**Class-XII**

**Session - 2022-23**

**Subject - Physics (Theory)**

**Sample Question Paper - 33**

**With Solution**

## BLUE PRINT

| Ch. No. | Chapter Name | Per Unit Marks | Section-A VSA/A-R/MCQs (Case based) 1 Mark | Section-B SA 2 Marks | Section-C LA-I 3 Marks | Section-D LA-II 5 Marks | Section-E Case Study 4 Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|
| 1 | Electric Charges and Fields | 16 | 1 (Q. 17) | 1 (Q. 21) | | | | 3 |
| 2 | Electrostatic Potential and Capacitance | | 1 (Q. 1) | | | 1 (Q. 31) | | 6 |
| 3 | Current Electricity | | 2 (Q. 7, 8) | 1 (Q. 19) | 1 (Q. 27) | | | 7 |
| 4 | Moving Charges and Magnetism | 17 | 3 (Q. 2, 3, 4) | | | | 1 (Q. 34) | 7 |
| 5 | Magnetism and Matter | | | 1 (Q.24) | | | | 2 |
| 6 | Electromagnetic Induction | | | | | 1 (Q. 32) | | 5 |
| 7 | Alternating Current | | | | 1 (Q. 26) | | | 3 |
| 8 | Electromagnetic Waves | 18 | 2 (Q. 11, 14) | 1 (Q. 22) | | | | 4 |
| 9 | Ray optics and Optical Instruments | | 3 (Q. 5, 6, 15) | 2 (Q. 23, 25) | | | | 7 |
| 10 | Wave Optics | | 2 (Q. 9, 10) | 1 (Q. 20) | 1 (Q. 28) | | | 7 |
| 11 | Dual Nature of Radiation and Matter | 12 | 1 (Q. 12) | | | | 1 (Q. 35) | 5 |
| 12 | Atoms | | 1 (Q. 16) | | 1 (Q. 29) | | | 4 |
| 13 | Nuclei | | | | 1 (Q. 30) | | | 3 |
| 14 | Semiconductor Electronics: Materials, Devices and Simple Circuits | 7 | 2 (Q. 13, 18) | | | 1 (Q. 33) | | 7 |
| | Total Marks (Total Questions) | | 18 (18) | 14 (7) | 15 (5) | 15 (3) | 8 (2) | 70 (35) |

**NOTE :** The number given inside the bracket denotes question number, ask in the sample paper, while the number given outside the bracket are the number of questions from that particular chapter.

**Time Allowed : 3 Hours** **Max. Marks : 70**

## 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

**1.** Which of the following is NOT the property of equipotential surface?
(a) They do not cross each other.
(b) The rate of change of potential with distance on them is zero.
(c) For a uniform electric field they are concentric spheres.
(d) They can be imaginary spheres.

**2.** The coil of a moving coil galvanometer is wound over a metal frame in order to
(a) reduce hysteresis (b) increase sensitivity
(c) increase moment of inertia (d) provide electromagnetic damping

**3.** A current of 10 A is flowing in a wire of length 1.5 m. A force of 15 N acts on it when it is placed in a uniform magnetic field of 2 T. The angle between the magnetic field and the direction of the current is
(a) 30° (b) 45° (c) 60° (d) 90°

**4.** The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of loop?
(a) 125 μT (b) 150 μT (c) 250 μT (d) 75 μT

**5.** In normal adjustment, for a refracting telescope, the distance between objective and eye piece is 30 cm. The focal length of the objective, when the angular magnification of the telescope is 2, will be:
(a) 20 cm (b) 30 cm (c) 10 cm (d) 15 cm

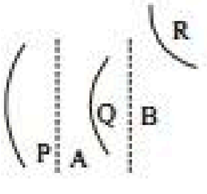
**6.** An object is placed 40 cm from a concave mirror of focal length 20 cm. The image formed is
(a) real, inverted and same in size (b) real, inverted and smaller
(c) virtual, erect and larger (d) virtual, erect and smaller

**7.** When a current I is set up in a wire of radius r, the drift velocity is $v_d$. If the same current is set up through a wire of radius 2 r, the drift velocity will be
(a) $4\ v_d$ (b) $2\ v_d$ (c) $v_d/2$ (d) $v_d/4$

**8.** By increasing the temperature, the specific resistance of a conductor and a semiconductor–
(a) increases for both.
(b) decreases for both.
(c) increases for a conductor and decreases for a semiconductor.
(d) decreases for a conductor and increases for a semiconductor.

**9.** Two sources of light are said to be coherent, when they give light waves of same
(a) amplitude and phase
(b) wavelength and constant phase difference
(c) intensity and wavelength
(d) phase and speed

**10.** Figure shows wavefront P passing through two systems A and B and emerging as Q and then as R. The system A and B could, respectively, be
(a) a prism and a convergent lens
(b) a convergent lens and a prism
(c) a divergent lens and a prism
(d) a convergent lens and a divergent lens



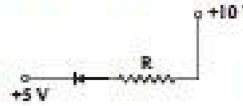
11. In a plane electromagnetic wave propagating in space has an electric field of amplitude $9 \times 10^3$ V/m, then the amplitude of the magnetic field is

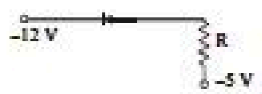
(a) $2.7 \times 10^{12}$ T (b) $9.0 \times 10^{-3}$ T (c) $3.0 \times 10^{-4}$ T (d) $3.0 \times 10^{-5}$ T

