PHYSICS (Theory)

Time allowed : 3 hours *Maximum Marks : 70*

General Instructions:

(i) All questions are compulsory.

(ii) There are 30 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.

(iii) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the choice in such questions.

(iv) Use of calculators is **not** permitted.

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

$c = 3 \times 10^8\ \text{ms}^{-1}$

$h = 6.626 \times 10^{-34}$ Js

$e = 1.602 \times 10^{-19}$ C

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

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

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

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

Boltzmann's constant $k = 1.381 \times 10^{-23}\ \text{JK}^{-1}$

Avogadro's number $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

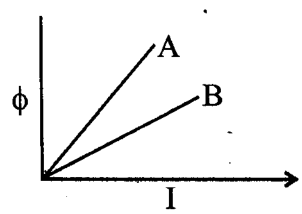
Radius of earth = 6400 km

QUESTION PAPER CODE 51/1/1

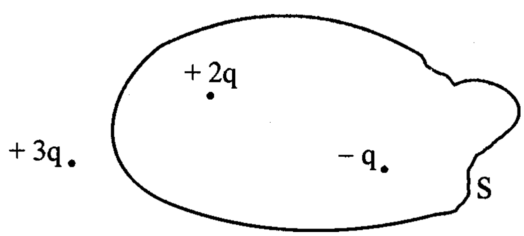
1. In which orientation, a dipole placed in a uniform electric field is in (i) stable, (ii) unstable equilibrium ? 1

2. Which part of electromagnetic spectrum has largest penetrating power ? 1

3. A plot of magnetic flux (ϕ) versus current (I) is shown in the figure for two inductors A and B. Which of the two has larger value of self inductance ? 1



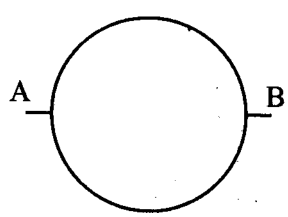
4. Figure shows three point charges, + 2q, – q and + 3q. Two charges + 2q and – q are enclosed within a surface 'S'. What is the electric flux due to this configuration through the surface 'S' ? 1



5. A glass lens of refractive index 1.45 disappears when immersed in a liquid. What is the value of refractive index of the liquid ? 1

6. What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atom ? 1

7. A wire of resistance 8R is bent in the form of a circle. What is the effective resistance between the ends of a diameter AB ? 1



8. State the conditions for the phenomenon of total internal reflection to occur. 1

9. Explain the function of a repeater in a communication system. 2

10. (i) Write two characteristics of a material used for making permanent magnets. 2

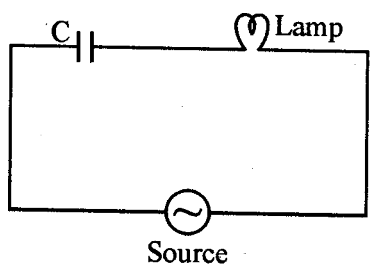
(ii) Why is core of an electromagnet made of ferromagnetic materials ?

OR

Draw magnetic field lines when a (i) diamagnetic, (ii) paramagnetic substance is placed in an external magnetic field. Which magnetic property distinguishes this behaviour of the field lines due to the two substances ?

11. Draw the circuit diagram of an illuminated photodiode in reverse bias. How is photodiode used to measure light intensity ? 2

12. An electric lamp having coil of negligible inductance connected in series with a capacitor and an AC source is glowing with certain brightness. How does the brightness of the lamp change on reducing the (i) capacitance, and (ii) the frequency ? Justify your answer. 2



13. Arrange the following electromagnetic radiations in ascending order of their frequencies : 2

(i) Microwave

(ii) Radio wave

(iii) X-rays

(iv) Gamma rays

Write two uses of any one of these.

14. The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If focal length of the lens is 12 cm, find the refractive index of the material of the lens. 2

15. An electron is accelerated through a potential difference of 100 volts. What is the de-Broglie wavelength associated with it ? To which part of the electromagnetic spectrum does this value of wavelength correspond ? 2

16. A heavy nucleus X of mass number 240 and binding energy per nucleon 7.6 MeV is split into two fragments Y and Z of mass numbers 110 and 130. The binding energy of nucleons in Y and Z is 8.5 MeV per nucleon. Calculate the energy Q released per fission in MeV. 2

17. (a) The bluish colour predominates in clear sky. 2

(b) Violet colour is seen at the bottom of the spectrum when white light is dispersed by a prism.

State reasons to explain these observations.

18. Plot a graph showing the variation of stopping potential with the frequency of incident radiation for two different photosensitive materials having work functions W_1 and W_2 ($W_1 > W_2$). On what factors does the (i) slope and (ii) intercept of the lines depend ? 2

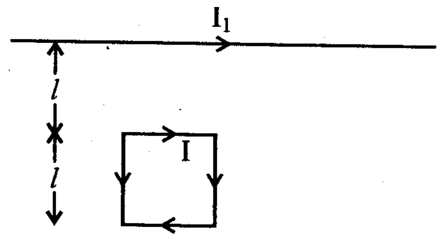
19. A parallel plate capacitor is charged by a battery. After sometime the battery is disconnected and a dielectric slab with its thickness equal to the plate separation is inserted between the plates. How will (i) the capacitance of the capacitor, (ii) potential difference between the plates and (iii) the energy stored in the capacitor be affected ?

Justify your answer in each case. 3

20. Write the principle of working of a potentiometer. Describe briefly, with the help of a circuit diagram, how a potentiometer is used to determine the internal resistance of a given cell. 3

21. Write the expression for the magnetic moment ($\vec{m}$) due to a planar square loop of side '*l*' carrying a steady current I in a vector form.

In the given figure this loop is placed in a horizontal plane near a long straight conductor carrying a steady current I_1 at a distance l as shown. Give reasons to explain that the loop will experience a net force but no torque. Write the expression for this force acting on the loop. 3



22. (a) Depict the equipotential surfaces for a system of two identical positive point charges placed a distance 'd' apart.

    (b) Deduce the expression for the potential energy of a system of two point charges q_1 and q_2 brought from infinity to the points $\vec{r}_1$ and $\vec{r}_1$ respectively in the presence of external electric field $\vec{E}$. 3

23. What is an unpolarized light ? Explain with the help of suitable ray diagram how an unpolarized light can be polarized by reflection from a transparent medium. Write the expression for Brewster angle in terms of the refractive index of denser medium. 3

24. (i) Define 'activity' of a radioactive material and write its S.I. unit.

    (ii) Plot a graph showing variation of activity of a given radioactive sample with time.

    (iii) The sequence of stepwise decay of a radioactive nucleus is

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta} D_2$$

If the atomic number and mass number of D_2 are 71 and 176 respectively, what are their corresponding values for D ? 3

25. A long straight wire of a circular cross-section of radius 'a' carries a steady current 'I'. The current is uniformly distributed across the cross-section. Apply Ampere's circuital law to calculate the magnetic field at a point 'r' in the region for (i) $r < a$ and (ii) $r > a$. 3

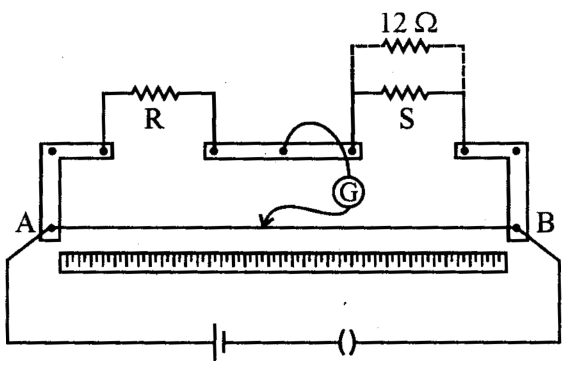
OR

State the underlying principle of working of a moving coil galvanometer. Write two reasons why a galvanometer can not be used as such to measure current in a given circuit. Name any two factors on which the current sensitivity of a galvanometer depends.

26. What is space wave propagation ? Give two examples of communication system which use space wave mode.

A TV tower is 80 m tall. Calculate the maximum distance upto which the signal transmitted from the tower can be received. 3

27. In a meter bridge, the null point is found at a distance of 40 cm from A. If a resistance of 12 Ω is connected in parallel with S, the null point occurs at 50.0 cm from A. Determine the values of R and S.



28. Describe briefly, with the help of a labelled diagram, the basic elements of an A.C. generator. State its underlying principle. Show diagrammatically how an alternating emf is generated by a loop of wire rotating in a magnetic field. Write the expression for the instantaneous value of the emf induced in the rotating loop. 5

OR

A series LCR circuit is connected to an ac source having voltage $\nu = \nu_m \sin \omega t$. Derive the expression for the instantaneous current I and its phase relationship to the applied voltage.

Obtain the condition for resonance to occur. Define 'power factor'. State the conditions under which it is (i) maximum and (ii) minimum.

29. State Huygens's principle. Show, with the help of a, suitable diagram, how this principle is used to obtain the diffraction pattern by a single slit.

Draw a plot of intensity distribution and explain clearly why the secondary maxima become weaker with increasing order (n) of the secondary maxima. 5

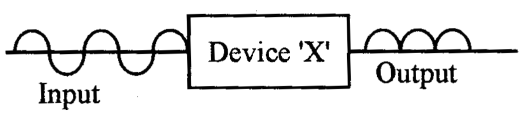
OR

Draw a ray diagram to show the working of a compound microscope. Deduce an expression for the total magnification when the final image is formed at the near point.

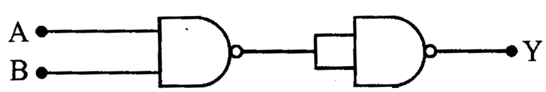
In a compound microscope, an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eye piece has a focal length of 5 cm and the final image is formed at the near point, estimate the magnifying power of the microscope.

30. (a) Explain the formation of depletion layer and potential barrier in a p-n junction.

(b) In the figure given below the input waveform is converted into the output waveform by a device 'X'. Name the device and draw its circuit diagram.



(c) Identify the logic gate represented by the circuit as shown and write its truth table. 5



OR

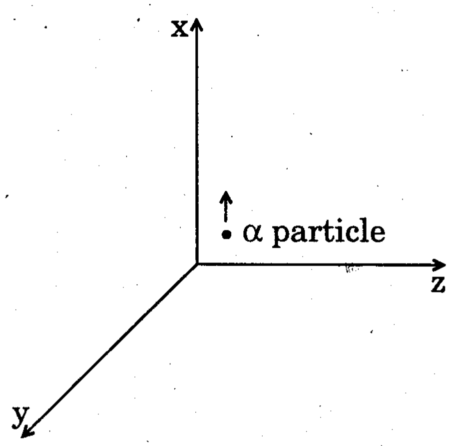
(a) With the help of the circuit diagram explain the working principle of a transistor amplifier as an oscillator.

(b) Distinguish between a conductor, a semiconductor and an insulator on the basis of energy band diagrams.

