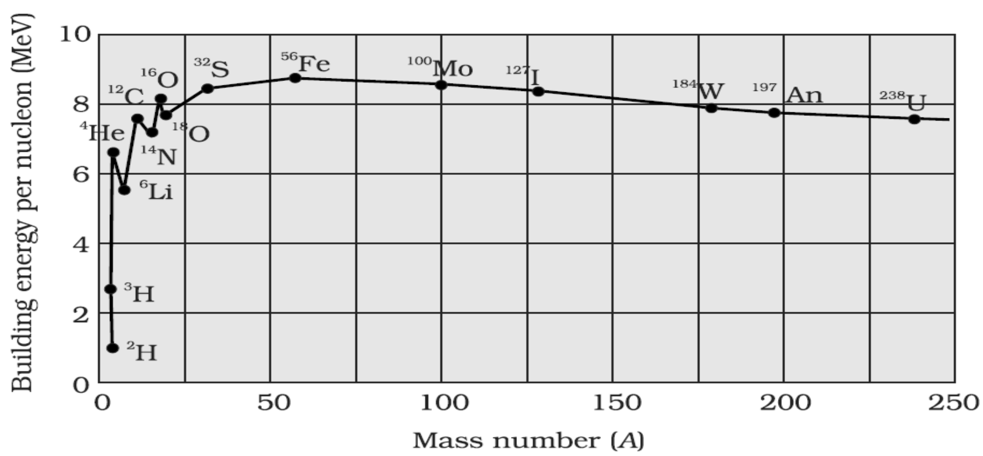
Thus Mass defect $\Delta m = 29 \times 1.00783 + 34 \times 1.00867 - 62.92960$ u $= 0.59225$u 1M

Nuclear energy required for one atom $= 0.59225 \times 931.5$ MeV ½ M

Nuclear energy required for 3 gram of Cu $= 0.59225 \times 931.5 \times 2.86 \times 10^{22}$ MeV

$= 1.58 \times 10^{25}$ MeV 1M

OR



The binding energy per nucleon as a function of mass number.

2 M

(i) the binding energy per nucleon, E_{bn}, is practically constant, i.e. practically independent of the atomic number for nuclei of middle mass number ($30 < A < 170$). The curve has a maximum of about 8.75 MeV for $A = 56$ and has a value of 7.6 MeV for $A = 238$.

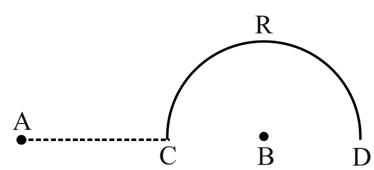
(ii) E_{bn} is lower for both light nuclei ($A<30$) and heavy nuclei ($A>170$).

We can draw some conclusions from these two observations:

(i) The force is attractive and sufficiently strong to produce a binding energy of a few MeV per nucleon.

(ii) The constancy of the binding energy in the range $30 < A < 170$ is a consequence of the fact that the nuclear force is short-ranged. **1M**

A23:



$V_C = 0$, **1M**

$$V_D = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{3L} - \frac{q}{L}\right] = \frac{-q}{6\pi\varepsilon_0 L}$$ **1M**

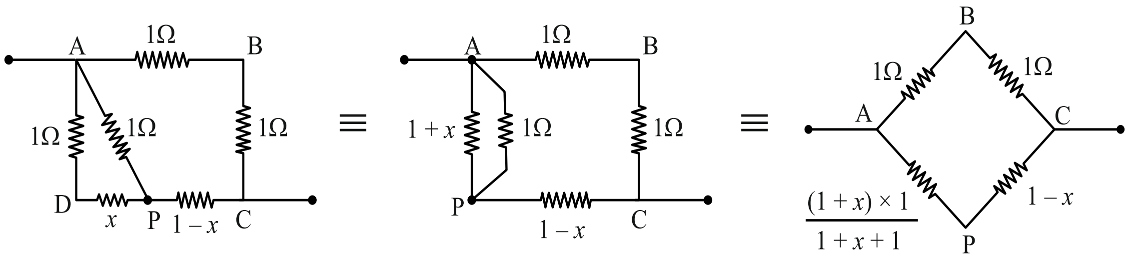
$$W = Q\,[V_D - V_C] = \frac{-Qq}{6\pi\varepsilon_0 L}$$ **1M**

A24 : formula K=-E , U = -2K **1M**

(a) K = 3.4 eV & (b) U= -6.8 eV **1M**

(c) The kinetic energy of the electron will not change. The value of potential energy and consequently, the value of total energy of the electron will change. **1M**

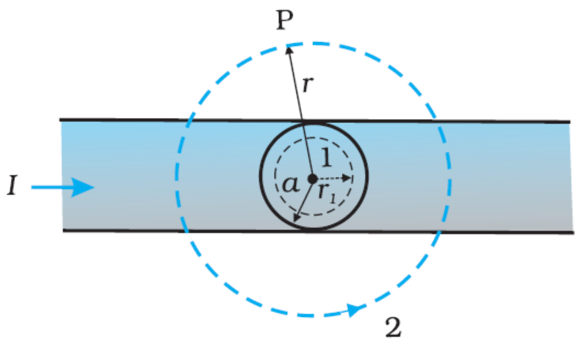
A25:



1.5M

As the points B and P are at the same potential, $\frac{1}{1} = \frac{\frac{(1+x)}{(2+x)}}{(1-x)} \Rightarrow x = (\sqrt{2} - 1)\ ohm$ **1.5M**

A26:



(a) Consider the case $r > a$. The Amperian loop, labelled 2, is a circle concentric with the cross-section. For this loop, $L = 2\pi r$

Using Ampere circuital Law, we can write,

$B(2\pi r) = \mu_0 I$, $B = \frac{\mu_0 I}{2\pi r}$, $B \propto \frac{1}{r}$ $(r > a)$ **1.5 M**

(b)Consider the case $r < a$. The Amperian loop is a circle labelled 1. For this loop, taking the radius of the circle to be r, $L = 2\pi r$

Now the current enclosed I_e is not I, but is less than this value. Since the current distribution is uniform, the current enclosed is,

$I_e = I\left(\frac{\pi r^2}{\pi a^2}\right) = \frac{Ir^2}{a^2}$ Using Ampere's law, $B(2\pi r) = \mu_0 \frac{Ir^2}{a^2}$

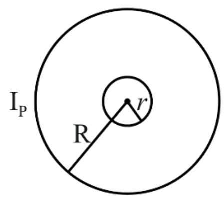
$B = \left(\frac{\mu_0 I}{2\pi a^2}\right) r$ $B \propto r$ $(r < a)$ **1.5M**

A27: (a) Infrared (b) Ultraviolet (c) X rays **½ + ½ + ½** M

Any one method of the production of each one **½ + ½ + ½** M

A28 (a) : Definition and S.I. Unit. ½ + ½ **M**

(b)



Let a current I_P flow through the circular loop of radius R. The magnetic induction at the centre of the loop is

$$B_P = \frac{\mu_0 I_P}{2R}$$ **½ M**

As, $r << R$, the magnetic induction B_P may be considered to be constant over the entire cross sectional area of inner loop of radius r. Hence magnetic flux linked with the smaller loop will be

$$\phi_S = B_P A_S = \frac{\mu_0 I_P}{2R}\pi r^2$$ **½ M**

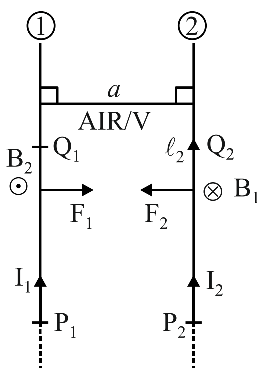
Also, $$\phi_S = M I_P$$ **½ M**

∴ $$M = \frac{\phi_S}{I_P} = \frac{\mu_0 \pi r^2}{2R}$$ **½ M**

OR

The magnetic induction B_1 set up by the current I_1 flowing in first conductor at a point somewhere in the middle of second conductor is

$$B_1 = \frac{\mu_0 I_1}{2\pi a} \quad ...(1)$$ **½ M**



The magnetic force acting on the portion P_2Q_2 of length ℓ_2 of second conductor is

$$F_2 = I_2 \ell_2 B_1 \sin 90° \quad ...(2)$$

From equation (1) and (2),

$$F_2 = \frac{\mu_0 I_1 I_2 \ell_2}{2\pi a}$$, towards first conductor **½ M**

$$\frac{F_2}{\ell_2} = \frac{\mu_0 I_1 I_2}{2\pi a} \quad ...(3)$$

The magnetic induction B_2 set up by the current I_2 flowing in second conductor at a point somewhere in the middle of first conductor is

$$B_2 = \frac{\mu_0 I_2}{2\pi a} \quad ...(4)$$ ½ M

The magnetic force acting on the portion P_1Q_1 of length ℓ_1 of first conductor is

$F_1 = I_1\ell_1B_2 \sin 90°$ ...(5)

From equation (3) and (5)

$F_1 = \frac{\mu_0 I_1 I_2 \ell_1}{2\pi a}$, towards second conductor ½ M

$\frac{F_1}{\ell_1} = \frac{\mu_0 I_1 I_2}{2\pi a}$ ...(6)

The standard definition of 1A

If $I_1 = I_2 = 1A$

$\ell_1 = \ell_2 = 1m$

$a = 1m$ in V/A then $\frac{F_1}{\ell_1} = \frac{F_2}{\ell_2} = \frac{\mu_0 \times 1 \times 1}{2\pi \times 1} = 2\times10^{-7}$ N/m

∴ One ampere is that electric current which when flows in each one of the two infinitely long straight parallel conductors placed 1m apart in vacuum causes each one of them to experience a force of 2×10^{-7} N/m. **1**M