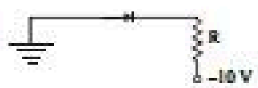
12. For an electron accelerated from rest through a potential $V$, the de Broglie wavelength associated will be

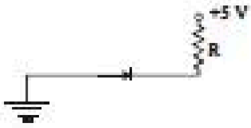
(a) $\frac{1.772}{\sqrt{V}}$ nm (b) $\frac{1.227}{\sqrt{V}}$ μm (c) $\frac{1.227}{\sqrt{V}}$ nm (d) $\frac{1.772}{\sqrt{V}}$ μm

13. Of the diodes shown in the following diagrams, which one is reverse biased?

(a) 


(b) 


(c) 


(d) 


14. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along

(a) E (b) B (c) B × E (d) E × B

15. A prism has a refracting angle of 60°. When placed in the position of minimum deviation, it produces a deviation of 30°. The angle of incidence is

(a) 30° (b) 45° (c) 15° (d) 60°

***For question numbers 16, 17 and 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 but 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

16. **Assertion (A) :** Balmer series lies in the visible region of electromagnetic spectrum.

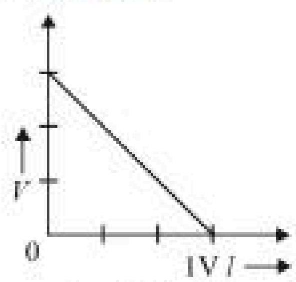
**Reason (R) :** $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ where $n$ = 3, 4, 5.

17. **Assertion (A) :** The property that the force with which two charges attract or repel each other are not affected by the presence of a third charge, is known as superposition of charges.
**Reason (R) :** Force on any charge due to a number of other charge is the vector sum of all the forces on that charge due to other charges, taken one at a time.

18. **Assertion (A) :** In semiconductors, thermal collisions are respossible for taking a valence electron to the conduction band.
**Reason (R) :** The number of conduction electrons go on increasing with time as thermal collisions continuously take place.

## SECTION-B

19. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is shown below. What is the emf and internal resistance of each cell ?




20. Draw the graphs showing intensity pattern in young's double slit experiment and diffraction due to a single slit.

**OR**

Two narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered, what is the name of the pattern obtained now on the screen?

21. Two point charges 3 μ C and – 3 μ C are located 20 cm apart in vacuum.

(a) Calculate the electric field at the mid point O of the line AB, joining the charges.
(b) What is the force experienced by a negative test charge of magnitude $1.5 \times 10^{-9}$ C placed at this point?

**22.** Name the constituent radiation of electromagnetic spectrum which is used for
(i) aircraft navigation (ii) studying the crystal structure
Write the frequency range for each.

**23.** An equiconvex lens of focal length 15 cm is cut into two equal halves in thickness. What is the focal length of each half?

**OR**

A convex lens of focal length 30 cm is placed coaxially in contact with a concave lens of focal length 40 cm. Determine the power of the combination. Will the system be converging or diverging in nature?

**24.** Compare the magnetic field of a bar magnet and a solenoid.

**25.** The velocity of light in air is $3 \times 10^8$ ms$^{-1}$ and in a liquid is $2.5 \times 10^8$ ms$^{-1}$. If the ray of light passes from liquid to air, calculate the value of critical angle.

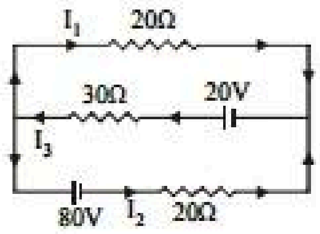
## SECTION-C

**26.** An inductor L of inductance $X_L$ is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (i) number of turn in the inductor is reduced, (ii) an iron rod is inserted in the inductor and (iii) a capacitor of reactance $X_C = X_L$ is inserted in series in the circuit. Justify your answer in each case.

**27.** Two heating elements of resistances $R_1$ and $R_2$ when operated at a constant supply of voltage V, consume powers $P_1$ and $P_2$, respectively. Deduce the expressions for the power of their combination when they are, in turn, connected in
(i) series and (ii) parallel across their same voltage supply.

**OR**

Use Kirchhoff's rules to determine the value of the current $I_1$ flowing in the circuit shown in the figure.




**28.** Explain the formation of secondary minima in the diffraction pattern due to a single slit.

**29.** Using Rutherford model of the atom, derive the expression for the total energy of the electron in hydrogen atom. What is the significance of total negative energy possessed by the electron?

**OR**

Using Bohr's postulates of the atomic model, derive the expression for radius of $n^{th}$ electron orbit. Hence obtain the expression for Bohr's radius.

**30.** If both the no. of $p^+$ and no. of $n^0$ s are conserved in each nuclear reaction, in what way is mass converted into energy or vice versa?

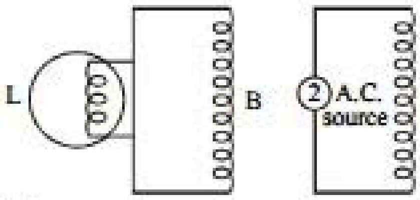
## SECTION-D

**31.** Derive the relation $C = \frac{\varepsilon_0 A}{d}$ for the capacitance of a parallel plate capacitor, where symbols have their usual meanings. A parallel plate capacitor is charged to a potential difference 'V' and disconnected from the supply. If the distance between the plates is doubled, explain how does (i) electric field and (ii) energy stored in the capacitor change?