QUESTION PAPER CODE 51/1

1. Name the physical quantity whose S.I. unit is JC^{-1}. Is it a scalar or a vector quantity ? 1

2. A beam of a particles projected along + x-axis, experiences a force due to a magnetic field along the + y-axis. What is the direction of the magnetic field ? 1



3. Define self-inductance of a coil. Write its S.I. unit. 1

4. A converging lens is kept coaxially in contact with a diverging lens – both the lenses being of equal focal lengths. What is the focal length of the combination ? 1

5. Define ionisation energy. What is its value for a hydrogen atom ? 1

6. Two conducting wires X and Y of same diameter but different materials are joined in series across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires. 1

7. Name the part of electromagnetic spectrum whose wavelength lies in the range of 10^{-10} m. Give its one use. 1

8. When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a decrease in the energy carried by the light wave ? Justify your answer. 1

9. Deduce the expression for the magnetic dipole moment of an electron orbiting around the central nucleus. 2

10. A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge 'Q'. A charge 'q' is placed at the centre of the shell.

   (a) What is the surface charge density on the (i) inner surface, (ii) outer surface of the shell ?

   (b) Write the expression for the electric field at a point $x > r_2$ from the centre of the shell. 2

11. Draw a sketch of a plane electromagnetic wave propagating along the z-direction. Depict clearly the directions of electric and magnetic fields varying sinusoidally with z. 2

12. Show that the electric field at the surface of a charged conductor is given by

   $\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$, where σ is the surface charge density and $\hat{n}$ is a unit vector normal to the surface in the outward direction. 2

13. Two identical loops, one of copper and the other of aluminium, are rotated with the same angular speed in the same magnetic field. Compare (i) the induced emf and (ii) the current produced in the two coils. Justify your answer. 2

14. An α-particle and a proton are accelerated from rest by the same potential. Find the ratio of their de Broglie wavelengths. 2

15. Write two factors justifying the need of modulating a signal.

   A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75% ? 2

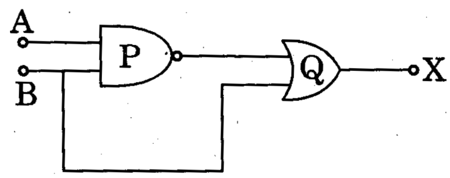
16. Write Einstein's photoelectric equation. State clearly the three salient features observed in photoelectric effect, which can be explained on the basis of the above equation. 2

17. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces. 2

OR

Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei, $2 \leqslant A \leqslant 240$. How do you explain the constancy of binding energy per nucleon in the range $30 < A < 170$ using the property that nuclear force is short-ranged ? 2

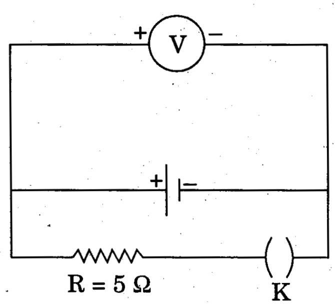
18. (i) Identify the logic gates marked P and Q in the given logic circuit.



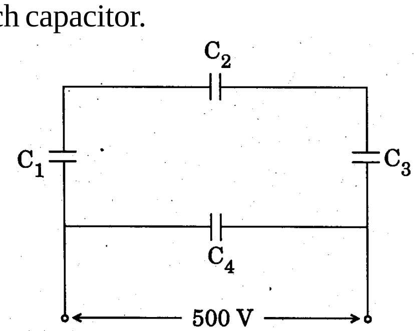
(ii) Write down the output at X for the inputs A = 0, B = 0 and A = 1, B = 1. 2

19. Which mode of propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz ? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode ? 3

20. Write any two factors on which internal resistance of a cell depends. The reading on a high resistance voltmeter, when a cell is connected across it, is 2.2 V. When the terminals of the cell are also connected to a resistance of 5 Ω as shown in the circuit, the voltmeter reading drops to 1.8 V. Find the internal resistance of the cell. 3



21. A network of four capacitors each of 12 μF capacitance is connected to a 500 V supply as shown in the figure. Determine (a) equivalent capacitance of the network and (b) charge on each capacitor. 5



22. (i) Draw a neat labelled ray diagram of an astronomical telescope in normal adjustment. Explain briefly its working.

(ii) An astronomical telescope uses two lenses of powers 10 D and 1 D. What is its magnifying power in normal adjustment ? 3

OR

(i) Draw a neat labelled ray diagram of a compound microscope. Explain briefly its working.

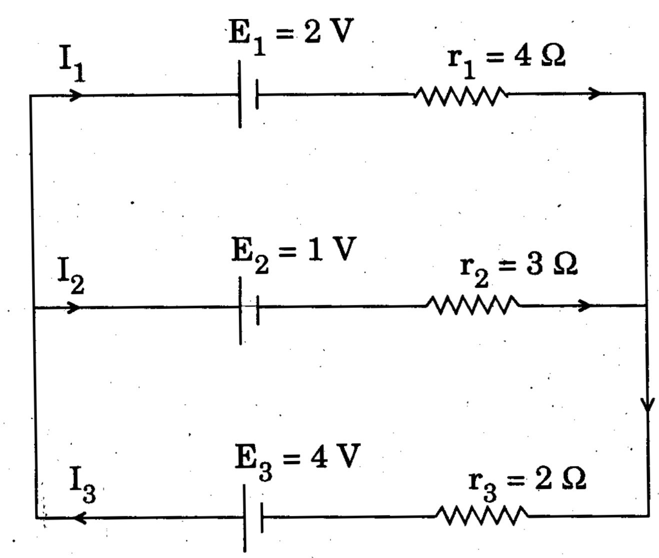
(ii) Why must both the objective and the eye-piece of a compound microscope have short focal lengths ? 3

23. In Young's double slit experiment, the two slits 0.15 mm apart are illuminated by monochromatic light of wavelength 450 nm. The screen is 1.0 m away from the slits.

(a) Find the distance of the second (i) bright fringe, (ii) dark fringe from the central maximum.

(b) How will the fringe pattern change if the screen is moved away from the slits ? 3

24. State Kirchhoff's rules. Use these rules to write the expressions for the currents I_1, I_2 and I_3 in the circuit diagram shown. 3



25. (a) Write symbolically the β^- decay process of $^{32}_{15}$P.

(b) Derive an expression for the average life of a radionuclide. Give its relationship with the half-life. 3

26. How does an unpolarised light get polarised when passed through a polaroid ?

Two polaroids are set in crossed positions. A third polaroid is placed between the two making an angle θ with the pass axis of the first polaroid. Write the expression for the intensity of light transmitted from the second polaroid. In what orientations will the transmitted intensity be (i) minimum and (ii) maximum ? 3

27. An illuminated object and a screen are placed 90 cm apart. Determine the focal length and nature of the lens required to produce a clear image on the screen, twice the size of the object. 3

28. (a) With the help of a diagram, explain the principle and working of a moving coil galvanometer.

(b) What is the importance of a radial magnetic field and how is it produced ?

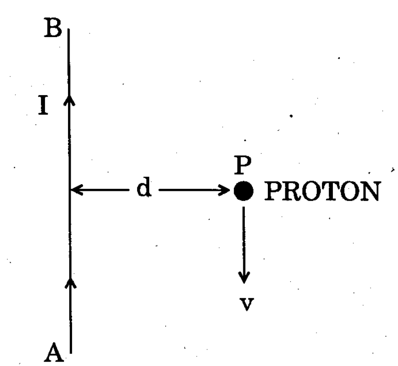
(c) Why is it that while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used ? 5

OR

(a) Derive an expression for the force between two long parallel current carrying conductors.

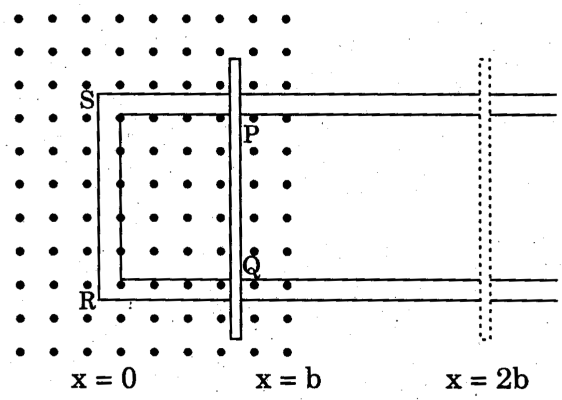
(b) Use this expression to define S.I. unit of current.

(c) A long straight wire AB carries a current I. A proton P travels with a speed v, parallel to the wire, at a distance d from it in a direction opposite to the current as shown in the figure. What is the force experienced by the proton and what is its direction ? 5



29. State Faraday's law of electromagnetic induction.

Figure shows a rectangular conductor PQRS in which the conductor PQ is free to move in a uniform magnetic field B perpendicular to the plane of the paper. The field extends from $x = 0$ to $x = b$ and is zero for $x > b$. Assume that only the arm PQ possesses resistance r. When the arm PQ is pulled outward from $x = 0$ to $x = 2b$ and is then moved backward to $x = 0$ with constant speed v, obtain the expressions for the flux and the induced emf. Sketch the variations of these quantities with distance $0 \leqslant x \leqslant 2b$. 5



OR

Draw a schematic diagram of a step-up transformer. Explain its working principle. Deduce the expression for the secondary to primary voltage in terms of the number of turns in the two coils. In an ideal transformer, how is this ratio related to the currents in the two coils ?

How is the transformer used in large scale transmission and distribution of electrical energy over long distances ? 5

30. (a) Draw the circuit diagrams of a p-n junction diode in (i) forward bias, (ii) reverse bias. How are these circuits used to study the V - I characteristics of a silicon diode ? Draw the typical V - I characteristics.

(b) What is a light emitting diode (LED) ? Mention two important advantages of LEDs over conventional lamps. 5

OR

(a) Draw the circuit arrangement for studying the input and output characteristics of an n-p-n transistor in CE configuration. With the help of these characteristics define (i) input resistance, (ii) current amplification factor.

(b) Describe briefly with the help of a circuit diagram how an n-p-n transistor is used to produce self-sustained oscillations. 5

Marking Scheme ó Physics (Theory)

General Instructions :

1. The Marking Scheme provides general guidelines to reduce subjectivity in the marking. The answers given in the marking scheme are suggested answers. The content is thus indicative. If a student has given any other answer, which is different from the one given in the Marking Scheme, but conveys the meaning correctly, such answers should be given full weightage.

2. Evaluation is to be done as per instructions provided in the marking scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed.

3. If a question has parts, please award marks in the right hand side for each part. Marks awarded for different part of the question should then be totalled up and written in the left hand margin and circled.

4. If a question does not have any parts, marks are be awarded in the left hand margin only.

5. If a candidate has attempted an extra question, marks obtained in the question attempted first should be retained and the other answer should be scored out.

6. No marks are to be deducted for the cumulative effect of an error. The student should be penalized only once.

7. Deduct ½ mark for writing wrong units, or missing units, in the final answer to numerical problems.

8. Formula can be taken as implied from the calculations even if not explicitly written.

9. In short answer type questions, asking for two features/characteristics/ properties, if a candidate writes three features/characteristics/properties or more, only the first two should be evaluated.

10. Full marks should be awarded to a candidate if his/her answer in a numerical problem, is close to the value given in this scheme.