SECTION D

A29 (i) d (ii) c (iii) c OR b (iv) d

A30: (i) a (ii) b (iii) b (iv) d OR c

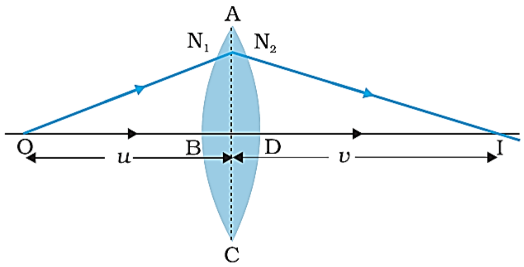
SECTION E

A31: i. DIAGRAM/S : 1M

DERIVATION : 2M

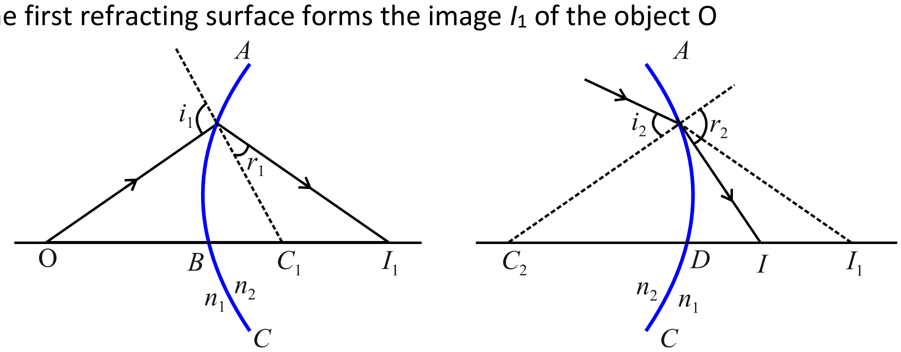
NUMERICAL : 2 M

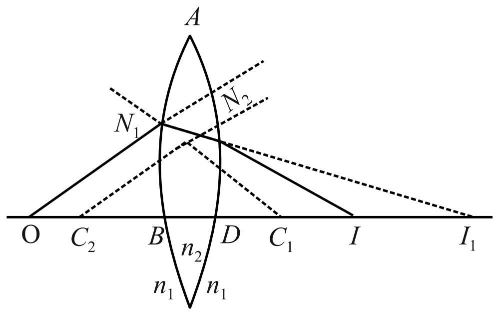
Lens maker's Formula



When a ray refracts from a lens (double convex), in above figure, then its image formation can be seen in term of two steps :

Step 1: The first refracting surface forms the image I_1 of the object O





Step 2: The image of object O for first surface acts like a virtual object for the second surface.
Now for the first surface ABC, ray will move from rarer to denser medium, then

$$\frac{n_2}{BI_1}+\frac{n_1}{OB}=\frac{n_2-n_1}{BC_1} \qquad ...(i) \qquad ½\text{ M}$$

Similarly for the second interface, ADC we can write.

$$\frac{n_1}{DI}-\frac{n_2}{DI_1}=\frac{n_2-n_1}{DC_2} \qquad ...(ii) \qquad ½\text{ M}$$

DI_1 is negative as distance is measured against the direction of incident light.
Adding equation (1) and equation (2), we get

$$\frac{n_2}{BI_1}+\frac{n_1}{OB}+\frac{n_1}{DI}-\frac{n_2}{DI_1}=\frac{n_2-n_1}{BC_1}+\frac{n_2-n_1}{DC_2}$$

or $$\frac{n_1}{DI}+\frac{n_1}{OB}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right) \qquad ...(iii)\ (\because \text{ for thin lens } BI_1 = DI_1)$$

Now, if we assume the object to be at infinity *i.e.* $OB \to \infty$, then its image will form at focus F (with focal length f), *i.e.* ½ M

$DI = f$, thus equation (iii) can be rewritten as

$$\frac{n_1}{f}+\frac{n_1}{\infty}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right)$$

or $$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right) \qquad ...(iv)$$

Now according to the sign conventions

$$BC_1 = +R_1 \text{ and } DC_2 = -R_2 \qquad ...(v) \qquad ½\text{ M}$$

Substituting equation (v) in equation (iv), we get

$$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

(ii) $$\frac{1}{f_a}=(1.6-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad ...(1) \qquad \textbf{1M}$$

$$\frac{1}{f_\ell}=\left[\frac{1.6}{1.3}-1\right]\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad ....(2) \qquad \textbf{1M}$$

From equation (1) and (2)

$$\frac{f_\ell}{f_a}=\left[\frac{0.6}{0.3}\times 1.3\right] \Rightarrow f_\ell = 2.6\times 10\,\text{cm} \Rightarrow f_\ell = 26\,\text{cm}$$

OR

(i) A wavefront is defined as a surface of constant phase.

(a) The ray indicates the direction of propagation of wave while the wavefront is the surface of constant phase.

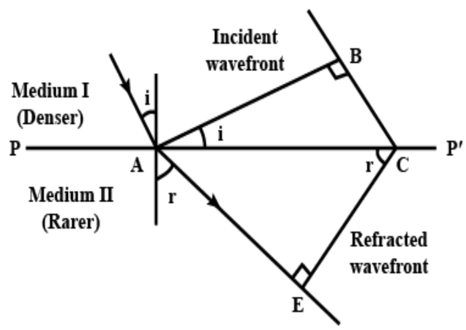
(b) The ray at each point of a wavefront is normal to the wavefront at that point.

1M

(ii) AB: Incident Plane Wave Front & CE is Refracted Wave front . **2M**

Sin i =BC/AC & Sin r = AE /AC

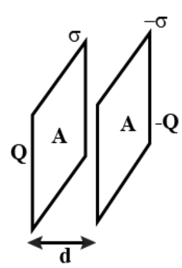
Sin i / Sinr = BC /AE = v_1 /v_2 = constant



(iii) ϴ = λ /a i.e. $a = \frac{\lambda}{\theta} = \frac{6\times10^{-7}}{0.1\times\frac{\pi}{180}} = 3.4\times10^{-4}\,\text{m}$ **1M**

(iv) Two differences between interference pattern and diffraction pattern **1M**

A32: (i) Derivation of the expression for the capacitance **2M**



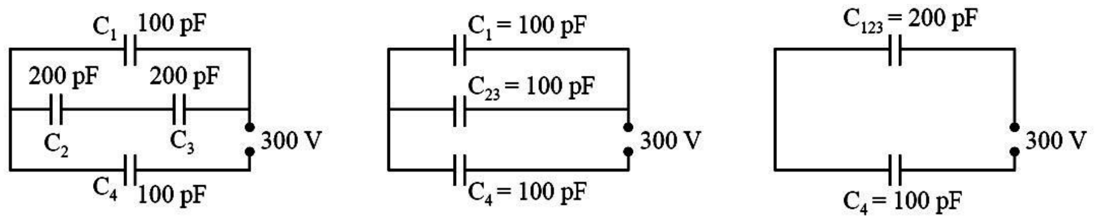
Let the two plates be kept parallel to each other separated by a distance d and cross-sectional area of each plate is A. Electric field by a single thin plate E = $\sigma/2\epsilon_0$

Total electric field between the plates E= σ/ϵ_0 = $Q/A\epsilon_0$

Potential difference between the plates V=Ed = $[Q/A\epsilon_0]$ d.

Capacitance C= Q / V = $A\epsilon_0/d$

(ii)



1 M

The equivalent capacitance = $\frac{200}{3}$ pF

charge on C_4 = $\frac{200}{3} \times 10^{-12} \times 300$= 2×10^{-8} C, **½ M**

potential difference across C_4 = $\frac{200\times10^{-12}\times300}{3\times100\times10^{-12}}$ = 200 V

potential difference across C_1 = 300 – 200 = 100 V

charge on C_1 = $100 \times 10^{-12} \times 100 = 1 \times 10^{-8}$ C **½ M**

potential difference across C_2 and C_3 series combination = 100 V

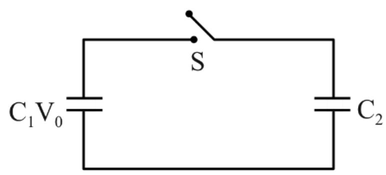
potential difference across C_2 and C_3 each = 50 V

charge on C_2 and C_3 each = $200 \times 10^{-12} \times 50 = 1 \times 10^{-8}$ C **½+½ M**

OR

(i) Derivation of the expression for capacitance with dielectric slab ($t < d$) **3M**

(ii)



Before the connection of switch S,

Initial energy U_i = $\frac{1}{2}C_1V_0^2 + \frac{1}{2}C_2 0^2 = \frac{1}{2}C_1V_0^2$ **½ M**

After the connection of switch S

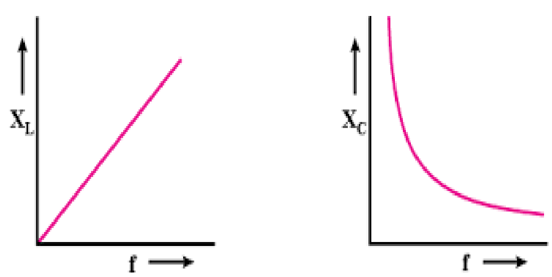
common potential V = $\frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{C_1V_0}{C_1 + C_2}$ **½ M**

Final energy = U_f = $\frac{1}{2}(C_1 + C_2)\frac{(C_1V_0)^2}{(C_1+C_2)^2} = \frac{1}{2}\frac{C_1^2V_0^2}{(C_1+C_2)}$ **½ M**

$U_f : U_i = C_1/(C_1 + C_2)$ **½ M**

A33:

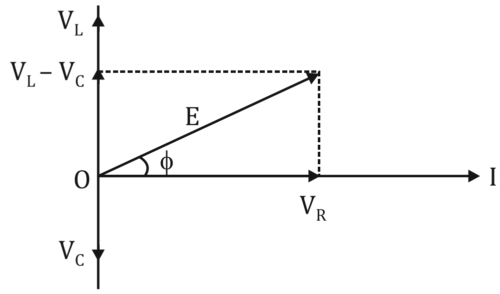
(a)



(a) (b)

½ + ½ M

(b)



1M

(c)(i) In device X, Current lags behind the voltage by π /2, X is an inductor

In device Y, Current in phase with the applied voltage, Y is resistor **½ + ½ M**

(ii) We are given that

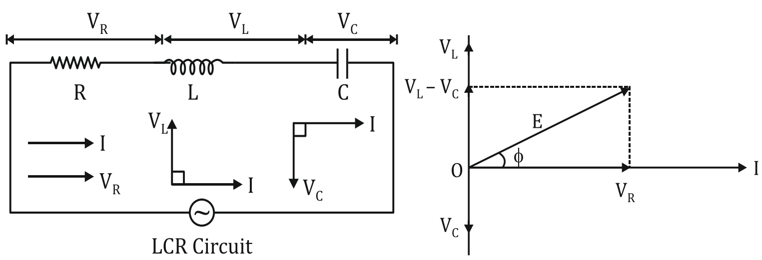
$0.25 = 220/X_L$, $X_L = 880\Omega$, Also $0.25 = 220/R$, $R = 880\Omega$ **1M**

For the series combination of X and Y,

Equivalent impedance $Z = 880\sqrt{2}\ \Omega$, $I = 0.177$ A **1M**

OR

a.