**OR**

A capacitor is charged to potential $V_1$. The power supply is then disconnected and the capacitor is then connected in parallel to another capacitor of potential $V_2$.
(a) Derive an expression for the common potential of the combination of capacitor.
(b) Show that the total energy of combination is less than the sum of the energy stored in them before they are connected.

**32.** (i) State Faraday's law of electromagnetic induction.
(ii) In the diagram given, a coil B is connected to low voltage bulb L and placed parallel to another coil 'A' as shown. Explain the following observations.
(a) Bulb lights and

(b) Bulb gets dimmer if the coil 'B' is moved upwards. 


**OR**

(a) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce a current which opposes the change of magnetic flux that produces it.

(b) The current flowing through an inductor of self inductance L is continuously increasing. Plot a graph showing the variation of

(i) Magnetic flux versus the current

(ii) Induced emf versus dI/dt

(iii) Magnetic potential energy stored versus the current.

**33.** Explain the different types of materials on the basis of their energy gaps.

**OR**

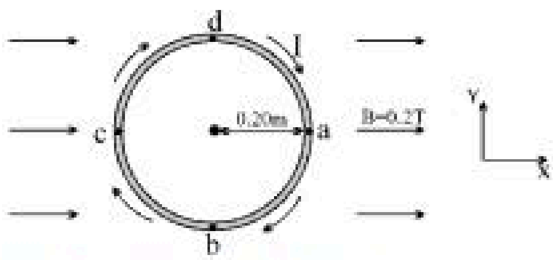
Explain the effect of doping on energy bands of a semiconductor.

## SECTION-E

**34. Case Study: Torque on a Coil**

**Read the following paragraph and answer the questions.**

A rigid circular loop has a radius of 0.20 m and is in the x-y plane. A clockwise current I is carried by the loop, as shown. The magnitude of the magnetic moment of the loop is 0.75 A-m$^2$. A uniform external magnetic field, B = 0.20 T in the positive x-direction, is present




**(i)** Find the magnitude of the magnetic torque exerted on the loop

**(ii)** In figure, an external torque changes the orientation of loop from one of lowest potential energy to one of highest potential energy. Find the work done by the external torque.

**(iii)** Current I is flowing in a coil of area A and number of turns is N, then find the magnetic moment of the coil.

**OR**

**(iii)** A circular loop of area 0.02 m$^2$ carrying a current of 10A, is held with its plane perpendicular to a magnetic field induction 0.2 T. Calculate the torque acting on the loop is.

**35. Case Study: Photoelectric Effect**

**Read the following paragraph and answer the questions.**

Read the following paragraph and answer the questions.

A physicist wishes to eject electrons by shining light on a metal surface. The light source emits light of wavelength of 450 nm. The table lists the only available metals and their work functions.

| Metal | $W_0$ (eV) |
|---|---|
| Barium | 2.5 |
| Lithium | 2.3 |
| Tantalum | 4.2 |
| Tungsten | 4.5 |

**(i)** Which metal(s) can be used to produce electrons by the photoelectric effect from given source of light ?

**(ii)** In a photoelectric effect experiment, for radiation with frequency $\upsilon_0$ with $h\upsilon_0$ = 8eV, electrons are emitted with energy 2 eV. What is the energy of the electrons emitted for incoming radiation of frequency 1.25 $\upsilon_0$?

**(iii)** Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. What will be the photoelectric current if the frequency is halved and intensity is doubled?

**OR**

**(iii)** Find the momentum of photon whose frequency is f.

# Solutions

## SAMPLE PAPER-4

1. **(c)** As all other statements are correct. In uniform electric field equipotential surfaces are never concentric spheres but are planes ⊥ to Electric field lines. (1 mark)

2. **(d)** The coil of a moving coil galvanometer is wound over metallic frame to provide electromagnetic damping so it becomes dead beat galvanometer. (1 mark)

3. **(a)** $F = IlB \sin\theta$ or $\sin\theta = \frac{F}{IlB}$

$\sin\theta = \frac{15}{10 \times 1.5 \times 2} = \frac{1}{2}$ or $\theta = 30°$ (1 mark)

4. **(c)** $B = \frac{\mu_0 i a^2}{2(x^2+a^2)^{3/2}}$

$B' = \frac{\mu_0 i}{2a} = \frac{\mu_0 i a^2}{2a(x^2+a^2)^{3/2}}\left(\frac{(x^2+a^2)^{3/2}}{a^2}\right)$

$B' = \frac{B.(x^2+a^2)^{3/2}}{a^3}$

Put $x = 4$ & $a = 3 \Rightarrow B' = \frac{54(5^3)}{3 \times 3 \times 3} = 250\mu T$ (1 mark)

5. **(a)** $\because f_0 + f_e = 30$

And magnification, $m = \frac{f_0}{f_e}$

$2 = \frac{f_0}{f_e} \Rightarrow f_0 = 2f_e \Rightarrow f_0 + \frac{f_0}{2} = 30 \therefore f_0 = 20$ cm (1 mark)

6. **(a)** Real, inverted and same in size because object is at the centre of curvature of the mirror. (1 mark)

7. **(d)** $I = nAev_d$ or $v_d \propto 1/\pi r^2$ (1 mark)

8. **(c)** Specific resistance of a conductor increases and for a semiconductor decreases with increase in temperature because for a conductor, temperature coefficient of resistivity $\alpha$ = +ve and for a semiconductar, $\alpha$ = –ve (1 mark)

9. **(b)** For coherent sources $\lambda$ is same and phase is also same or phase diff. is constant. (1 mark)