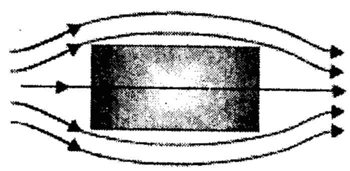
QUESTION PAPER CODE 55/1/1

Q. No.	Expected Answer/value Points	Marks	Total Marks
1.	When dipole is (i) parallel to field (ii) antiparallel to the field (or correct fig of two cases.)	½ +½	1
2.	γ Rays.	1	1
3.	Line A	1	1
4.	Electric flux $\phi = \frac{q}{\varepsilon_0}$	1	1
5.	1.45	1	1
6.	$r \propto n^2 \therefore \frac{r_1}{r_2} = 4:1$ (award ½ mark if student writes only formula)	1	1
7.	$R_{effective} = 2R$	1	1
8.	(i) Refraction should take place from denser to rarer medium (ii) Angle of incidence should be greater than the critical angle.	½+½	1
9.	Function of repeater — 2		
	A repeater, picks up the signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in carrier frequency. Repeaters are used to extend the range of a communication system.	2	2
10.	Two characteristics of material — ½+½ Reason — 1		
	(i) (a) High Coercivity (b) High Retentivity (c) High Permeability. (any two)	½+½	
	(ii) Because of high permeability and low retentivity.	½+½	2

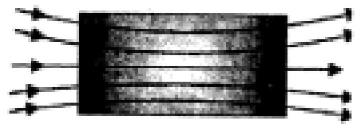
OR

Drawing of magnetic field lines	½+½
Property to distinguish the behaviour	1

(i) Diamagnetic material ½



(ii) Paramagnetic material ½



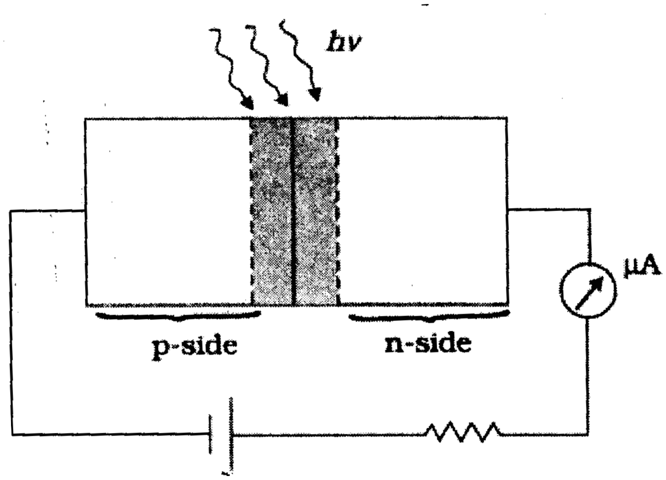
Paramagnetic substance: permeability slightly greater than one/susceptibility small but positive.

Diamagnetic substance: permeability very slightly less than one/susceptibility very small but negative. ½+½ 2

11.

Circuit diagram	1
Explanation for measurement of light intensity	1

Circuit diagram of an illuminated photodiode:



1

Explanation:

The magnitude of the photo current depends on the intensity of incident light (photo current is proportional to incident light intensity). Thus photo diode can be used to measure light intensity. 1 2

12.

Effect of change in capacitance	1
Effect of change in frequency	1

(i) $X_c = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$ ½

As C decreases, Xc will increase. Hence brightness will decrease. ½

(ii) $X_c = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$ ½

As frequence (ν) decreases, Xc will increase. Hence brightness will decrease. ½ 2

13.

Arrangement in ascending order of frequency	1
Two uses of any one	½+½

Radio waves < Microwaves < X-rays < Gamma rays 1

Two uses of any one of these. ½+½

14.

Formula	1
Substitution and calculation	1

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

$$\frac{1}{12} = (\mu - 1)\left(\frac{1}{10} - \frac{1}{-15}\right) \Rightarrow \mu = 1.5$$ ½+½ 2

15.

Formula	1
Calculation of wavelength	½
Name of the part of spectrum	½

$\lambda = \frac{h}{\sqrt{2meV}}$ or $\lambda = \frac{12.27}{\sqrt{V}} \mathring{A}$ 1

$\lambda = \frac{12.27}{\sqrt{100}} \mathring{A} = 12.27 \mathring{A}$ ½

This wavelength corresponds to the **X rays**. ½ 2

16.

Reaction	1
Calculation of energy released	1

X^{240} $y^{110} + Z^{130} + Q$ 1

Energy released per nucleon = 8.5 MeV - 7.6 MeV = 0.9 MeV
Therefore energy released= 0.9 × 240 MeV = 216 MeV 1 2

Alternatively:

Energy released = [240 × 8.5 – 7.6 (110+130)] MeV = 216 MeV

17.

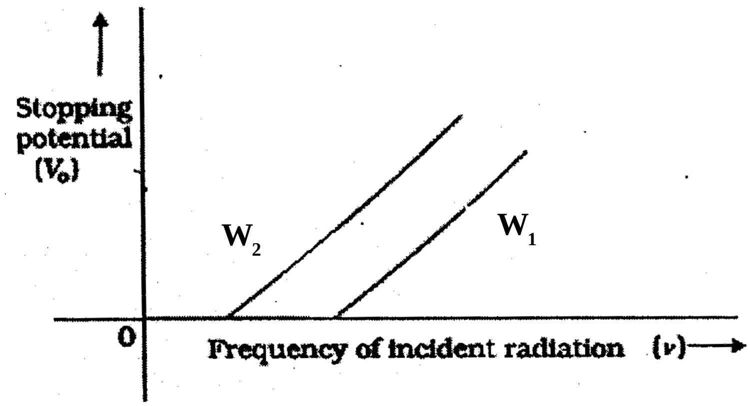
Reason of predominance of bluish colour	1
Reason of violet colour	1

(a) As per Rayleigh's law (scattering α $1/\lambda^4$), lights of shorter wavelengths scattered more by the atmospheric particles. This results in a dominance of bluish colour in the scattered light. 1

(b) In the visible spectrum, violet light having its shortest wavelength, has the highest refractive index. Hence it is deviated the most. 1 2

18.

Graph	1
Factors	½+½



1

(i) Slope is determined by h and e.(or slope is independent of the metal used) ½

(ii) Work function of the metal. ½ 2

19.

Effect on (i) capacitance (ii) potential difference	
(iii) energy stored	1 + 1 + 1

(i) Capacltance $C = \frac{K\varepsilon_0 A}{d}$, Hence capacitance Increases *K* times. ½+½

(ii) Potential difference $V = \frac{V_0}{K}$, Hence potential difference decreases

by a factor *K*. ½+½

(iii) Energy stored $E = \frac{1}{2}CV^2$, As capacitance becomes *K* times &

potential difference becomes $1/K$ times therefore energy stored becomes $1/K$ times. ½+½ 3

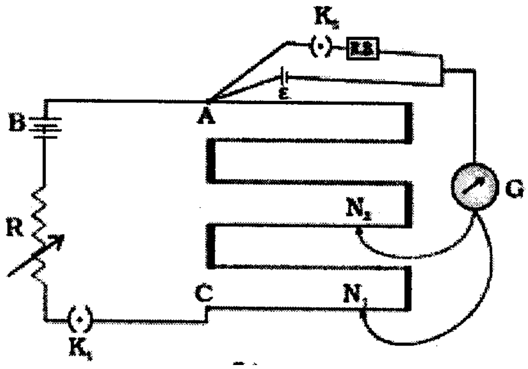
Alternatively:

Energy stored = $Q^2/2C$. As capacitance increases by a factor *K*, the energy stored will decrease by the same factor.

20.

Working principle	½
Circuit diagram	1
Determination of internal resistance	½

Working principle: When constant current flows through a wire of uniform cross section, then potential difference across the wire is directly proportional to the length. $V \propto l$ ½



1

With key K_2 open, balance is obtained at length l_1 (AN_1). Then,

$\varepsilon = \phi l_1$ (ϕ = potential gradient)

When key K_2 is closed, the cell sends a current (I) through the resistance box (R). If V is the terminal potential difference of the cell and balance is obtained at length l_2 (AN_2),

$V = \phi l_2$

But $\frac{\varepsilon}{V} = \frac{I(R+r)}{IR} = \left(1 + \frac{r}{R}\right)$ ½

$\therefore \left(1 + \frac{r}{R}\right) = \frac{l_1}{l_2}$ ½

$\Rightarrow r = \frac{(l_1 - l_2)}{l_2} R$ ½ 3

21.

Expression for magnetic moment	1
Reason	1
Expression	1

$\vec{m} = I\vec{A}$ ($\vec{A}$ = *area vector*) 1

(for students using the corrected current direction)

Torque: The magnetic field due to the long current carrying wire is perpendicular to the plane of paper. Hence the force acting on each of the four sides is in the plane of the paper and the net torque is zero. 1

Alternatively

$\vec{m}$ is perpendicular to the plane of paper and $\vec{B}$ is perpendicular to the plane of paper. Hence $\vec{\tau} = \vec{m} \times \vec{B} = 0$

Force:

Force on upper horizontal side = $\dfrac{Il\,\mu_0\,I_1}{2\pi l} = \dfrac{I\,\mu_0\,I_1}{2\pi}$ (attractive) ½

Force on lower horizontal side = $\dfrac{Il\,\mu_0\,I_1}{2\pi(2l)} = \dfrac{I\,\mu_0\,I_1}{4\pi}$ (repulsive)

The direction of these forces being opposite to each other therefore net

force = $\dfrac{\mu_0 I_1 I}{4\pi}$ (attractive) ½

(The net force on the two vertical sides is zero) 3

(for students using the given current direction)

Torque: The magnetic field due to the long current carrying wire is perpendicular to the plane of paper. Hence the force acting on each of the four sides is in the plane of the paper and the net torque is zero.

Alternatively

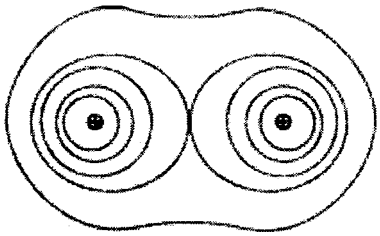
$\vec{m}$ is perpendicular to the plane of paper and $\vec{B}$ is perpendicular to the plane of paper. Hence $\vec{\tau} = \vec{m} \times \vec{B} = 0$

Force: Award this mark irrespective of result obtained or calculation done by the students.

22.

Drawing of equipotential surface	1
Expression of potential energy	2

(a) Equipotential surfaces for a system of two identical positive charges:



1

(b) Expression for the potential energy of a system of two point charges in external field:

Work done in bringing the charge q_1 from infinity to $\mathbf{r}_1$. ½

Work done = $q_1 \ V(\mathbf{r}_1)$

Work done in bringing the charge q_1 from infinity to $\mathbf{r}_2$.

Work done against the external electric field = $q_2 V(\mathbf{r}_2)$ ½

Work done = work done against the external electric field + Work done on q_2 against the field due to q_1 ½

$$= q_2 V(\mathbf{r}_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$$

Potential energy of the system

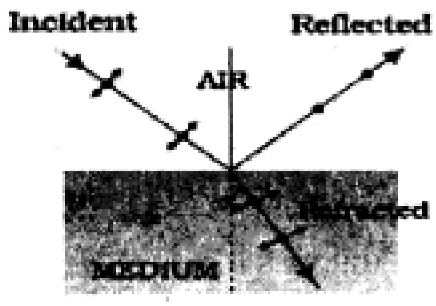
= the total work done in assembling the configuration

$$= q_1 V(\boldsymbol{r}_1) + q_2 V(\boldsymbol{r}_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$$ ½ 3

23.