1M

$E = E_0 \sin\omega t$ is applied to a series LCR circuit. Since all three of them are connected in series the current through them is same. But the voltage across each element has a different phase relation with current. The potential difference V_L, V_C and V_R across L, C and R at any instant is given by

$V_L = IX_L$, $V_C = IX_C$ and $V_R = IR$, where I is the current at that instant.

V_R is in phase with I. V_L leads I by 90° and V_C lags behind I by 90° so the phasor diagram will be as shown

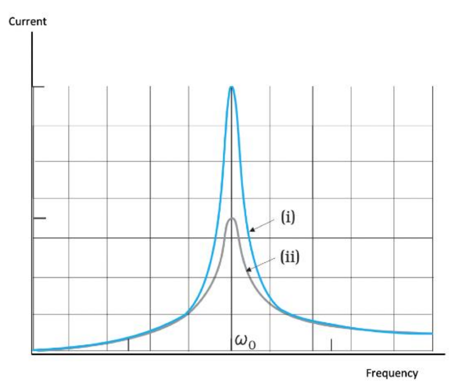
Assuming $V_L > V_C$, the applied emf E which is equal to resultant of potential drop across R, L & C is given as

$E^2 = I^2\ [R^2 + (X_L - X_C)^2\ ]$

Or $I = \frac{E}{\sqrt{[R^2 + (X_L - X_C)2\ ]}} = \frac{E}{Z}$, where Z is Impedance. **3M**

Emf leads current by a phase angle φ as $\tan\varphi = \frac{V_L - V_C}{R} = \frac{X_L - X_C}{R}$

b. The curve (i) is for R_1 and the curve (ii) is for R_2 **1M**



SAMPLE QUESTION PAPER
PHYSICS
Subject Code – 042
CLASS – XII
Academic Session 2024 – 25

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

General Instructions

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each**, **Section B** contains **five questions of two marks each**, **Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each**.
(5) 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. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary

i. $c = 3 \times 10^8$ m/s
ii. $m_e = 9.1 \times 10^{-31}$ kg
iii. $m_p = 1.7 \times 10^{-27}$ kg
iv. $e = 1.6 \times 10^{-19}$ C
v. $\mu_0 = 4\pi \times 10^{-7}$ T m $\boldsymbol{A^{-1}}$
vi. $h = 6.63 \times 10^{-34}$ J s
vii. $\varepsilon_0 = 8.854 \times 10^{-12}$ $\boldsymbol{C^2 N^{-1} m^{-2}}$
viii. Avogadro’s number = 6.023 X $\mathbf{10^{23}}$ per gram mole

[SECTION – A] **(16x1=16 marks)**

Q1. A uniform electric field pointing in positive X-direction exists in a region. Let A be the origin, B be the point on the X-axis at x = +1 cm and C be the point on the Y-axis at y = +1 cm. Then the potential at points A, B and C satisfy.

(A) $V_A < V_B$ (B) $V_A > V_B$. (C) $V_A < V_C$ (D) $V_A > V_C$

Q2. A conducting wire connects two charged conducting spheres such that they attain equilibrium with respect to each other. The distance of separation between the two spheres is very large as compared to either of their radii.

The ratio of the magnitudes of the electric fields at the surfaces of the two spheres is

(A) $\frac{r_1}{r_2}$ (B) $\frac{r_2}{r_1}$ (C) $\frac{{r_2}^2}{{r_1}^2}$ (D) $\frac{{r_1}^2}{{r_2}^2}$

Q3. A long straight wire of circular cross section of radius 'a' carries a steady current I. The current is uniformly distributed across its cross section. The ratio of magnitudes of the magnetic field at a point a/2 above the surface of wire to that of a point a/2 below its surface is

(A) 4:1 (B) 1:1 (C) 4: 3 (D) 3 :4

Q4. The diffraction effect can be observed in

(A) sound waves only (B) light waves only

(C) ultrasonic waves only (D) sound waves as well as light waves

Q5. A capacitor consists of two parallel plates, with an area of cross-section of 0.001 m^2, separated by a distance of 0.0001 m. If the voltage across the plates varies at the rate of 10^8 V/s, then the value of displacement current through the capacitor is

(A) $8.85 \times 10^{-3} A$ (B) $8.85 \times 10^{-4} A$ (C) $7.85 \times 10^{-3} A$ (D) $9.85 \times 10^{-3} A$

Q6. In a series LCR circuit, the voltage across the resistance, capacitance and inductance is 10 V each. If the capacitance is short circuited the voltage across the inductance will be

(A) 10 V (B) $10\sqrt{2}$ V (C) $10/\sqrt{2}$ V (D) 20 V

Q7. Correct match of column I with column II is

C-l (waves)	C-ll (Production)
(1) Infra-red	P . Rapid vibration of electrons in aerials
(2) Radio	Q . Electrons in atoms emit light when they move from higher to lower energy level.
(3) Light	R . Klystron valve
(4) Microwave	S . Vibration of atoms and molecules

(A) 1-P, 2-R, 3-S, 4-Q (B) 1-S, 2-P, 3-O, 4-R

(C) 1-Q, 2-P, 3-S, 4-R (D) 1-S. 2-R, 3-P, 4-Q

Q8. The distance of closest approach of an alpha particle is *d* when it moves with a speed V towards a nucleus.

Another alpha particle is projected with higher energy such that the new distance of the closest approach is *d*/2. What is the speed of projection of the alpha particle in this case?

(A) V /2 (B) $\sqrt{2}$ V (C) 2 V (D) 4 V

Q9. A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of virtual image from the surface of the sphere is

(A) 2 cm (B) 4 cm (C) 6 cm (D) 12 cm

Q10. Colours observed on a CD (Compact Disk) is due to

(A) Reflection (B) Diffraction (C) Dispersion (D) Absorption

Q11. The number of electrons made available for conduction by dopant atoms depends strongly upon

(A) doping level (B) increase in ambient temperature

(C) energy gap (D) options (a) and (b) both

Q12. If copper wire is stretched to make its radius decrease by 0.1%, then the percentage change in its resistance is approximately

(A) –0.4%   (B) +0.8%   (C) +0.4%   (D) +0.2%

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

A. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
C. If Assertion is true but Reason is false.
D. If both Assertion and Reason are false.

Q13. Assertion (A): On increasing the current sensitivity of a galvanometer by increasing the number of turns may not necessarily increase its voltage sensitivity.

Reason(R) : The resistance of the coil of the galvanometer increases on increasing the number of turns.

Q14. Assertion (A): In a hydrogen atom there is only one electron but its emission spectrum shows many lines.

Reason (R): In a given sample of hydrogen there are many atoms each containing one electron; hence many electrons in different atoms may be in different orbits so many transitions from higher to lower orbits are possible.

Q15. Assertion (A): Nuclei having mass number about 60 are least stable..

Reason (R): When two or more light nuclei are combined into a heavier nucleus then the binding energy per nucleon will decrease.

Q16. Assertion (A): de Broglie's wavelength of a freely falling body keeps decreasing with time.

Reason (R): The momentum of the freely falling body increases with time.

[SECTION – B]   (05x2=10 marks)

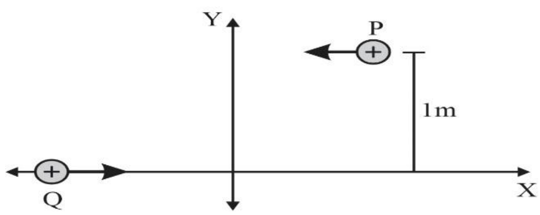
Q17. A platinum surface having work function 5.63 eV is illuminated by a monochromatic source of 1.6×10^{15} Hz. What will be the minimum wavelength associated with the ejected electron.

Q18. (I) In Young's double-slit experiment using monochromatic light of wavelength λ, the intensities of two sources is I. What is the intensity of light at a point where path difference between wave front is $\lambda/4$?

OR

(II) A beam of light consisting of two wavelengths, 4000 Å and 6000 Å, is used to obtain interference fringes in a Young's double-slit experiment. What is the least distance from the central maximum where the dark fringe is obtained?

Q19. P and Q are two identical charged particles each of mass 4×10^{-26} kg and charge 4.8×10^{-19} C, each moving with the same speed of 2.4×10^5 m/s as shown in the figure. The two particles are equidistant (0.5 m) from the vertical Y -axis. At some instant, a magnetic field B is switched on so that the two particles undergo head-on collision.



Find –

(I) the direction of the magnetic field and

(II) the magnitude of the magnetic field applied in the region.

(for VI candidates)

A proton is moving with speed of 2×10^5 m s^{-1} enters a uniform magnetic field B = 1.5 T. At the entry velocity vector makes an angle of 30° to the direction of the magnetic field. Calculate

(a) the pitch of helical path described by the charge

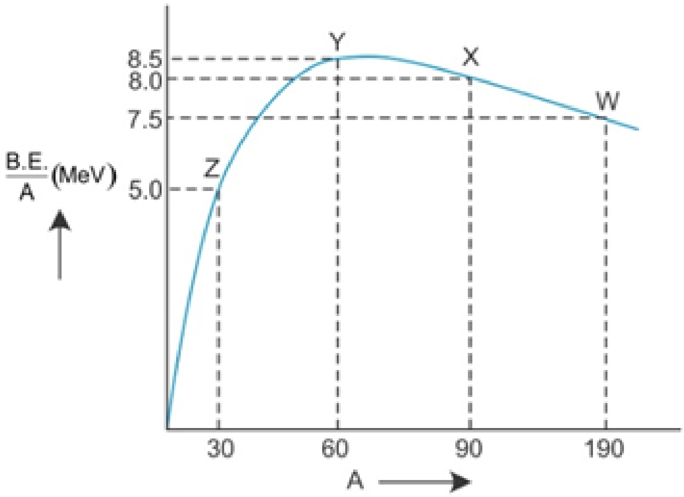
(b) Kinetic energy after completing half of the circle.