10. **(b)** P to Q: convergence increasing; Q to R : direction changing. (1 mark)

11. **(d)** $B_0 = \frac{E_0}{c} = \frac{9 \times 10^3}{3 \times 10^8} = 3 \times 10^{-5} T$. (1 mark)

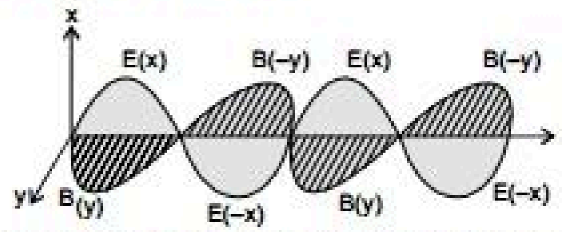
12. **(c)** $\lambda = \frac{1.227}{\sqrt{V}}$ nm, as $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

Substituting the numerical values of $h$, $m$ and $e$ we get the result. (1 mark)

13. **(d)** Positive terminal is at lower potential (0V) and negative terminal is at higher potential 5V. (1 mark)

14. **(d)** The direction of propagation of electromagnetic wave is perpendicular to both electric field E and magnetic field B, *i.e.*, in the direction of E × B by right thumb rule.

The diagram given below




So, electromagnetic wave is along the z-direction which is give the cross product of E and B direction is perpendicular to E and B from $\vec{E}$ to $\vec{B}$ .*i.e.*, $(E \times B)$ in z-direction. (1 mark)

15. **(b)** $i = \frac{A + \delta_m}{2} = \frac{60 + 30}{2} = 45°$ (1 mark)

16. **(a)** For Balmer series $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ where , $n = 3, 4, 5$ (1 mark)

17. **(b)** The individual force are unaffected due to presence of other charges. This is the principal of superposition of charges. Force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to the other charges, taken one at a time. (1 mark)

18. **(c)** Thermal collisions are responsible for taking a valence electron to the conduction band. (1 mark)

19. According to the definition of the terminal potential difference,

$V = E - Ir$

E is the EMF and r is the total internal resistance of the circuit.

$I = 0 \quad \Rightarrow V = E$

From the graph we can see

$E = 6\,V$

As there are three cells we can write,

$E = 3 \times e \quad \Rightarrow e = 2\,V$

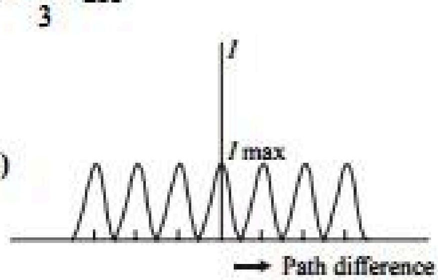
And, when, $V = 0$

$\Rightarrow E = Ir \Rightarrow r = \frac{E}{I} = \frac{6}{1} = 6\Omega$ (1+1 marks)

As per the question the cells are connected in series, so

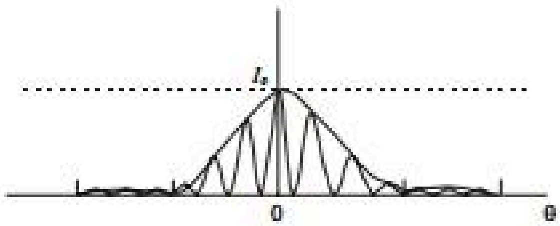
$r' = \frac{r}{3} = 2\Omega$

20. (i)




(1 mark)

(ii)




(1 mark)

**OR**

When two narrow slits are illuminated by a single monochromatic source, the pattern obtained on the screen is interference pattern which consists of alternate bright and dark fringes.

When one of the slits is covered, there is a diffraction pattern on the screen. (2 marks)

**21.** (a)


Electric field at 'O' due to +3μC at

$$A\ E_A = \frac{1}{4\pi \epsilon_0}\frac{q_A}{AO^2} = \frac{9\times10^9\times3\times10^{-6}}{(10\times10^{-2})^2}$$

$= 27\times10^5$ N/C along AO.

Electric field at 'O' due to –3μC at B,

$$E_B = \frac{1}{4\pi \epsilon_0}\frac{q_B}{BO^2} = \frac{9\times10^9\times3\times10^{-6}}{(10\times10^{-2})^2}$$

$= 27\times10^5$ N/C along OB.

Total field at O = $54 \times 10^5$ N/C towards right. (1½ marks)

(b) Force on test charge

$F = qE = 1.5\times10^{-9}\times54\times10^5 = 8.1\times10^{-3}$ N

The force is attractive acting along OA. (½ mark)

**22.** (i) Microwaves are used for aircraft navigation, their frequency range is $10^9$ Hz to $10^{12}$ Hz.

(ii) X-rays are used to study crystal structure, their frequency range is $10^{18}$ Hz to $10^{20}$ Hz. (1 + 1 = 2 marks)

**23.** As $\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ f= 15 cm

$\frac{1}{15} = (\mu-1)\left(\frac{1}{R}+\frac{1}{R}\right)$ $R_1 = R$

$R_2 = -R$

$\frac{1}{15} = (\mu-1)\frac{2}{R} \Rightarrow \frac{\mu-1}{R} = \frac{1}{30}$

When the lens is cut into two equal halves

$R_1 = R, R_2 = \infty$

$\therefore \frac{1}{f'} = (\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right) \Rightarrow (\mu-1)\times\frac{1}{R}$

$\Rightarrow \frac{1}{f'} = \frac{1}{30}$ (2 marks)

$\therefore$ f' = 30 cm.