Definition	1
Method of polarization	1
Expression of Brewster angle	1

In an unpolarised light the vibrations of electric field vector are in every plane perpendicular to the direction of propagation of light. 1



When unpolarised light is incident on the boundary between two transparent media, the reflected light is polarised with its electric vector perpendicular to the plane of incidence when the refracted and reflected rays make a right angle with each other. 1

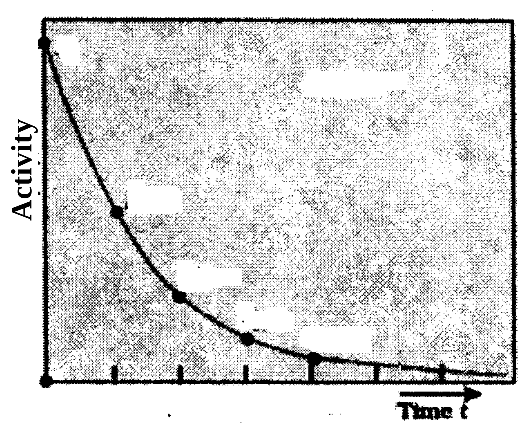
Brewster angle: $\mu = \tan i_p$ 1 3

24.

i)	Definition	½
	SI unit	½
ii)	Graph	1
iii)	Values for D	½+½

(i) The total decay rate (of a sample)at the given instant, i.e., the number of radionuclides disintegrating per unit time is called the *activity* of that sample. The SI unit for activity is becquerel (Bq). ½ ½

(ii) Graph:

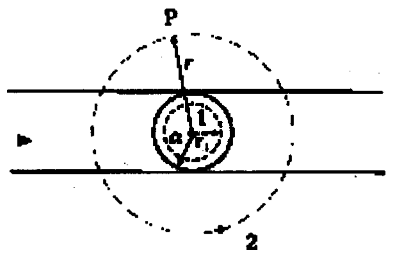


1

(iii) 72 and 180 ½+½ 3

25.

Diagram	½
Calculation of magnetic field (i) inside (ii) outside	1½ + 1



½

(a) 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 $I_e = I\left(\dfrac{\pi r^2}{\pi a^2}\right) = \dfrac{Ir^2}{a^2}$ ½

Using Ampere's law,

$B\,(2\pi r) = \dfrac{\mu_0\ Ir^2}{a^2} \Rightarrow B = \dfrac{\mu_0 Ir}{2\pi a^2}$ 1

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

Ie = Current enclosed by the loop = I ½

$B\,(2\pi r) = \mu_0 I$

$\Rightarrow B = \dfrac{\mu_0 I}{2\pi r}$ ½ 3

OR

Principle	1
Two reasons	½+½
Two factors	½+½

Principle: Torque acts on a current carrying coil suspended in magnetic field. ($\tau = NIAB \sin \theta$) 1

Two reasons: (i) Galvanometer is a very sensitive device, it gives a full-scale deflection for a current of the order of a few μA.

(ii) For measuring currents, the galvanometer has to be connected in series, and as it has a finite resistance, this will change the value of the current in the circuit. ½+½

Two factors: The current sensitivity of a moving coil galvanometer can be increased by (i) increasing the number of turns (ii) increasing area of the loop. (iii) increasing magnetic field (iv) decreasing the torsional constant of the suspension wire. (Any two) ½+½ 3

26.

Space wave propagation	1
Two examples	½+½
Calculation of maximum distance	1

When waves travel in space in a straight line from the transmitting antenna to the receiving antenna, this mode of propagation is called the space wave propagation. 1

Examples: Television broadcast, microwave links, satellite communication (Any two) ½+½

$d = \sqrt{2hR} = \sqrt{2 \times 80 \times 6.4 \times 10^6} = 32$ km ½+½ 3

27.

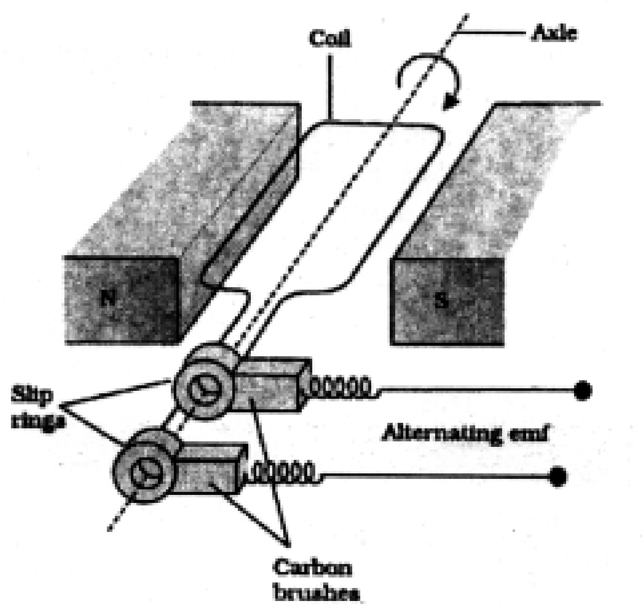
Determination of values of R and S	1½+1½

$\frac{R}{S} = \frac{40}{60} = \frac{2}{3}$ ½

$\frac{R(12+S)}{12S} = \frac{50}{50} = 1$ 1½

$\Rightarrow$ R = 4Ω and S = 6Ω ½+½ 3

28.	Description of basic elements with Labelled diagram	2
	Underlying principle	1
	Production of emf in loop	1½
	Expression	½

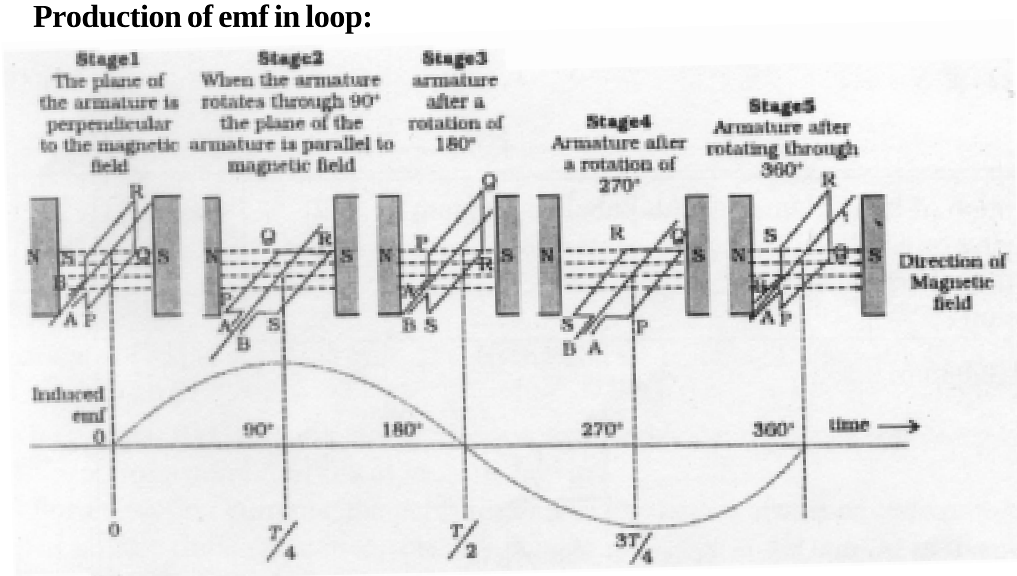


1

It consists of a coil mounted on a rotor shaft. The axis of rotation of the coil is perpendicular to the direction of the magnetic field. The coil (called armature) is mechanically rotated in the uniform magnetic field by some external means. The ends of the coil are connected to an external circuit by means of slip rings and brushes. 1

Underlying principle: As the coil rotates in a magnetic field **B**, the effective area of the loop (the face perpendicular to the field) which is A cos θ, where θ is the angle between area **(A)** and magnetic field **(B)** changes continuously. Hence, magnetic flux linked with the coil keeps on changing with time and an induced emf is produced. 1

Production of emf in loop:



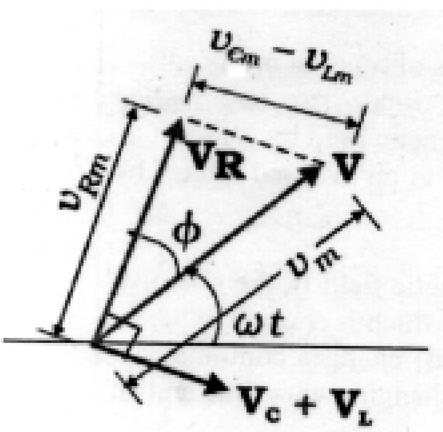
1

½

The instantaneous value of the emf is $\varepsilon = NBA\omega \sin\omega t$ ½ 5

OR

Derivation of Expression for instantaneous current	3
Obtaining condition of resonance	½
Definition of power factor	½
Condition of maximum and minimum power factor	½+½



½

From the phasor diagram, we have

$$v_m^2 = v_{Rm}^2 + \left(v_{Cm} - v_{Lm}\right)^2$$ ½

$$= i_m^2\left[R^2 + \left(X_C - X_L\right)^2\right]$$

$$i_m \frac{v_m}{\left[R^2 + (X_C - X_L)^2\right]}$$ ½

The current is seen to lead the voltage by an angle , where

$\tan\phi = \dfrac{X_C - X_L}{R}$, ½

hence $i = i_m \sin(\omega t + \phi)$ ½

(Accept the analytical approach also)

Where $i_m = \dfrac{v_m}{\sqrt{R^2 + (X_C - X_L)^2}}$ *and* $\phi = \tan^{-1}\left[\dfrac{\left(\omega L \sim \dfrac{1}{\omega C}\right)}{R}\right]$ ½

Condition of resonance: $\omega L \sim \dfrac{1}{\omega C} = 0$ *or* $\omega L = \dfrac{1}{\omega C}$ *or* $\omega = \dfrac{1}{\sqrt{LC}}$ ½

Power factor equals the cosine of the phase angle, i.e., ϕ

Power factor $\cos\phi = \dfrac{R}{Z}$ ½

Power factor is maximum when cos ϕ = 1, i.e. when R=Z or $X_L = X_C$ ½

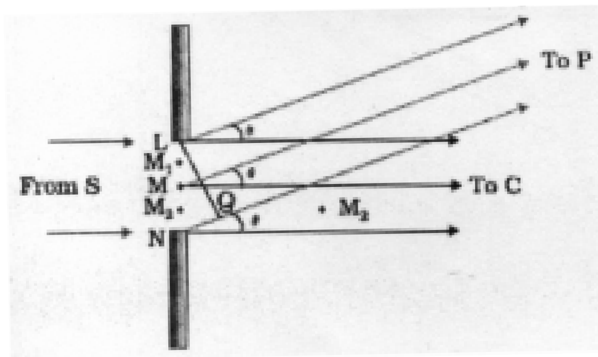
Power factor is minimum when cos ϕ = 0, i.e. when R = 0 ½ 5

29.