Q.20. Binding energy per nucleon vs mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. Identify which of the following nuclei is most likely to undergo

(i) Nuclear Fission

(ii) Nuclear Fusion.

Justify your answer.



(for V.I. Candidates)

Binding energy per nucleon and mass number of the following nuclei are given in the below table

Nuclei	Binding energy per nucleon (MeV)	Mass number
W	7.5	190
X	8.0	90
Y	8.5	60
Z	5.0	30

Identify which of the following nuclei is most likely to undergo

(i) Nuclear Fission

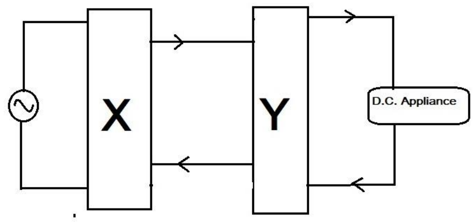
(ii) Nuclear Fusion.

Justify your answer.

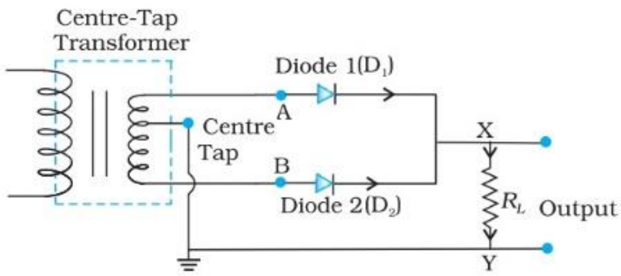
Q21. What should be the radius 'r' of nearest possible orbits of satellite of mass 'm' revolving around the planet of mass 'M' as per Bohr Postulates in terms of m, M, G, h where G is Gravitational constant and h is plank's constant.

[SECTION – C] **(07x3=21 marks)**

Q22. (I) Identify the circuit elements X and Y as shown in the given block diagram and draw the output waveforms of X and Y.



(II) If the centre tapping is shifted towards Diode D1 as shown in the diagram, draw the output waveform of the given circuit.



(for V.I. candidates)

Which device is used to convert AC into DC. State it's underlying principle and explain its working. If the frequency of input AC to this device is 60 Hz, then what will be frequency of the output of this device.

Q23. Find the expression for the capacitance of a parallel plate capacitor of plate area A and plate separation d when (I) a dielectric slab of thickness t and (II) a metallic slab of thickness t, where (t < d) are introduced one by one between the plates of the capacitor. In which case would the capacitance be more and why?

Q24. (I) Draw a ray diagram for the formation of image by a Cassegrain telescope.

(II)Why these types of telescopes are preferred over refracting type telescopes. (Write 2 points)

(for V.I. Candidates)

A Cassegrain telescope is built with an arrangement of two mirrors placing them 20 mm apart. If the radius of curvature of the large mirror is 200mm and the small mirror is 150mm, where will the final image of an object at infinity be?

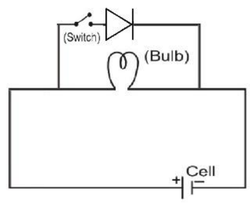
Q25. (I) Draw the energy band diagram for P-type semiconductor at (i) T=0K and (ii) room temperature.

(II)In the given diagram considering an ideal diode, in which condition will the bulb glow

(a) when the switch is open

(b) when the switch is closed

Justify your answer.



(for V.I. Candidates)

Explain briefly how

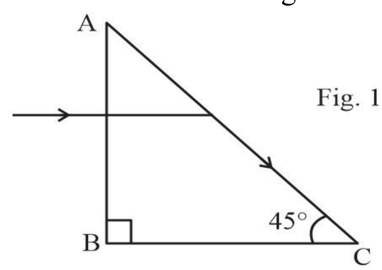
(i) barrier potential is formed in p-n junction diode.

(ii) Width of depletion region of the diode is affected when it is (a) forward biased, (b) reverse biased.

Q26. A boy is holding a smooth, hollow and non-conducting pipe vertically with charged spherical ball of mass 10 g carrying a charge of +10 mC inside it which is free to move along the axis of the pipe. The boy is moving the pipe from East to West direction in the presence of magnetic field of 2T. With what minimum velocity, should the boy move the pipe such that the ball does not move along the axis. Also determine the direction of the magnetic field.

Q27. A light ray entering a right-angled prism undergoes refraction at the face AC as shown in Fig. 1.

(I) What is the refractive index of the material of the prism in Fig. 1?



(II) (a) If the side AC of the above prism is now surrounded by a liquid of refractive index $\frac{2}{\sqrt{3}}$, as shown in Fig. 2, determine if the light ray continues to graze along the interface AC or undergoes total internal reflection or undergoes refraction into the liquid.

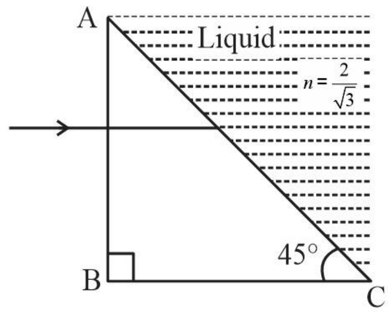


Fig. 2

(b) Draw the ray diagram to represent the path followed by the incident ray with the corresponding angle values.

(Given, $sin^{-1}(\frac{\sqrt{2}}{\sqrt{3}}) = 54.6^{\circ}$)

(for V.I. candidates)

A ray of light is incident on an equilateral prism at an angle 3/4 th of the angle of the prism. If the ray passes symmetrically through the prism, find the (a) angle of minimum deviation, and (b) refractive index of the material of the prism.

Q28. (I) State Gauss's theorem in electrostatics. Using this theorem, derive an expression for the electric field due to an infinitely long straight wire of linear charge density λ.

OR

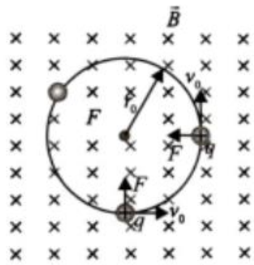
(II) (a) Define electric flux and write its SI unit.

(b) Use Gauss's law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet of charge.

[SECTION D] (02x4=08 marks)

Q29. **Case Study Based Question**: **<u>Motion of Charge in Magnetic Field</u>**

An electron with speed $v_o << c$ moves in a circle of radius r_o in a uniform magnetic field. This electron is able to traverse a circular path as the magnetic force acting on the electron is perpendicular to both v_o and B ,as shown in the figure. This force continuously deflects the particle sideways without changing its speed and the particle will move along a circle perpendicular to the field. The time required for one revolution of the electron is T_o



(i) If the speed of the electron is now doubled to $2v_o$. The radius of the circle will change to

(A) $4r_o$ (B) $2\ r_o$ (C) r_o (D) $r_o/2$

(ii) If $v = 2v_o$, then the time required for one revolution of the electron (T_o) will change to

(A) $4\ T_o$ (B) $2\ T_o$ (C) T_o (D) $T_o/2$

(iii) A charged particles is projected in a magnetic field . The acceleration of the particle is found to be . Find the value of x.

(A) 4 ms^{-2} (B) -4 ms^{-2} (C) -2 ms^{-2} (D) 2 ms^{-2}

(iv) If the given electron has a velocity not perpendicular to B, then trajectory of the electron is

(A) straight line (B) circular (C) helical (D) zig-zag

OR

If this electron of charge (e) is moving parallel to uniform magnetic field with constant velocity v, the force acting on the electron is

(A) Bev (B) Be/v (C) B/ev (D) Zero

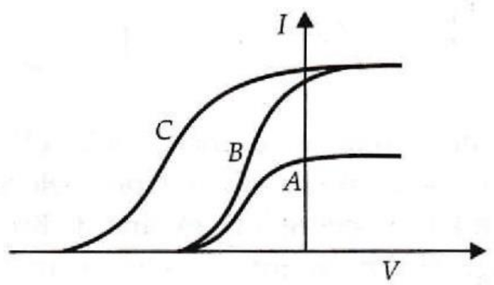
Q30. Case Study Based Question: Photoelectric effect

It is the phenomenon of emission of electrons from a metallic surface when light of a suitable frequency is incident on it. The emitted electrons are called photoelectrons.

Nearly all metals exhibit this effect with ultraviolet light but alkali metals like lithium, sodium, potassium, cesium etc. show this effect even with visible light. It is an instantaneous process i.e. photoelectrons are emitted as soon as the light is incident on the metal surface. The number of photoelectrons emitted per second is directly proportional to the intensity of the incident radiation.

The maximum kinetic energy of the photoelectrons emitted from a given metal surface is independent of the intensity of the incident light and depends only on the frequency of the incident light. For a given metal surface there is a certain minimum value of the frequency of the incident light below which emission of photoelectrons does not occur.

(I) In a photoelectric experiment plate current is plotted against anode potential.



(A) A and B will have same intensities while B and C will have different frequencies

(B) B and C will have different intensities while A and B will have different frequencies

(C) A and B will have different intensities while B and C will have equal frequencies

(D) B and C will have equal intensities while A and B will have same frequencies.

(II) Photoelectrons are emitted when a zinc plate is

(A) Heated | (B) hammered

(C) Irradiated by ultraviolet light | (D) subjected to a high pressure

(III) The threshold frequency for photoelectric effect on sodium corresponds to a wavelength of 500 nm. Its work function is about

(A) $4\text{x}10^{-19}$ J (B) 1 J (C) $2\text{x}10^{-19}$ J (D) $3\text{x}10^{-19}$ J

(IV) The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential is

(A) 2 V (B) 4 V (C) 6 V (D) 10 V

OR

The minimum energy required to remove an electron from a substance is called its

(A) work function (B) kinetic energy (C) stopping potential (D) potential energy

[SECTION E] **(03X5=15)**

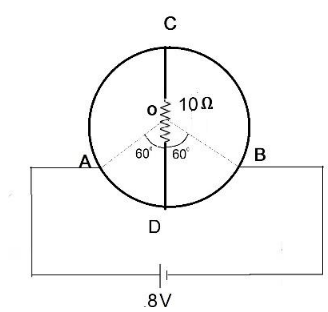
Q31. (I) a) Write two limitations of ohm's law. Plot their I-V characteristics.

b) A heating element connected across a battery of 100 V having an internal resistance of 1 Ω draws an initial current of 10 A at room temperature 20.0 °C which settles after a few seconds to a steady value. What is the power consumed by battery itself after the steady temperature of 320.0 °C is attained? Temperature coefficient of resistance averaged over the temperature range involved is 3.70×10^{-4} °C^{-1}.