**OR**

Focal length of convex lens, $f_1 = 30$ cm

focal length of concave lens, $f_2 = -40$ cm

As we know power of the lens

$$P = \frac{1}{f(\text{in metre})}$$

Power of the convex lens

$$P_1 = \frac{100}{f_1} = \frac{100}{30} = \frac{10}{3} = 3.33\ D$$

Power of the concave lens

$$P_2 = \frac{-100}{40} = -2.5D$$

∴ Power of the combination

$P = P_1 + P_2 = 3.33\ D - 2.5\ D = 0.83\ D$

Since the power of combination is +ve, hence system, is converging in nature. (2 marks)

**24.** The North and South poles of a bar magnet are fixed, so the direction of magnetic field of a bar magnet is fixed. The poles of a solenoid can be reverse by reversing the direction of current through it. So the direction of magnetic field of a solenoid can be changed. (2 marks)

**25.** Given : $c = 3\times10^8\ ms^{-1}$, $v = 2.5\times10^8 ms^{-1}$.

$$\mu = \frac{c}{v} = \frac{3\times10^8}{2.5\times10^8} = 1.2$$

As, $\sin c = \frac{1}{\mu} = \frac{1}{1.2} = 0.8333$

$\sin c \approx \sin 57° \therefore c = 57°$ (2 marks)

**OR**

Given : $A = 60°$. $\delta_m = 45°$.

for minimum deviation, $r_1 = r_2$

As, $r_1 + r_2 = A°$

$\therefore 2r_1 = 60° \therefore r_1 = 30°$ (2 marks)

**26.** (i) When the number of turns in the inductor is reduced, the self inductance of coil decreases; so impedance of circuit reduces and so current increases. Thus the brightness of the bulb increases.

(ii) If soft iron rod is inserted in the inductor, then the inductance L increases. Therefore, the current through the bulb will decrease, decreasing the brightness of the bulb.

(iii) When capacitor of reactance $X_C = X_L$ is introduced the net reactance of circuit becomes zero, so impedance of circuit decreases. Therefore Z = R, so current in the circuit increases, hence brightness of bulb increases. Thus brightness of bulb increases in both cases.

(1 + 1 + 1 = 3 marks)

**27.** Resistance of two heating elements are:

$P_1 = \frac{V^2}{R_1} \Rightarrow R_1 = \frac{V^2}{P_1}$ and $P_2 = \frac{V^2}{R_2}$, $R_2 = \frac{V^2}{P_2}$

(i) In series combination

$$R_S = R_1 + R_2 = \frac{V^2}{P_1} + \frac{V^2}{P_2} = V^2\left(\frac{P_1+P_2}{P_1 P_2}\right)$$

$$\therefore P_S = \frac{V^2}{R_s} = \frac{V^2}{V^2\left(\frac{P_1+P_2}{P_1 P_2}\right)} = \frac{P_1 P_2}{P_1+P_2}$$

(ii) In parallel combination

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{\frac{V^2}{P_1}} + \frac{1}{\frac{V^2}{P_2}} = \frac{P_1}{V^2} + \frac{P_2}{V^2}$$

$$\frac{1}{R_p} = \frac{1}{V^2}(P_1+P_2)$$

power consumption in parallel combination

$$P_p = \frac{V^2}{R_p} = V^2\left[\frac{1}{V^2}(P_1+P_2)\right] = P_1 + P_2$$ (1½+ 1½ =3 marks)

**OR**

From Kirchoff's Ist rule or junction rule

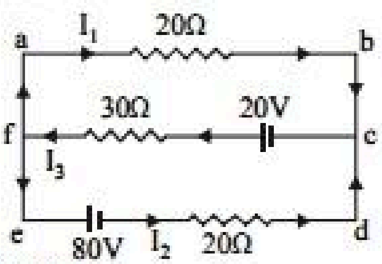
For junction f,

$I_1 + I_2 = I_3$

or, $I_1 = I_3 - I_2$ ... (i)

From kirchoff's 2nd rule or loop rule

In loop 'abcfa'




$-20I_1 + 20 - 30I_3 = 0$

or, $2I_1 + 3I_3 = 2$ ... (ii)

In loop 'fcdef,'

$30I_3 - 20 + 20I_2 - 80 = 0$

or, $3I_3 + 2I_2 = 10$ ... (iii)

Substituting equation (i) in (ii)

$2(I_3 - I_2) + 3I_3 = 2$

or, $5I_3 - 2I_2 = 2$ ...(iv)

Adding equations (iii) and (iv)

$8I_3 = 12$

or, $I_3 = 3/2$ A

Substituting in equation (iii) and solving

$I_2 = 11/4$A

Substituting for $I_3$ and $I_2$ in equation (i)

$I_1 = 3/2 - 11/4 = -5/4$ A (3 marks)

**28.** The positions of secondary minima are at $\theta = \frac{n\lambda}{a}$. Consider first the angle θ where the path difference is λ, then $\theta = \frac{\lambda}{a}$. Now divide the slit into two equal halves each of size $\frac{a}{2}$. Therefore, the path difference between the waves arising from the two halves of the slit will be $\frac{\lambda}{2}$. As a result the waves reaching at any point on the screen will have a phase difference of 180° and hence cancel each other. Therefore, the intensity fall to zero and a minimum is produced. (3 marks)