Statement of Huygen's principle	1
Application to diffraction pattern	2
Plot	1
Explanation	1

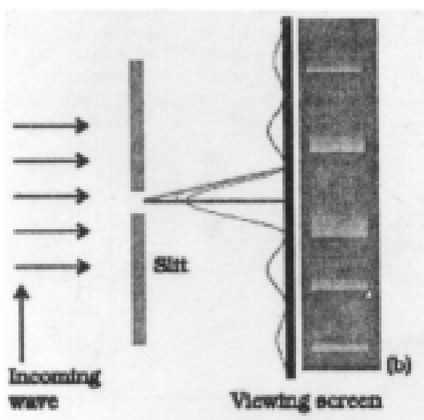
Huygenís principle: Each point of wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. The common tangent/ forward envelope, to all these secondary wavelets gives the new wavefront at later time. 1

Application to diffraction pattern: All the points of incoming wavefront (parallel to the plane of slit)are in phase with plane of slit. However the contribution of the secondary wavelets from different points, at any point, on the observation screen have phase differences dependent on the corresponding path differences. Total contribution, at any point, may add up to give a maxima or minima dependent on the phase differences. 1



1

Plot of intensity distribution and explanation:



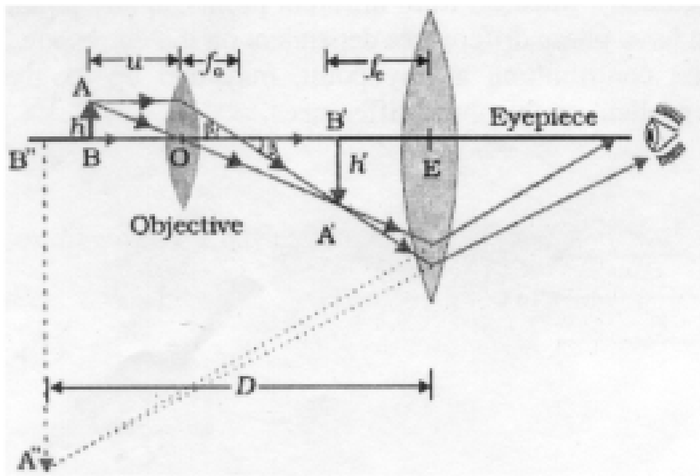
1

The central point is a maxima as the contribution of all secondary wavelet pairs are in phase here. Consider next a point on the screen where an angle $\theta = 3\lambda/2a$. Divide the slit into three equal parts. Here the first two-thirds of the slit can be divided into two halves which have a $\lambda/2$ path difference. The contributions of these two halves cancel. Only the remaining one-third of the slit contributes to the intensity at a point between the two minima. Hence, this will be much weaker than the central maximum (where the entire slit contributes in phase). We can similarly show that there are maxima at $\theta = (n + 1/2)\,\lambda/a$ with $n = 2, 3$, etc. These become weaker with increasing n, since only one-fifth, one-seventh, etc., of the slit contributes in these cases. 1 5

OR

Labelled Ray diagram	1
Derivation	2
Estmation of magnifying power	2

Labelled Ray diagram:



1

Expression for total magnification:

Magnification due to the **objective,**

$$m_o = \frac{h'}{h} = \frac{L}{f_o}$$ ½

Magnification m_e, due to eyepiece, (when the final image is formed at the near point)

$$m_e = \left(1 + \frac{D}{f_e}\right)$$ ½

Total magnification,

$$m = m_0 m_e = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$ 1

Estimation of magnifying power :

Given : u_0 = -1.5 cm ; f_0 = 1.25 cm we have ½

$$\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$$

$$\frac{1}{1.25} = \frac{1}{v_0} - \frac{1}{-1.5} \quad \Rightarrow v_0 = 7.5 \text{ cm}$$ ½

$$m \simeq \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$ ½

$$= \frac{7.5}{-1.5}\left(1 + \frac{25}{5}\right) \Rightarrow m = -30$$ ½ 5

30.

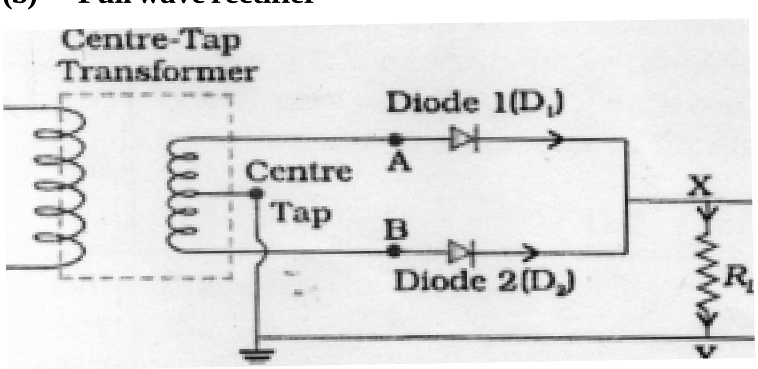
Explanation of depletion layer and potential barrier	1+1
Name of device and circuit diagram	½+1
Identification of logic gate and truth table	½+1

(a) ***depletion region:*** Due to the concentration gradient across p-, and n-sides, holes diffuse from p-side to n-side (p $\rightarrow$ n) and electrons diffuse from n-side to p-side (n $\rightarrow$ p). As the electrons diffuse from n $\rightarrow$ p, a layer of positive charge (or positive space-charge region) is developed on n-side of the junction. Similarly as the holes diffuse, a layer of negative charge (or negative space-charge region) is developed on the p-side of the junction. This space-charge region on either side of the junction together is known as *depletion region.* 1

Barrier potential:

The loss of electrons from the n-region and the gain of electron by the p-region causes a difference of potential across the junction of the two regions. The polarity of this potential is such as. to oppose further flow of carriers. 1

(b) Full wave rectifier ½



1

½

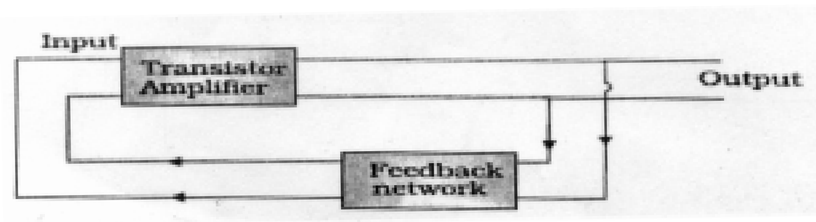
(c) AND Gate 1

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

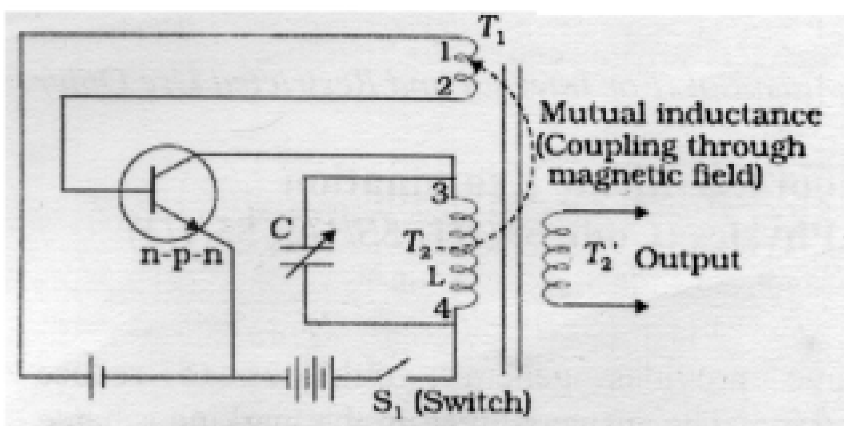
5

OR

Circuit diagram	1
Working principle	2½
Distinction	1½

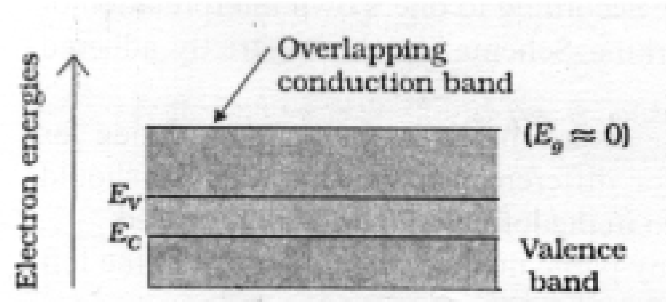


1

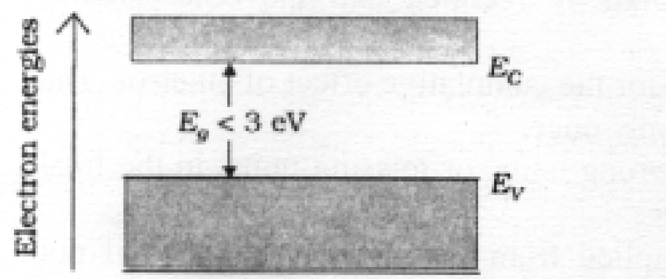


Working principle: In an oscillator, we get ac output without any external input signal, i.e. the output in an oscillator is *self-sustained*. To attain this, a portion of the output power of an amplifier, is returned back (fedback) to the input *in phase* with the starting power. 1½

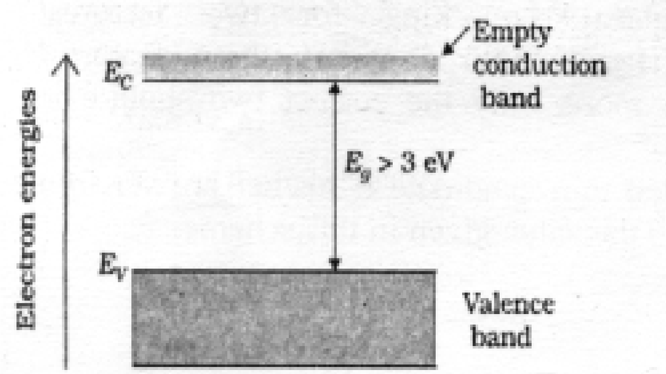
The energy band diagrams, showing the distinction between a conductor, a semiconductor and an insulator are shown below:



½



½



½ 5

QUESTION PAPER CODE 55/1

1.	Electric potential, scalar	½+½	1
2.	Negative Z direction ($-\hat{k}$)	1	1
3.	Magnetic flux linked through a coil when current flowing through is unity./ Induced emf in a coil when current is changing at the unit rate. SI unit is henry.	½+½	1
4.	$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ as $f_1 = -f_2$ (award 1 mark even if the student directly writes $f = \infty$) $\therefore\ f = \Rightarrow \infty$	½+½	1
5.	Minimum energy required to free an electron from the ground state. Its value for hydrogen atom is 13.6 eV	½+½	1
6.	$I = n_x eAv_x = n_y eAv_y$ $\Rightarrow \frac{v_X}{v_Y} = \frac{n_Y}{n_X} = \frac{n_Y}{2n_Y} = \frac{1}{2}$	½+½	1
7.	X-rays. Any one application.	½+½	1
8.	No, because energy depends on amplitude and frequency only./(or Energy does not depend on speed.)	½+½	1
9.	Derivation 2		
	Current due to revolution of electron $I = \frac{e}{T}$ and $T = \frac{2\pi r}{v}$	½	
	$\therefore\ I = ev/2\pi r$	½	
	Magnetic moment $\mu_l = I\pi r^2 = evr/2$	1	2

10.