OR

(II) a) Using Kirchhoff's laws obtain the equation of the balanced state in Wheatstone bridge.

b) A wire of uniform cross-section and resistance of 12 ohm is bent in the shape of circle as shown in the figure. A resistance of 10 ohms is connected to diametrically opposite ends C and D. A battery of emf 8V is connected between A and B. Determine the current flowing through arm AD.



(for V.I. Candidates)

(II) a) Using Kirchhoff's laws obtain the equation of the balanced state in Wheatstone bridge.

b) What do you understand by 'sensitivity of Wheatstone bridge' ? How the sensitivity of wheatstone bridge can be increased?

Q32. (I) Explain briefly, with the help of a labelled diagram, the basic principle of the working of an a.c. generator. In an a.c. generator, coil of N turns and area A is rotated at an angular velocity ω in a uniform magnetic field B. Derive an expression for the instantaneous value of the emf induced in coil. What is the source of energy generation in this device?

OR

(II) a) With the help of a diagram, explain the principle of a device which changes a low ac voltage into a high voltage . Deduce the expression for the ratio of secondary voltage to the primary voltage in terms of the ratio of the number of turns of primary and secondary winding. For an ideal transformer, obtain the ratio of primary and secondary currents in terms of the ratio of the voltages in the secondary and primary coils.

b) Write any two sources of the energy losses which occur in actual transformers.

c) A step-up transformer converts a low input voltage into a high output voltage. Does it violate law of conservation of energy? Explain.

Q33. (I) a) A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eyepiece of focal length 1.0 cm is used, what is angular magnification of the telescope in normal adjustment?

b) If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.48×10^6 m, and the radius of lunar orbit is 3.8×10^8 m.

OR

(II) A compound microscope consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at

a) the least distance of distinct vision (25 cm) and
b) infinity? What is the magnifying power of the microscope in each case?

MARKING SCHEME
PHYSICS
Subject Code – 042
CLASS – XII
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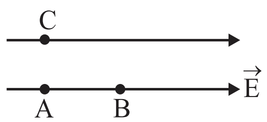
Maximum Marks: 70 **Time Allowed: 3 hours**

[SECTION – A]

Ans.1 - (B) **(1 mark)**



$V_A > V_B$ $[V_A = V_C]$

In the direction of electric field, the electric potential decreases.

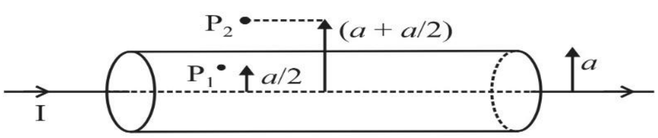
Ans.2 - (B) In the state of equilibrium, **(1 mark)**

The potential on the surface of bigger sphere = the potential at the surface of the smaller sphere

$$\frac{kq_1}{r_1} = \frac{kq_2}{r_2} \Rightarrow \frac{q_1}{q_2} = \frac{r_1}{r_2}$$

$$\therefore \quad \frac{E_1}{E_2} = \frac{q_1}{q_2}\frac{r_2^2}{r_1^2} = \frac{r_1}{r_2}\cdot\frac{r_2^2}{r_1^2} = \frac{r_2}{r_1}$$

Ans.3 - (C) **(1 mark)**



At P_2, $B_2 = \dfrac{\mu_0 I}{2\pi\left(\dfrac{3a}{2}\right)} = \dfrac{\mu_0 I}{3\pi a}$

At P_1, $B_1 = \dfrac{\mu_0 (I/4)}{2\pi(a/2)} = \dfrac{\mu_0 I}{4\pi a}$

$$\therefore \quad \frac{B_2}{B_1} = \frac{\left(\dfrac{\mu_0 I}{3\pi a}\right)}{\left(\dfrac{\mu_0 I}{4\pi a}\right)} \Rightarrow \frac{B_2}{B_1} = \frac{4}{3}$$

Ans.4 - (D) Sound waves as well as light waves (1 mark)

Ans.5 - (A) (1 mark)

Ans.6 - (C) When all the given components are connected (1 mark)

$IR = IX_C = IX_L = 10$ V

$X_C = X_L = R$

Z = $\sqrt{R^2 + (X_C - X_L)^2}$

Z = $\sqrt{R^2 + (R - R)^2}$

Z = R

$V_S = IZ = IR = 10$ V

So, the source voltage is also 10 V

When the capacitor is short circuited then

Z = $\sqrt{R^2 + (X_L)^2}$

= $\sqrt{R^2 + R^2} = R\sqrt{2}$

$V_L = I' X_L = \frac{10}{\sqrt{2}R} \times R = 5\sqrt{2}$ V

Ans.7 - (B) **(1 mark)**

Ans.8 - (B) The distance of closest approach **(1 mark)**

$$d = \frac{\text{const}}{V_1^2} \quad ...(1)$$

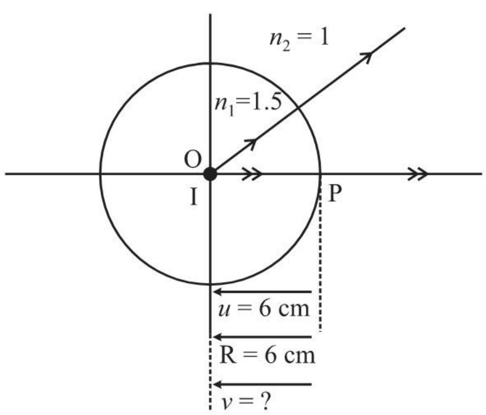
$$\frac{d}{2} = \frac{\text{const}}{V_2^2} \quad ...(2)$$

From equations (1) and (2),

$$2 = \frac{V_2^2}{V_1^2} \Rightarrow V_2 = \sqrt{2}\, V_1$$

$\therefore$ $V_2 = \sqrt{2}$ V Given, ($V_1 = V$)

Ans.9 - (C) **(1 mark)**



$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$$\frac{1}{v} - \frac{3}{2[-6]} = \frac{[1 - 3/2]}{-6}$$

$$\frac{1}{v}=\frac{-3}{12}+\frac{1}{12}=\frac{-2}{12}=\frac{-1}{6}$$

v = –6 cm

Ans.10 - (B) Diffraction (1 mark)

Ans.11 - (A) doping level (1 mark)

Ans.12 - (C) +0.4% (1 mark)

Ans.13 - (A) (1 mark)

Ans.14 - (A) (1 mark)

Ans.15 - (D) (1 mark)

Ans.16 - (A) (1 mark)

[SECTION – B]

Ans.17 –

Given $\emptyset_0 = 5.63eV = 5.63 \times 1.6 \times 10^{-19}J$

$$\nu = 1.6 \times 10^{15}Hz$$

$$K.E. = h\nu - \emptyset_0 = \frac{hc}{\lambda}$$ ½

$$\lambda = \frac{hc}{h\nu - \emptyset_0}$$ ½

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6.63 \times 10^{-34} \times 1.6 \times 10^{15} - 5.63 \times 1.6 \times 10^{-19}}$$ ½

$$= \frac{19.89 \times 10^{-26}}{1.6 \times 10^{-19}(6.63 - 5.63)}$$

$$= \frac{19.89 \times 10^{-26}}{1.6 \times 10^{15}} = 12.4 \times 10^{-7}\, m$$ ½

Ans.18 - $\lambda_1 = 4 \times 10^{-7}\, m$ $\lambda_2 = 6 \times 10^{-7}\, m$

Distance at which dark fringe is observed $x = \left(n + \frac{1}{2}\right)\frac{\lambda D}{d}$ ½

First Dark fringe for $\lambda_1 d_1 = \frac{1}{2}\, \frac{4 \times 10^{-7}}{10^{-2}}\, m = 2 \times 10^{-5}\, m$ ½

First Dark fringe for $\lambda_2 d_2 = \frac{1}{2}\ \frac{6\times10^{-7}}{10^{-2}}\ m = 3\ \times\ 10^{-5}\ m$

First dark fringe will be the distance where both dark fringes will coincide i.e LCM of d_1 & d_1 ½

i.e. $2\ \times\ 10^{-5}\ m\ \times\ 3\ \times\ 10^{-5}\ m$

$= 6\ \times\ 10^{-5}\ m$ ½

OR

(II) For a fringe of width β formed on the screen at distance D from the slits the angular fringe width would be

$\theta = \frac{\beta}{D} = \frac{D\lambda/d}{D} = \frac{\lambda}{d}$ **0.5 M**

or $d = \frac{\lambda}{\theta}$

Let the wavelength in water be λ′ and the angular fringe width be θ’ , then

$d = \frac{\lambda'}{\theta'}\quad \therefore\ \frac{\lambda}{\theta} = \frac{\lambda'}{\theta'}$ **0.5 M**

or $\theta' = \frac{\lambda'}{\lambda}\theta = \frac{\lambda/\mu}{\lambda}\theta = \frac{\theta}{\mu} = \frac{0.2^o}{4/3} = 0.15^o$ **1 M**

(2 Marks)

Ans.19 - (I) The direction of the magnetic field is perpendicular and inward into the plane of the paper **0.5M**

(II) For a head-on collision to take place, the radius of the path of each ion should be equal to 0.5 m.