**29.** If, $F_c$ – centripetal force required to keep a revolving electron in orbit

$F_e$ – electrostatic force of attraction between the revolving electron and the nucleus then, for a dynamically stable orbit in a hydrogen atom, where Z = 1,

$F_c = F_e$

$$\frac{mv^2}{r} = \frac{(e)(e)}{4\pi\varepsilon_0 r^2} \quad \text{...(i)}$$

$$r = \frac{e^2}{4\pi\varepsilon_0 mv^2} \quad \text{...(ii)}$$

K.E. of electron in the orbit, $K = \frac{1}{2}mv^2$

From equation (i), $K = \frac{e^2}{8\pi\varepsilon_0 r}$

Potential energy of electron in orbit,

$$U = \frac{(e)(-e)}{4\pi\varepsilon_0 r} = \frac{-e^2}{4\pi\varepsilon_0 r}$$

Negative sign indicates that revolving electron is bound to the positive nucleus.

∴ Total energy of electron in hydrogen atom

$$E = k + U = \frac{e^2}{8\pi\varepsilon_0 r} - \frac{e^2}{4\pi\varepsilon_0 r}\ ;\ \boxed{E = -\frac{e^2}{8\pi\varepsilon_0 r}}$$ (2 marks)

Therefore, total energy of electrons in orbit of hydrogen atom is negative. Hence, the electron bound to the nucleus i.e., the electron is not free to leave the orbit around the nucleus. (1 mark)

**OR**

According to the postulates of Bohr's atomic model, the electrons revolve around the nucleus only in those orbits for which the angular momentum is the integral multiple of $h/2\pi$. Where h is plank's constant.

$\therefore L = nh/2\pi$

Angular momentum is given by $L = mvr$

According to Bohr's postulate,

$$L_n = mv_n r_n = \frac{nh}{2\pi} \quad \text{...(i)}$$

$$v_n = \frac{nh}{2\pi m r_n}$$ [from equation (i)]

From, Bohr's postulate of atomic model

$$\frac{mv_n^2}{r_n} = \frac{Kze^2}{r_n^2}\ ;\ r_n = \frac{Kze^2}{mv_n^2}$$

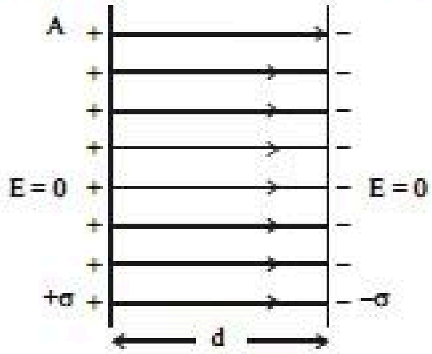
Putting the value of vn and z = 1 (for hydrogen atom).

$$r_n = \frac{n^2h^2}{4\pi^2 mKe^2}$$ (3 marks)

This is the expression for Bohr's radius. This shows $r \propto n^2$.

**30.** As $n^0$ no. and $p^+$ no. are conserved, the rest mass of $n^0$ and $p^+$ is same but total binding energy is not same on either side of nuclear reaction. This diference appears in form of energy released or absorbed in the nuclear reaction. Since B. E contributes to mass thus we say that difference in masses of nuclei on two sides of the reactio gets converted into energy. This is mass-energy interconversion. (3 marks)

**31.** Let Q = Total charge on each plate of the capacitor, A = Area of each plate




$\therefore$ Surface charge density $\sigma = \dfrac{Q}{A}$

$\because$ E is uniform between the plates

$\therefore\ E = \dfrac{\sigma}{\varepsilon_0} = \dfrac{Q}{\varepsilon_0 A}$

$\therefore\ C = \dfrac{Q}{V} = \dfrac{Q}{Ed} (\because V = Ed)$

or, $C = \dfrac{Q}{\dfrac{Qd}{\varepsilon_0 A}} = \dfrac{\varepsilon_0 A}{d}$ (3 marks)

When the capacitor is charged to a potential V, the charge stored in the capacitor Q = CV. Now capacitor is disconnected from the source and distance between the plates is doubled.

(i) Capacitance $= C = \dfrac{Q}{V} = \dfrac{Q}{Ed}$

$\therefore$ New capacitance $C' = \dfrac{Q}{2Ed} = \dfrac{C}{2}$

$\therefore$ Capacitance becomes half. (1 mark)

(ii) Energy $= \dfrac{Q^2}{2C'} = \dfrac{Q^2}{2C/2} = 2\dfrac{Q^2}{2C} = 2E.$

$\therefore$ Energy becomes double. (1 mark)

**OR**

(a) Let $C_1$ and $C_2$ are the capacitances, $q_1$ and $q_2$ are the charges, $V_1$ and $V_2$ are potential of the capacitors respectively.

$\therefore\ q_1 = C_1V_1$ and $q_2 = C_2V_2$

Before sharing, total charge $= q_1 + q_2$

$= C_1V_1 + C_2V_2$

When the capacitors are joined by a wire, charge will flow from higher to lower potential till both the potentials are equal. This equal potential is called common potential (V)

If $q'_1$ and $q'_2$ are charges on $C_1$ and $C_2$ after redistribution of charges, then

$q'_1 = C_1V$ and $q'_2 = C_2V$

$\because$ Total charge after connecting them together remains same as before.