(a)	surface charge density on inner and outer surface	½ + ½
(b)	expression for electric field	1

(a) (i) surface charge density on inner surface

$$\sigma = \frac{-q}{4\pi r_1^2}$$ ½

(ii) surface charge density on outer surface

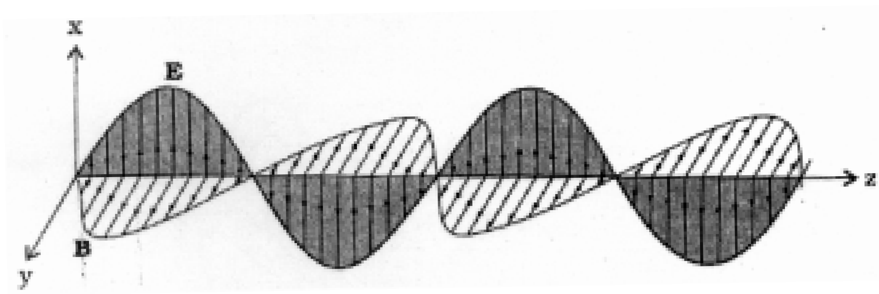
$$\sigma = \frac{Q+q}{4\pi r_2^2}$$ ½

Electric field at a (an outside) point distant x from centre of the shell

$$E = \frac{Q+q}{4\pi\varepsilon_0 x^2}$$ 1 2

11.

Sketch of plane electromagnetic wave	1
Directions of electric and magnetic fields	1

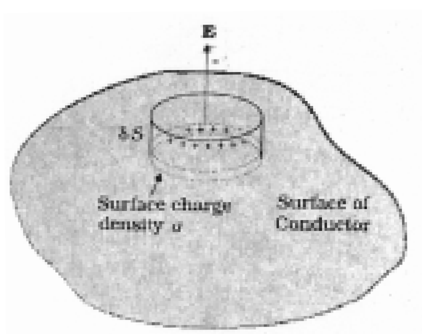


1+1 2

(Note: If diagram is drawn without indicating direction, award one mark. If only directions are written without any diagram, award one mark.)

12.

Derivation	2



½

$$E\delta S = \frac{\sigma \delta S}{\varepsilon_0}$$ ½

$$\Rightarrow E = \frac{\sigma}{\varepsilon_0}$$ ½

In vector form

$$\vec{E} = \frac{\sigma \hat{n}}{\varepsilon_0}$$ ½

Alternatively: Also accept the derivation of electric field on the surface of spherical shell. ½

$$\oint_s \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$$

$$E \times 4\pi r^2 = \frac{q}{\varepsilon_0}$$ ½

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

$$\Rightarrow \vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$ 1 2

13.

Comparison of induced emf	1
Comparison of currents	1

(i) Emf produced in two coils is same because it depends only on the rate of change of magnetic flux which is same for both the loops. 1

(ii) Current in copper loop is more because resistivity/resistance of copper is less. ($I=V/R$). 1 2

14.

Formula.	½
Substitution and calculation	1½

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$$ ½

As $m_\alpha = 4m_p$ and $q_\alpha = 2q_p$ ½

$$\frac{\lambda_\alpha}{\lambda_p} = \frac{\sqrt{2m_p q_p}}{\sqrt{2m_\alpha q_\alpha}} = \frac{\sqrt{m_p q_p}}{\sqrt{4m_p 2q_p}} = \frac{\sqrt{1}}{\sqrt{8}} = \frac{1}{2\sqrt{2}}$$ 1 2

15.

Two factors	1
Calculation of peak voltage of modulating signal	1

(i) Appropriate size of the antenna or aerial

(ii) Effective power radiated by an antenna

(iii) To avoid Mixing up of signals from different transmitters

(Any Two) ½+½

Modulation Index

$$\mu = \frac{a_m}{a_c}$$ ½

$$\therefore\ 0.75 = \frac{a_m}{12\text{V}}$$

$$\Rightarrow a_m = 9\text{V}$$ ½ 2

16.

Einstein's photoelectric equation	½
Three salient features	½ each

Einstein's photoelectric equation: ½

$$K_{max} = h\nu - \phi_0 = h(\nu - \nu_0)$$

(i) K_{max} of electrons depends linearly on ν.

(ii) K_{max} is independent of intensity of radiation.

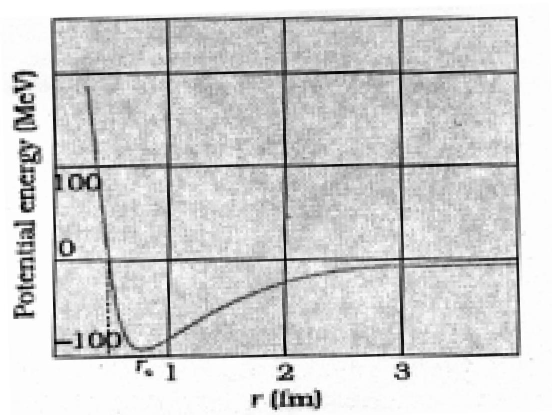
(iii) There exists a threshold frequency ν_0 $(= \phi_0/h)$ for the metal surface, below which no photoelectric emission is possible. (No matter how intense the incident radiation may be or how long it falls on the surface.)

(iv) For $v > v_0$, photoelectric current is proportional to intensity of incident radiations.

(Any three) $3\times\frac{1}{2}$ 2

17.

Plot of potential energy of pair of nucleon	1
Two important conclusions	½+½



1

Two important conclusions:

(i) The nuclear force between two nucleons falls rapidly to zero at distances more than a few femtometres;

(ii) The nuclear force is attractive for $r > r_0$.

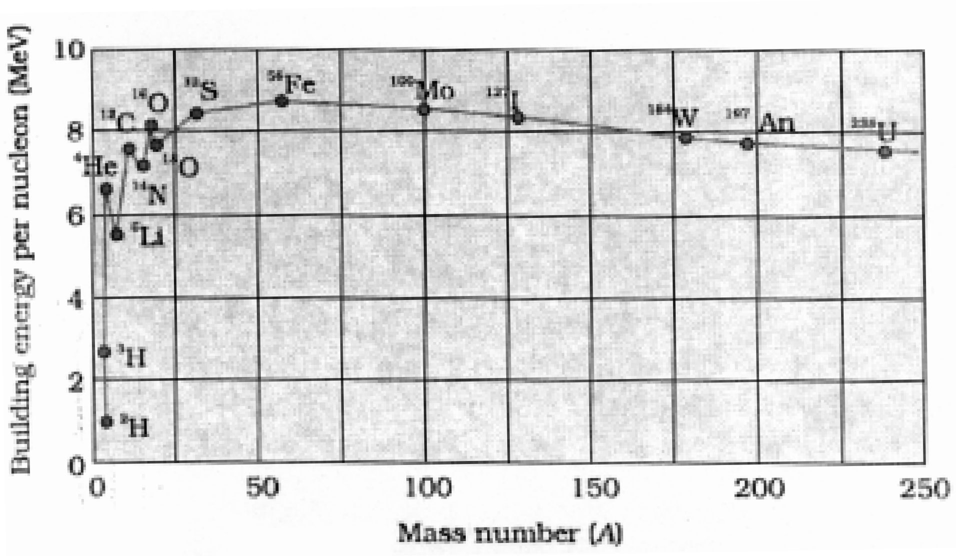
(iii) The nuclear force is repulsive for $r < r_0$.

(iv) The nuclear force is a strong force.

(Any two) ½+½ 2

OR

Plot of Binding Energy per nucleon	1
Explanation	1



1

(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.

If a nucleon can have a maximum of p neighbours within the range of nuclear force, its binding energy would be proportional to p. If we increase A by adding nucleons they will not change the binding energy of a nucleon inside. Since most of the nucleons in a large nucleus reside inside it and not on the surface, the change in binding energy per nucleon would be small. Hence the binding energy per nucleon is a constant. [saturation property of nuclear force.] 1 2

18.

Identification of gates P and Q	½+½
Output at X for the given inputs	½+½

(i) P: NAND gate ½

Q: OR gate ½

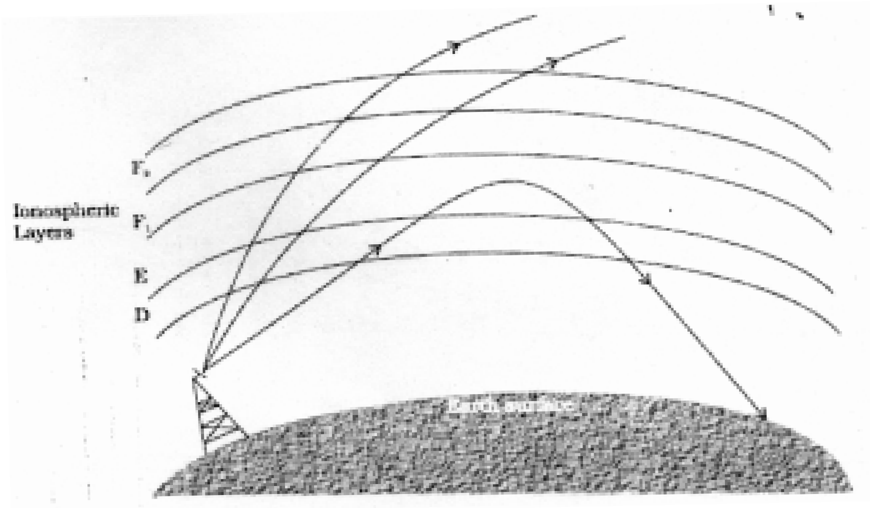
(ii) Inputs A = 0 and B = 0 then output X=1 ½

Inputs A = 1 and B = 1 then output X = 1 ½ 2

19.

Name of mode of propagation	½
Diagram + explanation	½+1
Reason for upper limit	1

Sky wave propagation/ Ionospheric reflection ½



½

Electromagnetic waves of these frequencies are reflected, by the ionosphere towards the earth. 1

Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape. 1 3

20.

Two factors:	½+½
Calculation of internal resistance:	2

(i) Nature of electrolyte.

(ii) Temperature of electrolyte.

(iii) Area of electrode

(iv) Concentration of electrolyte.

(v) Distance of separation between the electrodes

(Any two) 2×½

Calculation of internal resistance:

Given $E = 2.2$ V ; $R = 5\ \Omega$ and $V = 1.8\ V$ ½

$$\therefore I = \frac{V}{R} = \frac{1.8}{5} = 0.36$$ ½

$$V = E - Ir$$

$$\Rightarrow r = \frac{E-V}{I} = \frac{2.2-1.8}{0.36} = \frac{10}{9} = 1.1\ \Omega$$ ½+½

Alternatively: 1

$r = \left(\frac{E-V}{V}\right) \times R$ ½

$= \left(\frac{2.2-1.8}{1.8}\right) \times 5$

$\simeq 1.1\,\Omega$ ½ 3

21.