$r = \frac{mv}{qB} = 0.5\ \text{m}$ **0.5M**

$B = \frac{mv}{qr} = \frac{4\times10^{-26}\times2.4\times10^{5}}{4.8\times10^{-19}\times0.5}$ **0.5M**

B = 0.04 T **0.5M**

For VI Candidate

(a) As Pitch (p)=$\frac{2\pi mv\cos\theta}{qB}$ **0.5M**

Or, p= $\frac{2\ X\ 3.14\ X\ 1.7X10^{-27}X\ 2\ X10^{5}\ Cos\ 30^{0}}{1.6\ X10^{-19}X1.5}$**m**

Or, P=7.7X10^{-3}m **0.5M**

(b)As, done by magnetic field is always zero K.E=1/2mv^2 **0.5M**

KE=3.4 X 10^{-17}J **0.5M**

Ans.20 – (i) Nuclear fission –W 0.5M

Reason: As W has binding energy per nucleon less then Y and X and nucleus is larger in size. 0.5M

(ii) Nuclear fusion-Z 0.5M

Reason: As Z has binding energy per nucleon more then Y and X and nucleus is smaller in size. **0.5M**

Ans. 21 - $\frac{nh}{2\pi}$ = mvr (As Per Bohr’s Modal) ….(i) 0.5M

As Centripetal force is provided by gravity,

$\frac{mv^2}{r}=\frac{GMm}{r^2}$ 0.5M

Or, $V^2=\frac{GM}{r}$

From equation (i)

$V=\frac{nh}{2\pi mr}$

Or, $V^2=\{\frac{nh}{2\pi mr}\}^2$ 0.5M

or, $\frac{GM}{r}=\{\frac{nh}{2\pi mr}\}^2$

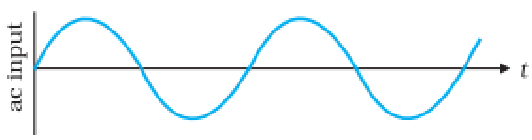
or, $r=\frac{n^2h^2}{4\pi^2m^2GM}$ 0.5M

[SECTION – C]

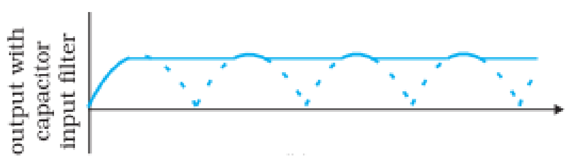
(3 Marks)

Ans.22 - (I) X = Full wave rectifier ½

Y = Filter ½

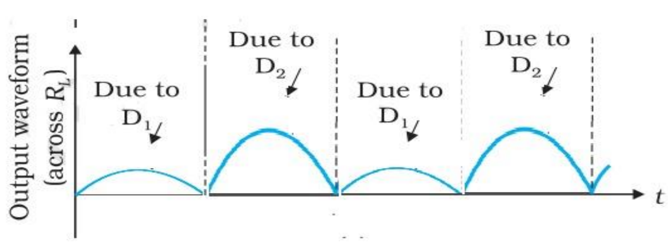


(Output Waveform for X) ½



(Output Waveform for Y) ½

(ii) 1



For VI Candidates

Rectifier 0.5M

Underlying principle of Rectifier

The basic principle of the rectifiers is the transformation of current by changing the frequency of the input signal, and diodes are used to do this. 0.5M

Working

In rectifier, one end of terminal which is connected to PN junction diode will never have negative potential, as it allows current in forward biasing only. Hence potential difference across load resistor will always be Positive or zero. 1M

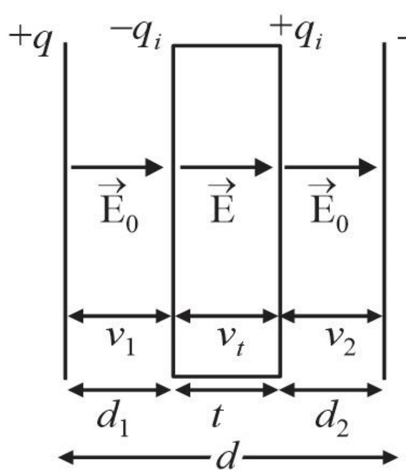
For 60 Hz input of AC, output of

Half wave rectifier will be 60Hz 0.5M

Full wave rectifier will be 120 Hz 0.5M

Ans.23 - (I) The capacitance of a parallel plate capacitor with dielectric slab (t < d)

(3 Marks)



0.5M

$+q, -q$ = the charges on the capacitor plates

$+q_i, -q_i$ = Induced charges on the faces of the dielectric slab

$E_0 \rightarrow$ electric field intensity in air between the plates

$E \rightarrow$ the reduced value of electric field intensity inside the dielectric slab.

When a dielectric slab of thickness $t < d$ is introduced between the two plates of the capacitor the electric field reduces to E due to the polarisation of the dielectric. The potential difference between the two plates is given by

$V = V_1 + V_t + V_2$

$V = E_0 d_1 + Et + E_0 d_2$ … (1) **0.5M**

Here E is the reduced value of electric field intensity

$\vec{E} = \vec{E}_0 + \vec{E}_i$. Here $\vec{E}_i$ is the electric field due to the induced charges [$+q_i$ and $-q_i$]

$E = \sqrt{E_0^2 + E_i^2 + 2E_0 E_i \cos 180°}$

$= \sqrt{(E_0 - E_i)^2}$

$E = E_0 - E_i$ **0.5M**

Also the dielectric constant K is given by

$$K = \frac{E_0}{E} \quad \text{... (2)}$$

$$E_0 = \frac{\sigma}{\varepsilon_0} = \frac{q}{A\varepsilon_0} \quad \text{... (3)}$$

From equations (1), (2) and (3)

$$V = E_0[d_1 + d_2] + \frac{E_0}{K}t$$

$$V = \frac{q}{A\varepsilon_0}\left[d - t + \frac{t}{K}\right] \quad \text{... (4)}$$

The capacitance of the capacitor on the introduction of the dielectric slab is

$$C = \frac{q}{V} \quad \text{... (5)}$$

From (4) and (5)

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$$ **0.5M**

If $t = d$, then $C = K\frac{\varepsilon_0 A}{d} \Rightarrow C = KC_0$ Here $C_0 = \frac{\varepsilon_0 A}{d}$

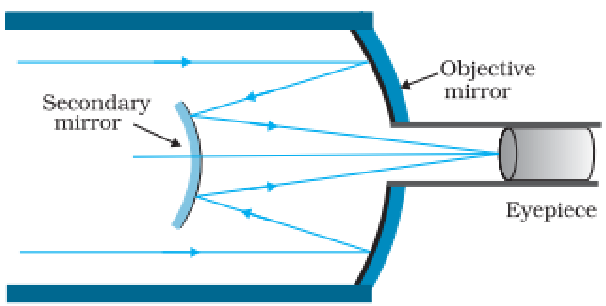
Since K > 1 therefore $C > C_0$

(II) For a metallic slab K is infinitely large, therefore $C = \frac{\varepsilon_0 A}{d - t}$ **1M**

(3 Marks)

Ans.24 - (i)

2



(ii) 1

- It has mirror objective, which is free from chromatic and spherical aberrations.
- It can gather more light as objectives can be made larger, hence images can be brighter.

Any other two equivalent examples can be accepted.

For V.I Candidates

Objective mirror,

Radius of curvature, R_1=200mm

Focal Length, $f_1=R_1/2$=100mm **0.5M**

Secondary Mirror,

Radius of curvature, R_1=150mm
Focal Length, $f_1=R_1/2$=75mm **0.5M**

Distance between two mirror, x=20mm
For object at infinity, image is formed by objective lens will act as virtual object for secondary mirror
U_2 =(100-20)mm=80mm **0.5M**
Applying, mirror formula for secondary mirror

$$\frac{1}{v_2} + \frac{1}{u_2} = \frac{1}{f_2}$$ **0.5M**

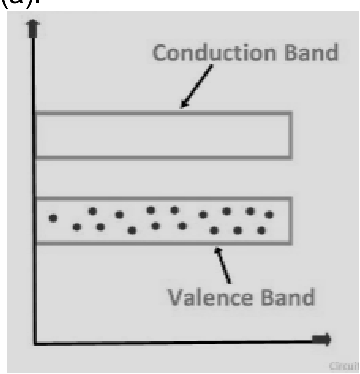
Or, $$\frac{1}{v_2} = \frac{1}{f_2} - \frac{1}{u_2}$$

$$= \frac{1}{75} - \frac{1}{80} = \frac{1}{1200}$$ **0.5M**

V_{2}=1200mm **0.5M**

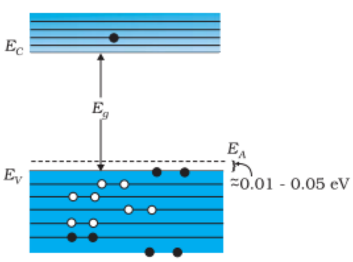
Ans.25 -

(a).



1M

(b) T = 0 K



1M

(ii) Answer will be (a) when switch is open **0.5M**
as when switch is closed diode will be forward biased and current will by-pass the bulb. **0.5M**

For V.I. Candidate

(i) A potential barrier is formed in a p-n junction due to the depletion layer, which is a layer of unmovable positive and negative charges that develops on either side of the junction. The depletion layer is created

when holes move towards electrons, causing a layer of electrons on the p-type side and a layer of holes on the n-type side. The potential difference across this region is called the barrier potential 2M

(ii)(a) In forward biasing width of depletion region decreases. 0.5M

(b) In reverse biasing width of depletion region increases. 0.5M

Ans.26 - **(3 Marks)**

Given

$B = 2\,T$, $q = 10mC$, $mass\ of\ the\ ball = 10^{-2}$kg , $g = 9.8\ {}^{m}/_{s^2}$

Magnetic force $(qvB\sin\theta) = gravitational\ force\ (mg)$

$$v = \frac{mg}{qB\sin\theta}$$ ½

For min. velocity $\sin\theta = 1$

$$v = \frac{mg}{qB\sin\theta} = v = \frac{mg}{qB}$$ ½

$$= \frac{10^{-2}\times 9.8}{10^{-2}\times 2}\text{ m/s}$$ ½

=4.9m/s

$$v = 4.9\ {}^{m}/_{s^2}$$ ½

As force is in upward direction so from Fleming's Left-hand rule, magnetic field will be along North to South. 1

(3 Marks)

Ans.27 - (I) Since the light ray enters perpendicular to the face AB, the angle of incidence on face AC will be 45°. **0.5M**

So,

$$\sin\theta_C = \frac{1}{n}$$

$sin\,45^\circ = \frac{1}{n} = \frac{1}{\sqrt{2}}$ So, $n = \sqrt{2}$ **0.5M**

(II) In fig. 2, the face AC of the prism is surrounded by a liquid so $n = \frac{ng}{n_l} = \frac{\sqrt{2}}{\left(\frac{2}{\sqrt{3}}\right)} = \frac{\sqrt{3}}{\sqrt{2}}$

$\sin\theta_C = \frac{1}{n} = \frac{\sqrt{2}}{\sqrt{3}}$ $\theta_C = sin^{-1}(\frac{\sqrt{2}}{\sqrt{3}}) = 54.6^\circ$

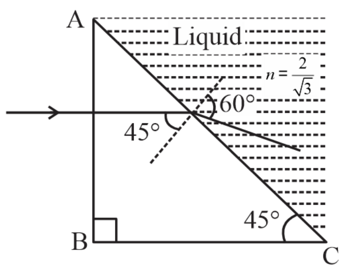
Since the angle of incidence on the surface AC is 45°, which is less than the critical angle for the pair of media (glass and the liquid), the ray neither undergoes grazing along surface AC, nor does it suffer total internal reflection **1M**

Instead it passes through the surface AC and undergoes refraction into the liquid.