$q = q'_1 + q'_2 = C_1V + C_2V = (C_1 + C_2)V$

$\therefore (C_1 + C_2)V = C_1V_1 + C_2V_2$

$V = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$ (2½ marks)

(b) P.E. before sharing $= \dfrac{1}{2}C_1V_1^2 + \dfrac{1}{2}C_2V_2^2$

P.E. after sharing $= \dfrac{1}{2}C_1V^2 + \dfrac{1}{2}C_2V^2 = \dfrac{1}{2}(C_1 + C_2)V^2$

$= \dfrac{1}{2}(C_1 + C_2)\left[\dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}\right]^2 = \dfrac{1}{2}\dfrac{(C_1V_1 + C_2V_2)^2}{(C_1 + C_2)}$

$\therefore$ Loss of energy $= \dfrac{1}{2}C_1V_1^2 + \dfrac{1}{2}C_2V_2^2$

$-\dfrac{1}{2}\dfrac{(C_1V_1 + C_2V_2)^2}{(C_1 + C_2)}$

$= \dfrac{1}{2(C_1 + C_2)}\ [(C_1V_1^2 + C_2V_2^2)\ (C_1 + C_2)$

$- (C_1V_1 + C_2V_2)^2]$

$= \dfrac{1}{2(C_1 + C_2)}\ [C_1^2V_1^2 + C_1C_2V_1^2 + C_1C_2V_2^2 + C_2V_2^2$

$- C_1^2V_1^2 - C_2^2V_2^2 - 2C_1C_2V_1V_2]$

$= \dfrac{1}{2(C_1 + C_2)}\ C_1C_2(V_1^2 + V_2^2 - 2V_1V_2)$

$= \dfrac{C_1C_2}{2(C_1 + C_2)}(V_1 - V_2)^2$ = Positive (2½ marks)

$\therefore$ Energy is lost due to sharing of charges.

**32.** (i) Faraday gave two laws of electromagnetic induction.

**First law :** *Whenever there is change in the magnetic flux associated with a circuit, an e.m.f. is induced in the circuit. This is also known as Neumann's law*

**Second law :** *The magnitude of the induced e.m.f. (e) is directly proportional to the time rate of change of the magnetic flux through the circuit.*

i.e., $e \propto \dfrac{\Delta\phi}{\Delta t}$ or, $e = k\dfrac{\Delta\phi}{\Delta t}$ (2 marks)

(a) (i) When coil A is placed parallel to B and near to it, due to mutual induction an e.m.f is induced in B and the bulb lights up.

(b) When the coil B is moved upwards, distance between A and B increases. Hence the magnetic flux linked with B decrease and mutual induction decreases and hence the bulb gets dimmer.

**OR**

(a) **Lenz's law and conservation of energy:** Lenz's law is according to law of conservation of energy because when N-pole of a magnet is moved towards the coil, the upper face of the coil acquires north polarity. So work has to be done against the force of repulsion in bringing the magnet closer to the coil.

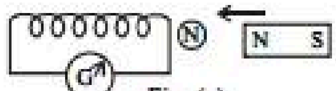


Fig. (a)

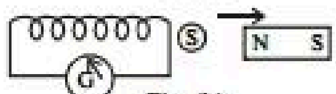


Fig. (b)

When the N-pole is moved away, south polarity is developed on the upper face of the coil. Therefore, work has to be done against the force of attraction in taking the magnet away from the coil. (2 marks)

∴ Mechanical work done is converted into electrical energy of the coil.

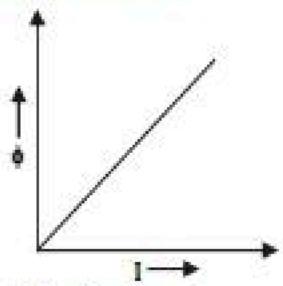
When the magnet does not move work done is zero, so no electrical energy is produced.

(b) (i) Since

where, $I$=Strength of current through the coil at any time

$\phi$ = Amount of magnetic flux linked with all turns of the coil at that time

and, L = Constant of proportionality called coefficient of self induction

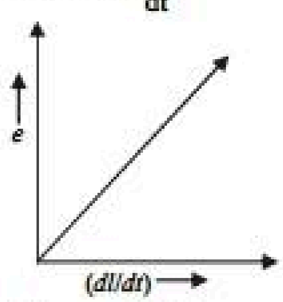



(1 mark)

(ii) Induced emf,

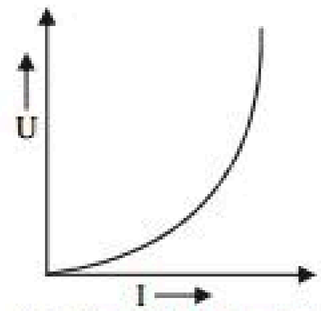
$$e = \frac{-d\phi}{dt} = \frac{-d}{dt}(LI)$$

i.e., $e = -L\frac{dI}{dt}$ (1 mark)



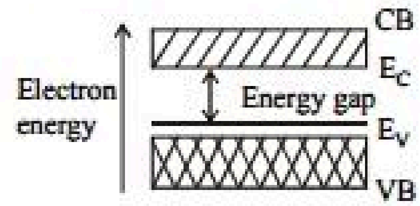

[The graph is drawn considering only magnitude of $e$]

(iii) Since magnetic potential energy is given by, $U = \frac{1}{2}LI^2$




(1 mark)

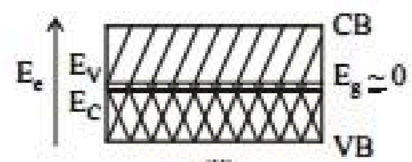
**33.** According to the band theory, each atom has two bands, valence band (energy $E_V$) and conduction band (energy $E_C$) consisting of closely spaced energy levels. Their difference is called energy gap or band gap $E_g$ (fig. (Q-1)).