Calculation of		
(a)	Equivalent capacitance	1½
(b)	Charge on each capacitor	1½

(a)

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ ½

$\frac{1}{C} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12} = \frac{1}{4}$

$C = 4\mu F$ or simply $C_s = \frac{C}{3} = \frac{13}{3}\ \mu F = 4\mu F$ ½

Equivalent capacitance

$C_{eq} = C + C_4 = 4 + 12 = 16\mu F$ ½

(b) Calculation of charge on each capacitor :

Charge on capacitor C_4

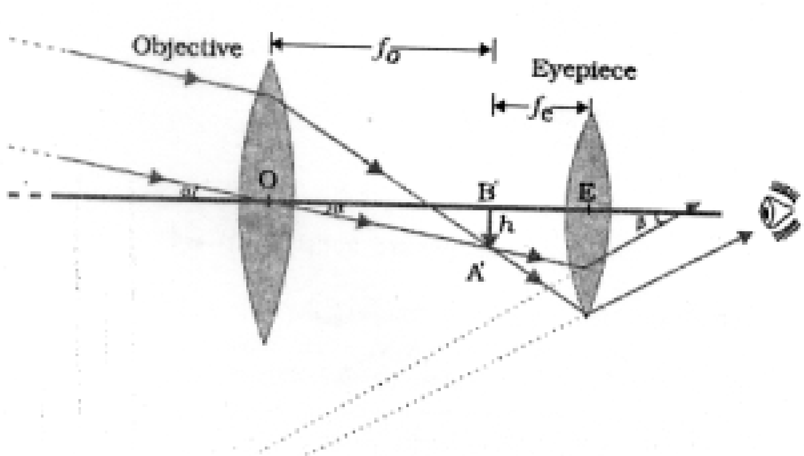
$Q_4 = C_4 V = 12 \times 500\mu C = 6000\mu C = 6 \times 10^{-3} C$ ½

Charge on capacitors C_1, C_2 and C_3

$Q_{123} = 4\mu F \times 500 V = 2 \times 10^{-3} C$ ½+½ 3

22.

Labelled ray diagram in normal adjustment	½+1
Brief working	½
Calculation of magnifying power	1



1½

(Deduct ½ mark if labelling is not done or arrows are not show.)

Light from a distant object enters the objective and a real image is formed in the tube at its second focal point. The eyepiece magnifies this image producing a final inverted image at infinity. ½

Calculation of magnifying power:

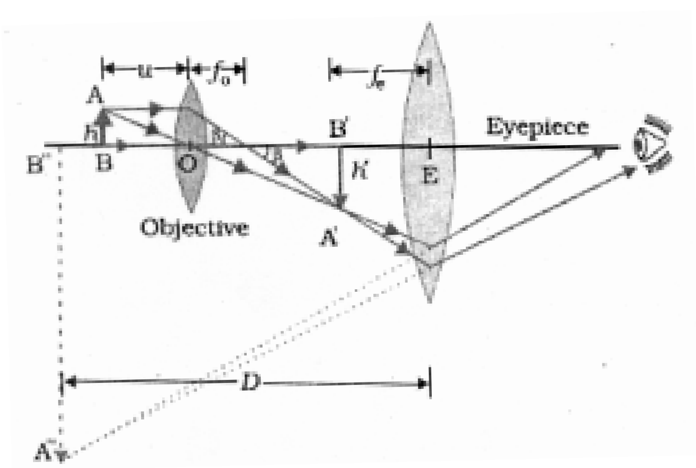
Given: Power of eyepiece = 10 D

Power of objective = 1 D

Magnifying power in normal adjustment : $m = \frac{f_o}{f_e} = \frac{p_e}{p_o} = \frac{10}{1} = 10$ ½+½

OR

Labelled ray diagram of compound microscope	½+1
Working in brief	½
Reason	1



½

(Deduct ½ mark if labelling is not done or arrows are not shown.)

The ***objective*** forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the ***eyepiece***, which functions essentially like a simple microscope or magnifier, produces the final image, which is enlarged and virtual. ½

To achieve a large magnification of a ***small*** object; both the objective and eyepiece should have small focal lengths. 1 3

23.

Calculation of distance of second bright and dark fringe	2
Effect on fringe Pattern	1

Distance of n^{th} maxima from central maxima

$$x_n = \frac{n\lambda D}{d}$$ ½

Given: $n = 2$, $d = 0.15$ mm, $\lambda = 450$ nm and $D = 1.0$ m

$$x_2 = \frac{2 \times 450 \times 10^{-9} \times 1.0}{0.15 \times 10^{-3}} = 6 \times 10^{-3} \text{ m} = 6\text{mm}$$ ½

Distance of n^{th} minima from central maxima

$$y_2 = \frac{(2n-1)\lambda D}{2d} = \frac{(2 \times 2 - 1)\, 450 \times 10^{-9} \times 1}{2 \times 0.15 \times 10^{-3}} = 4.5 \times 10^{-3} \text{ m} = 4.5\text{mm}$$ ½+½

When the screen is moved away from the slits fringes become farther apart. (Fringe width α distance of screen.) 1 3

24.

Statement of Kirchoff's rules	½+1
Equations for currents	½+½+½

(a) Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of currents leaving the junction. ½

(b) Loop rule: The algebraic sum of changes in potential, around any closed loop, involving resistors and cells in the loop, is zero. 1

Expressions for the currents I_1, I_2 and I_3 using given loop.

(i) $I_3 = I_2 + I_1$ ½

(ii) $4I_1 - 3I_2 + 1 = 0$ ½

(iii) $3I_2 + 2I_3 - 3 = 0$ ½ 3

(Accept the equations if all the sign of the terms are taken in opposite order.)

25.

Decay process	1
Derivation of average life	1
Relationship with half life	1

β^- decay process

$${}^{32}_{15}\mathrm{P} \rightarrow {}^{32}_{16}\mathrm{S} + e^- + \bar{\nu} \quad \text{or} \quad {}^{32}_{15}\mathrm{P} \rightarrow {}^{32}_{16}\mathrm{X} + {}_{-1}e^0 + \bar{\nu}$$ 1

Derivation of average life :

$$\tau = \frac{\lambda N_0 \int_0^\infty t e^{-\lambda t} dt}{N_0} = \lambda \int_0^\infty t e^{-\lambda t} dt$$ ½

$\Rightarrow \quad \tau = 1/\lambda$ ½

Relation of average life with half life :

$$T_{1/2} = \frac{\ell n\ 2}{\lambda} = \tau\ \ell n\ 2$$ 1 3

26.

Explanation of polarization of unpolarised light	1
Expression for the intensity	1
Orientation corresponding to minimum and maximum intensity	1

A polaroid consists of long chain molecules aligned in a particular direction. The electric vectors (associated with the propagating light wave) along the direction of the aligned molecules get absorbed. Thus, if an unpolarised light wave is incident on such a polaroid, then the light wave will get linearly polarised with the electric vector oscillating along a direction perpendicular to the aligned molecules. 1

(Give full credit if student explains it through a diagram)

Expression for the intensity transmitted through second Polaroid :

$I = (I_0 \cos^2\theta)\cos^2(90^0 - \theta) = I_0 (\cos\theta \sin\theta)^2 = I_0 \sin^2 2\theta / 4$ 1

where I_0 is the intensity of the polarized light after passing through the first polaroid.

Intensity will be maximum when $\theta = 45°$ and minimum when $\theta = 0°$ ½+½ 3

27.

Calculation of focal length	2½
Nature of lens	½

for real image $m = -2 = \frac{v}{u} \Rightarrow v = -2u$ ½

given $|u| + |v| = 90$ cm ½

$\Rightarrow 3|u| = 90$ cm

$\Rightarrow |u| = 30$ cm ½

We have for a lens

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

$$\therefore \frac{1}{f} = \frac{1}{60} - \frac{1}{-30}$$ ½

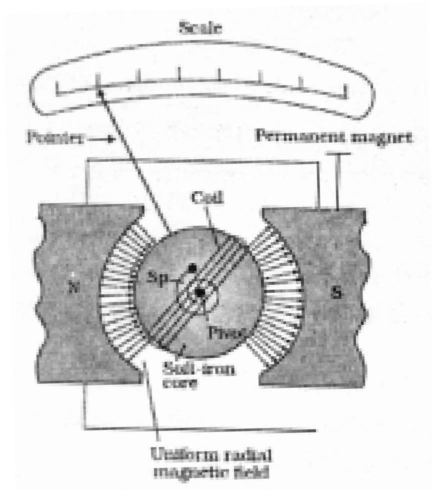
$$\frac{1}{f} = \frac{1}{20}$$

$\Rightarrow f = 20$ cm ½

Nature of lens : Convex / Converging ½ 3

28.

(a)	Diagram ,principle and working	1+1+1
(b)	Importance and production of radial magnetic field	½+½
(c)	Reason	½+½



1

Principle: Torque acts on the current carrying loop when placed in magnetic field. ($\tau = NIAB\sin\theta$.) 1

Working: The magnetic torque tends to rotate the coil. A spring provides a counter torque that balances the magnetic torque; resulting in a steady angular deflection. The deflection is indicated on the scale by a pointer attached to the spring. 1

Importance and production of radial magnetic field:

In a radial magnetic field magnetic torque remains maximum for all positions of the coils. ½+½

It is produced due to cylindrical pole pieces and soft iron core.

Reason:

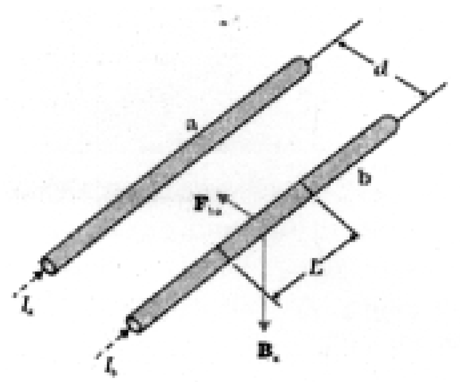
Voltmeter: This ensures that a very low current passes through the voltmeter and hence does not change (much) the original potential difference to be measured. ½

Ammeter: This ensures that the total resistance of the circuit does not change much and the current flowing remains (almost) at its original value. ½ 5

OR

(a)	Derivation of expression of force	2½
(b)	Definition of SI unit of current	1
(c)	Calculation of force (magnitude and direction)	1+½

(a)



½

Two long parallel conductors 'a' and 'b' are separated by a distance d and carry (parallel) currents I_a and I_b, respectively. The conductor 'a' produces, the same magnetic field $\mathbf{B}_a$ at all points along the conductor 'b'. 1

$$B_a = \frac{\mu_0 I_a}{2\pi d}$$

$\mathbf{F}_{ba}$, is the force on a segment L of 'b' due to 'a'. The magnitude of this force is given by ½

$F_{ba} = I_b L B_a$ ½

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

(b) 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 produce on each of these conductors a force equal to 2×10^{-7} newton per metre of length. 1

(c) Magnetic field due to the straight wire AB at a perpendicular distance d from it. ½

$$B = \frac{\mu_0 I}{2\pi d}$$

Therefore, force on proton moving with velocity 'v' perpendicular to B, is

$$f = qvB = \frac{\mu_0 I q v}{2\pi d} \qquad 1$$

Direction : Towards right ½ 5

29.