For refracting interface AC, $n_1 \sin i = n_2 \sin r$

$n_1 . sin45^\circ = \left(\frac{2}{\sqrt{3}}\right) sin\, r$

$sin\, r = \frac{\sqrt{3}}{2}$ $\therefore\ r = 60^\circ$.



1M

(3 Marks)

For V.I. candidates

(a) Let the angle of incidence of light at prism, I = x

So, angle of emergence as per question, e = x

Angle of prism, A = $\frac{4}{3}x$ **0.5M**

Since prism Is equilateral

3A=180^0 **0.5M**

Or, A= 60^0

Or, X=45^0

From prism formulae δ

δ= i+e-A **0.5M**

or, δ=45+45-60=30^0 **0.5M**

(b) $\mu = \frac{sin\frac{A+\delta m}{2}}{sin\frac{A}{2}}$ **0.5M**

Or, $\mu = \frac{sin\frac{60+30}{2}}{sin\frac{60}{2}}$

Or, $\mu = \sqrt{2}$ **0.5M**

Ans.28 – (I) Gauss's theorem: The flux of electric field through any closed surface is $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface.

$\phi = \frac{q}{\varepsilon_0}$ … (1)

By definition, the total electric flux through the closed surface is given by

$\phi = \oint \vec{E}.\overrightarrow{ds}$ … (2)

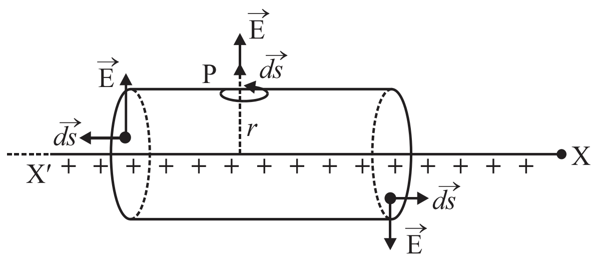
∴ From (1) and (2), Gauss's theorem may be expressed as follows

$\phi = \oint \vec{E}.\overrightarrow{ds} = \frac{q}{\varepsilon_0}$

∴ The surface integral of electric field over a closed surface is equal to $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface. **1M**

Application of Gauss's theorem

To find electric field due to a line charge let us consider an infinitely long line charge placed along XX' axis with linear charge density λ. Our aim is to find electric field intensity at a point P distant *r* from the line charge. We draw a cylindrical surface of radius *r* and length *l* coaxial with the line charge. The net flux through the cylindrical gaussian surface i.e.



0.5M

$\phi = \oint \vec{E}.\vec{ds} = \int_{LCF} \vec{E}.\vec{ds} + \int_{CS} \vec{E}.\vec{ds} + \int_{RCF} \vec{E}.\vec{ds}$ **0.5M**

$= \int_{LCF} Eds\cos 90° + \int_{CS} Eds\cos 0° + \int_{RCF} Eds\cos 90°$ **0.5M**

$\phi = \int_{CS} Eds\cos 0° = E.2\pi rl$ … (1)

The charge enclosed by the gaussian surface is $q = \lambda l$ … (2)

Using Gauss's theorem from equations (1) and (2)

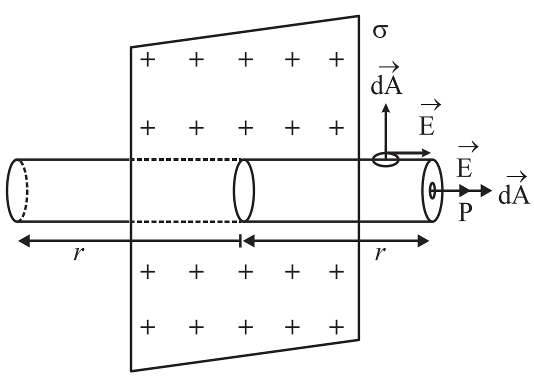
$E(2\pi rl) = \frac{\lambda l}{\varepsilon_0} \Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 r}$ **0.5M**

OR

(II) (a) Definition of electric flux and its SI unit **1M**

(b) Electric field due to an infinite plane sheet of charge.

Let us consider an infinite thin plane sheet of positive charge having a uniform surface charge density σ. Let P be the point where electric field E is to be found. Let us imagine a cylindrical gaussian surface of length 2*r* and containing P as shown. The net flux through the cylindrical gaussian surface.



0.5M

$\phi = \oint \vec{E} \cdot \vec{dA}$

$= \int_{RCF} \vec{E} \cdot \vec{dA} + \int_{LCF} \vec{E} \cdot \vec{dA} + \int_{CS} \vec{E} \cdot \vec{dA}$ **0.5M**

$$= \int_{RCF} EdA\cos 0° + \int_{LCF} EdA\cos 0° + \int_{CS} EdA\cos 90°$$ **0.5M**

= E A + EA + 0

ϕ = 2 EA ... (1)

Here A is the area of cross-section of each circular face *i.e.* LCF and RCF.

The total charge enclosed by the gaussian cylinder

= σA ... (2) **0.5M**

Using Gauss's theorem, from (1) and (2),

$$2\,EA = \frac{\sigma A}{\varepsilon_0}$$

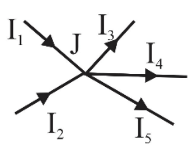
$$E = \frac{\sigma}{2\varepsilon_0}$$

Ans.29 - I (A) II (C) III (D) IV (C) 0R IV (B) **(4X1=4)**

Ans.30 - I (D) II (C) III (A) IV (B) 0R IV (A) **(4X1=4)**

(5 Marks)

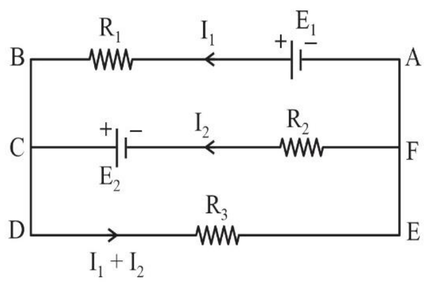
Ans.31 – (I) (a) Kirchhoff's I Law : The algebraic sum of all the currents meeting at a point in an electrical circuit is always equal to zero. **1M**



$[+I_1] + [+I_2] + [–I_3] +[–I_4] + [– I_5] = 0$

Or $I_1 + I_2 = I_3 + I_4 + I_5$

Kirchhoff's II Law : The algebraic sum of the changes in potential around any closed resistor loop must be zero. **1M**



For closed mesh ABCFA

$[+E_1] [– I_1R_1] + [–E_2] + [+I_2R] = 0$ … (1)

For closed mesh FCDEF

$[+E_2] + [-(I_1+I_2)]R_3 + [–I_2R_2] = 0$ … (2)

(b). $I = \frac{\varepsilon}{R_0 + r}$ $\quad Where\ R_0\ is\ resistor\ at\ room\ tempere\ 20^0$ ½

$\Rightarrow R_0 = \frac{\varepsilon}{I}$ -1

OR $R_0 = \frac{100}{10}$ -1 = $R_0 = 9\Omega$ ½

Now Final temperature is 320^0C

So, $R = R_0\,(1 + \alpha\Delta T)$ ½

= 9 ($(1 + 3.7 \times 10^{-4} \times 300)$

= 10 Ohm ½

Power Consumed by cell $(P) = i^2 r$ ½

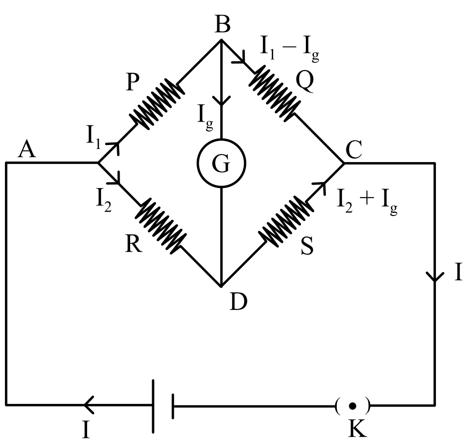
= $(\frac{\varepsilon}{R_0 + r})^2 \times r \quad Watt$

= $(\frac{100}{11})^2$ = 82.64 W ½

OR

(II) (a) The Wheatstone bridge is as shown in the figure

1M



0.5M

Applying Kirchhoff's II law to mesh ABDA

$I_1P + I_gG - I_2R = 0$ .....(1) **0.5M**

For the mesh BCDB

$(I_1 - I_g)Q + [-(I_2 + I_g)S] + [-I_gG] = 0$ (2) **0.5M**

When the bridge is balanced, no current flows through the galvanometer

i.e. $Ig = 0$ (3)

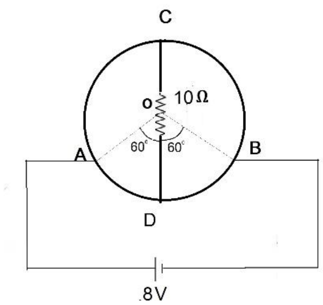
∴ From equations (1) and (2) and (3)

$I_1P = I_2R$ … (4)

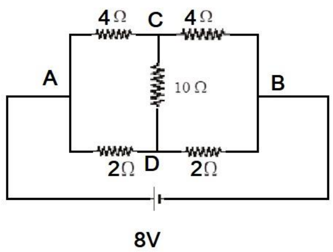
$I_1Q = I_2S$ … (5)

From equations (4) and (5) , P/Q = R/S. **0.5M**

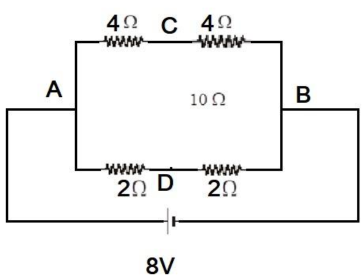
(b).