(i)

(2 marks)

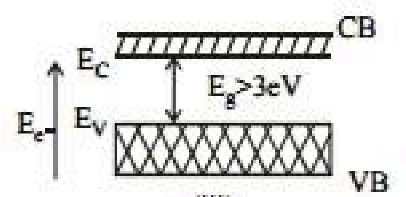
**Case 1:** When both bands overlap (fig. (ii)), electrons in valence orbit are free to move in conduction band and cause current to flow ($E_g \approx 0$). These are **metals.**



(ii)

(1 mark)

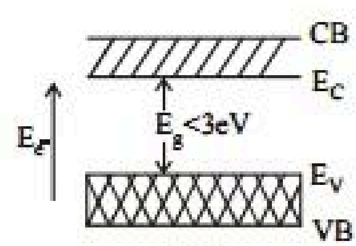
**Case 2:** When band gap is large, the electrons in valence band are bound and cannot move to conduction band ($E_g > 3$ eV). These materials donot not carry current. They are **insulators** (fig. (iii)).



(iii)

(1 mark)

**Case 3:** When band gap is finite but small ($E_g < 3$ eV) then electron from valence band can easily pick external energy (heat or voltage) and go to conduction band. Such materials have resistance lower than insulators and are called semiconductors.

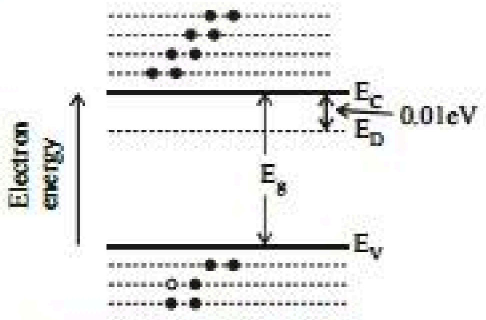


(iv)

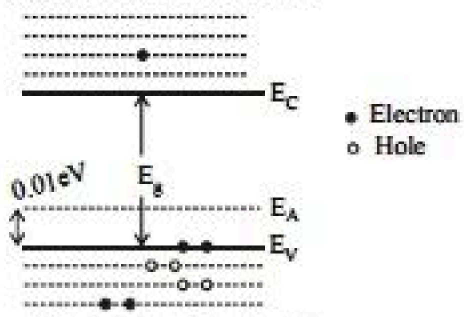
(1 mark)

**OR**

The energy band structure of a semiconductor has donor or acceptor energy states after doping, which are given by $E_D$ or $E_A$ respectively. In n–type semiconductor, donor energy level $E_D$ is slightly below the bottom $E_C$ of the conduction band and electrons from this level can easily move into the conduction band with very small amount of energy.



**(a) n–type semiconductor**



**(b) p-type semiconductor**

At room temperature most donar atoms are ionised but very few Si atoms are ionised so that conduction band has mostly donor electrons. For p–type semiconductor, the acceptor energy level $E_A$ is slightly above valence band so that electrons from valence band can easily jump to this level $E_A$ and ionise acceptor atom, thus leaving a hole in the valence band. At room temperature, most of acceptor atoms get ionised leaving holes in the valence band which conduct charge. The electron and hole concentration in a semiconductor is given by $n_e n_h = n_i^2$ (5 marks)

**34.** **(i)** $\tau = m\beta\sin\theta = 0.75 \times 0.20 = 0.15$ Nm (1 mark)

**(ii)** Work done by external torque,

$W = MB(1 - \cos\theta)$

$= 0.75 \times 0.2(1 - \cos 180°)$

$= 0.15(1+1) = 0.3$ J (2 marks)

**(iii)** Magnetic moment = NIA (1 mark)

**OR**

**(iii)** Torque = IAB

$= 10 \times 0.02 \times 0.2 = 0.04$ Nm (1 mark)

**35.** **(i)** $\Delta E = \frac{12400}{4500 Å} = 2.75$ eV (1 mark)

For photoelectric effect, $\Delta E > W_0$ (work function).

Barium or Lithium can be used to produce electrons.

**(ii)** $h\upsilon = W_{ex}$ + maximum kinetic energy

$h\upsilon_0 = 8\text{ eV} = W_{ex} + 2\text{ eV} \Rightarrow W_{ex} = 6\text{ eV}$

For incoming radiation, energy is

$h \times 1.25\,\upsilon_0 = 10\text{ eV}, W_{ex} = 6\text{ eV}$

$\therefore$ Kinetic energy (maximum) = 4 eV. (1 mark)

**(iii)** For photoelectric emission, photoelectric current, incident light frequency should be greater than threshold frequency.

Light of frequency 1.5 times the threshold frequency $v_0$ incident.

$$v = \frac{3}{2}v_0$$

If frequency is halved,

$$\therefore v' = \frac{v}{2} = \frac{3}{4}v_0 \qquad \because v' < v_0$$

$\therefore$ No photoelectric emission will take place. (2 marks)

**OR**

**(iii)** Moment of photon $= p = \frac{h}{\lambda} \because E = mc^2$

But, $p = mc$ $\quad \therefore E = mc.c$ So, $E = pc$ or $E = \frac{hc}{\lambda}$

$\therefore \frac{hc}{\lambda} = pc$ or $p = \frac{h}{\lambda}$ and $\lambda = \frac{c}{f}$

$\therefore p = \frac{hf}{c}$ (2 marks)