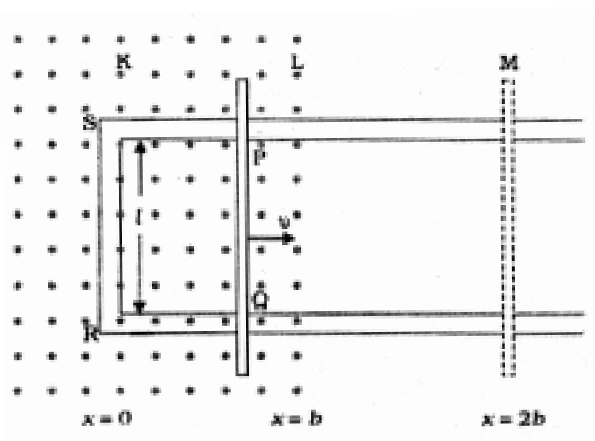
Faraday's law of electromagnetic induction	1
Expression for flux and induced emf	1+1
Sketch of the variation of these quantities with distance	1+1

The magnitude of the induced emf in a circuit is equal to the time rate of change of magnetic flux through the circuit. 1

Alternatively

Mathematically, the induced emf is given by

$$e = \frac{-d\phi}{dt}$$



First consider the forward motion from $x = 0$ to $x = 2b$

The flux ϕ_B linked with the circuit SPQR is

$\phi_B = Blx \quad 0 \leq x < b$ ½

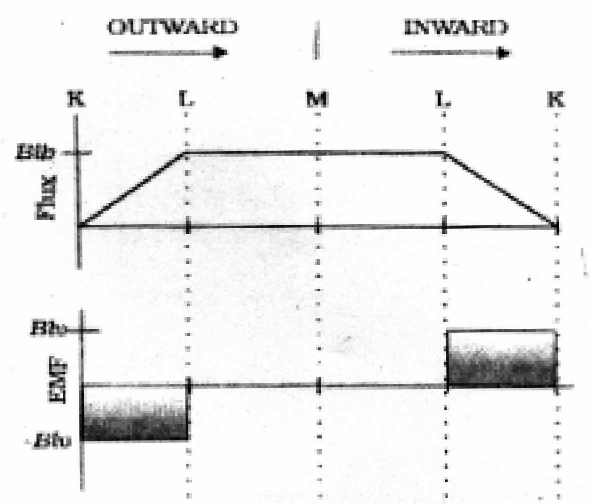
$\quad = Blb \quad b \leq x < 2b$ ½

The induced emf is

$$\varepsilon = \frac{d\phi_B}{dt}$$

$= -Blu \quad 0 \leq x < b$ ½

$= 0 \quad b \leq x < 2b$ ½

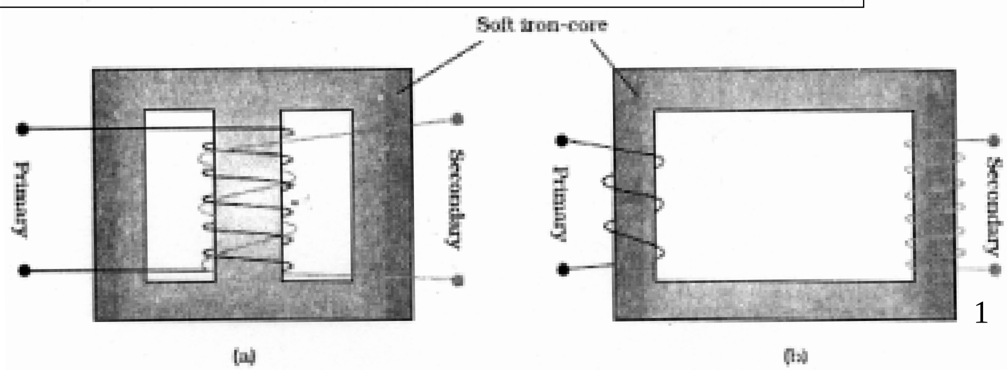


1

1 5

OR

Schematic diagram	1
Working principle	1
Derivation	1½
Ratio of currents	½
Distribution of energy over long distance	1



1

(Any one of the above diagrams)

Principle: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it (mutual induction). 1

Derivation:

The induced emf or voltage e_s, in the secondary, with N_s turns, is ½

$$e_s = \frac{-N_s d\phi}{dt}$$

The alternating flux ϕ also induces an emf, called back emf, in the primary. This is

$$e_p = \frac{-N_p d\phi}{dt}$$

But $e_s = v_s$ and $e_p = v_p$

therefore

$$v_s = \frac{-N_s d\phi}{dt} \quad \text{and} \quad v_p = \frac{-N_p d\phi}{dt}$$ ½

Hence $\dfrac{v_s}{v_p} = \dfrac{N_s}{N_p}$ ½

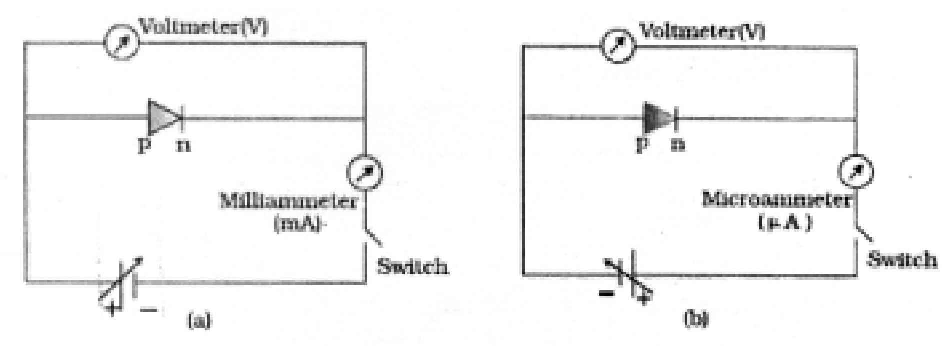
If the transformer is assumed to be 100% efficient (no energy losses), the power input is equal to the power output, and since $p = i\,v$, $i_p v_p = i_s v_s$. then

$$\frac{v_s}{v_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s}$$ ½

The large scale transmission and distribution of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up (so that current is reduced and consequently, the I^2R loss is cut down). It is then transmitted over long distances to an area sub-station near the consumers. There the voltage is stepped down. It is further stepped down at distributing sub-stations and utility poles before a power supply of 240 V reaches our homes. 1 5

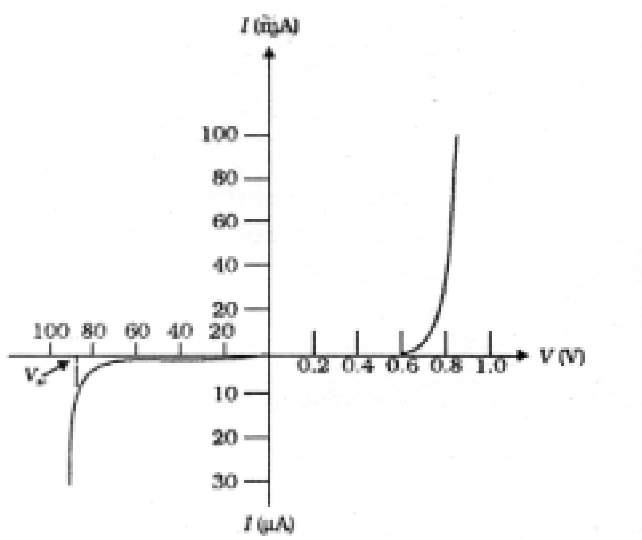
30.

(a)	Circuit diagram	1+1
	Typical *V-I* characteristics	½+½
(b)	LED; two important advantages	1+½+½



1+1

The battery is connected to the diode through a potentiometer (or rheostat) so that the applied voltage to the diode can be changed. For different values of voltages, the value of the current is noted. A graph between V and I is obtained. Note that in forward bias measurement, we use a milliammeter (since the expected current is large) while a microammeter is used in reverse bias.



½+½

Typical *V-I* characteristics of a silicon diode.

Light emitting diode

It is a heavily doped p-n junction which under forward bias emits spontaneous radiation./ p-n junction diode which emits light when forwardly biased. 1

Advantages:

(i) Low operational voltage and less power.

(ii) Fast action and no warm-up time required.

(iii) The bandwidth of emitted light is 100 Å to 500 Å, or in other words it is nearly (but not exactly) monochromatic.

(iv) Long life and ruggedness.

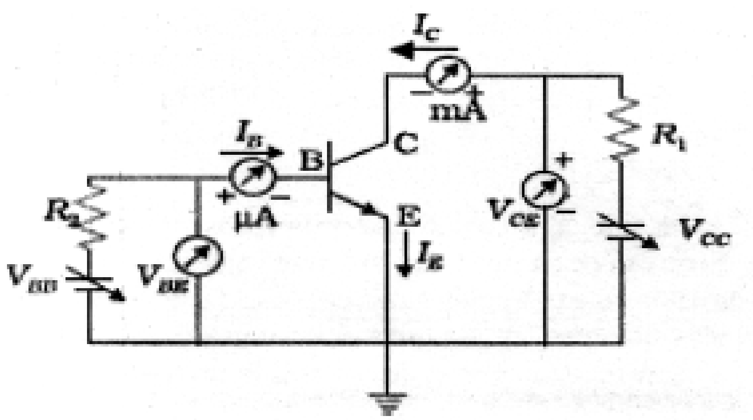
(v) Fast on-off switching capability

(Any two) ½+½ 5

OR

(a)	Circuit diagram for transistor characteristics	2
	Definitions	½+½
(b)	Circuit diagram	1
	Explanation of self sustained oscillations	1

(a)



2

(i) **Input resistance:** This is defined as the ratio of change in base emitter voltage (ΔV_{BE}) to the resulting change in base current (ΔI_B) at constant collector-emitter voltage (V_{CE}).

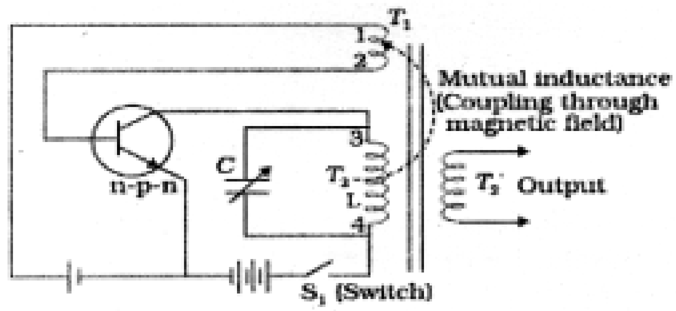
$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$ ½

(ii) **Current amplification factor (β):** This is defined as the ratio of the change in collector current to the change in base current at a constant collector-emitter voltage (V_{CE}) when the transistor is in active state.

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$ ½

(Give each of these marks if student writes only the correct expressions.)

(b) Circuit diagram:



1

Working: In an oscillator, we get an ac output without any external input signal. Hence, the output in an oscillator is self-sustained. To attain this, an amplifier is taken. A portion of the output power is returned back (feedback) to the input in phase with the starting power (this process is termed positive feedback). 5

[Give ½ mark if student just draws the block diagram.]