This circuit is balanced wheat stone bridge that can be drawn as below,



As it is balanced wheatston bridge ,so circuit will be as below 1



$V_{AB} = 8V\text{ , }hence\ Current\ through\ ADB = \frac{8}{4} = 2A$ 1

(for V.I. Candidates)

(II) (a) question is same

(b) The sensitivity of a Wheatstone bridge is the amount of deflection in the attached galvanometer for every unit change in the unknown resistance **1M**

A Wheatstone bridge is most sensitive when its four arms have resistances that are of the same order of magnitude. This means that all four resistors provide the same output resistance. A Wheatstone bridge is in a balanced state when its voltmeter shows zero deflection **1M**

Ans.32 - (I) AC Generat **(5 Marks)**

It is a device used to convert mechanical energy into electrical energy

Principle: It is based on the principle of electromagnetic induction. When a closed coil is rotated rapidly in a strong magnetic field, the magnetic flux linked with the coil changes continuously. Hence an emf is induced in the coil and a current flows in it. In fact, the mechanical energy expended in rotating the coil appears as electrical energy in the coil.

1M

Construction: Main Parts **1M**

1. **Armature**: It is a rectangular coil ABCD having a large number of turns of insulated copper wire wound on a soft-iron core. The use of soft-iron core increases the magnetic flux linked with the armature.

2. **Field Magnet:** It a strong electromagnet having concave pole pieces N and S. The armature is rotated between these pole pieces about an axis perpendicular to the magnetic field.

3. **Slip Rings:** The leads from the armature coil ABCD are connected to two copper rings R_1 and R_2 called the 'slip rings'. These rings are concentric with the axis of the armature coil and rotate with it.

4. **Brushes:** These are two carbon pieces B_1 and B_2 called brushes which remain stationary pressing against the slip rings R_1 and R_2 respectively. The brushes are connected to an external circuit.

Working Theory : When the coil ABCD is rotated inside the field, an emf is induced between its two ends. Let the plane of the coil be at right angles to the magnetic field at $t = 0$ and angular speed of the rotation of the coil be ω. Then at time t, $\theta = \omega t$. The magnetic flux linked with the coil at time t is

$$\phi = n\,BA\cos\omega t$$

Induced emf $e = \frac{-d\phi}{dt} = \frac{-d}{dt}[nBA\cos\omega t]$

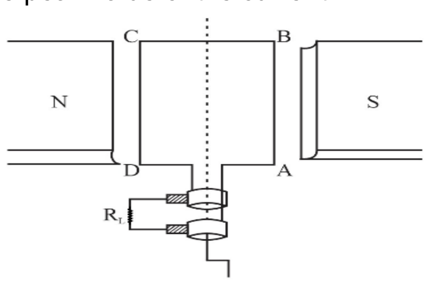
$\Rightarrow e = n\,BA\,\omega\sin\omega t$

$e = e_0\sin\omega t$ Where $e_0 = nBA\omega$ is the peak value of emf.

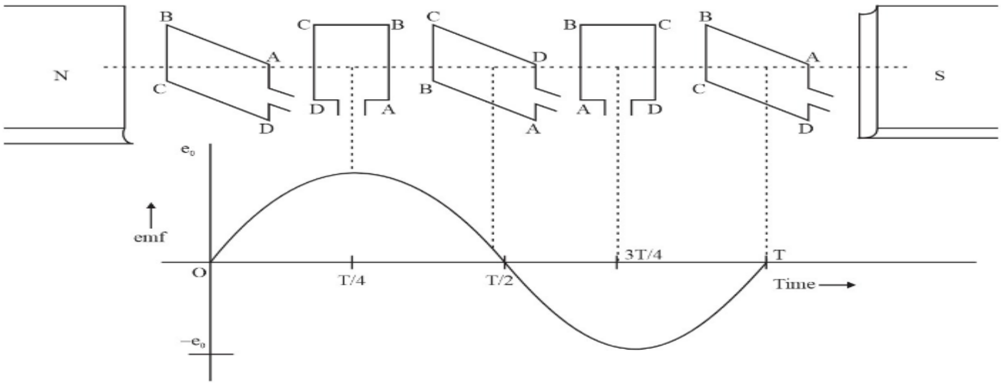
The current in the external load is given by

$$i = \frac{e_0\sin\omega t}{R_L}$$

$i = i_0\sin\omega t$ Here i_0 is the peak value of the current **1M**



1M



1M

In an ac generator the source of electrical energy is the mechanical energy.

OR

(II)

(a)TRANSFORMER

Use: It is a device which converts low ac voltage at high current into high ac voltage at low current and vice – versa.

Principle: It consists of two coils P and S wound on a closed soft iron core. The coil which is fed from the ac supply is called primary coil (P) and the other connected to the load is called secondary coil (S). The core of the transformer is made of soft -iron to reduce hysteresis loss and is laminated to reduce eddy current losses. **1M**

Working: When an alternating emf e_p is impressed on the primary winding it sends an ac current through it which sets up an alternating magnetic flux in the core. This induces an alternating emf e_s in the secondary. If N_P and N_s are the number of turns in primary and secondary coil, their linkages with the flux are

$\phi_P = N_P BA$ B → Magnetic induction

$\phi_S = N_s BA$ A → Area of cross section **0.5 M**

The magnitude of the emf induced in the secondary

$$e_s = \frac{d\phi_S}{dt} = N_S A \frac{dB}{dt} \quad \ldots (1)$$

The changing flux also induces an emf in the primary, whose magnitude

$$e_P = \frac{d\phi_P}{dt} = N_P A \frac{dB}{dt} \quad \ldots (2)$$

From equations (1) and (2)

$$\frac{\text{emf induced in secondary}}{\text{voltage applied to primary}} = \frac{e_s}{e_P} = \frac{N_s}{N_P} \quad \ldots (3)$$ **0.5 M**

$\frac{N_S}{N_P}$ = turns ratio or transformation ratio.

If $N_s > N_P$, $e_S > e_P$ → Such a transformer is called step-up transformer

If $N_S < N_P$, $e_s < e_P$ → Such a transformer is called step-down transformer

In an ideal transformer

Instantaneous output power = instantaneous input power

$e_s i_s = e_P i_P$ … (4)

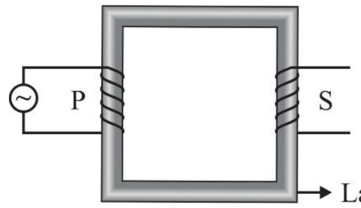
From equations (3) and (4)

$\frac{e_s}{e_p} = \frac{i_p}{i_s} = \frac{N_s}{N_p}$ **0.5 M**

In a step- up transformer $N_s > N_p$, $e_s > e_p$ but $i_s < i_p$

In a step-down transformer $N_s < N_p$, $e_s < e_p$ but $i_s > i_p$

At the generating station a step-up transformer is used for stepping up the voltage and at the various receiving substations a step-down transformer is used



0.5M

(b) The two sources of energy losses are eddy current losses and flux leakage losses. **1M**

(c) There is no violation of the principle of the conservation of energy in a step up transformer. When output voltage increases the output current decreases automatically keeping the power the same. **1M**

(5 Marks)

Ans.33 – (I) Given f_0=15m, f_e=1cm=0.01m

(i) Angular magnification of the telescope M = $\frac{f_0}{f_e}=\frac{15}{0.01}$=1500 **1M**

(ii) Let d be the diameter of moon's image formed by the objective lens.

Therefore, Angle subtended by the moon at the objective lens

$\alpha = \frac{diameter\ of\ the\ moon}{Radius\ of\ lunar\ orbit} = \frac{3.48\times10^6}{3.8\times10^8} \quad (1)$ **1.5M**

Similarly, the angle subtended by moon's image (formed by the objective) at the objective

$\alpha = \frac{diameter\ of\ moon's\ image}{f_0} = \frac{d}{15}$ (2) **1.5M**

Comparing equations (1) and (2) we have

$\frac{d}{15} = \frac{3.48\times10^6}{3.8\times10^8}$

$d = \frac{3.48\times10^6}{3.8\times10^8} \times 15$=0.137m=13.7cm **1M**

OR

(II) (a) For eyepiece, v_e = -25cm, f_e= 6.25cm, u_e= ?

Using $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{6.25} = \frac{-1}{5}$ **0.5M**

u_e = - 5cm **0.5M**

Therefore the image formed by the objective is formed at a distance of 10 cm towards the eyepiece.

Hence for the objective, v_0 = +10 cm, f_0 = 2 cm, v_0 = ?

$$\frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{10} - \frac{1}{2}$$ **0.5M**

u_0 = - 2.5 cm **0.5M**

Therefore the magnifying power M = $\frac{v_0}{|u_0|}(1+\frac{D}{f_e}) = \frac{10}{2.5}(1+\frac{25}{6.25})$ = 20 **0.5M**

(b) When the final image is formed at infinity the object for the eyepiece must lie at its principal focus. Therefore the distance of the image formed by the objective from its optical center,

v_0 = 15-6.25 = 8.75 cm **0.5M**

$$\frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{8.75} - \frac{1}{2} = \frac{6.75}{17.50}$$ **0.5M**

$u_0 = \frac{-17.5}{6.75}$ = - 2.6 cm **0.5M**

M = $\frac{v_0}{|u_0|}.\frac{D}{f_e} = \frac{8.75}{2.6} \times \frac{25}{6.25}$ = 13.5 **1M**