Code No. **042**

Roll No. ☐☐☐☐☐☐☐

- Please check that this question paper contains **5** printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains **33** questions.
- **Please write down the Serial Number of the question before attempting it.**
- 15 minutes time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

PHYSICS–XII
Sample Paper (Solved)

Time allowed : 3 hours *Maximum marks : 70*

General Instructions:

SECTION-A

All questions are compulsory. In case of internal choices, attempt any one of them.

Q.1. Does the charge given to a metallic sphere depend on whether it is hollow or solid? Give reason for your answer.

Q.2. Name the part of electromagnetic spectrum whose wavelength lies in the range of 10^{-10} m. Give its *one* use.

Or

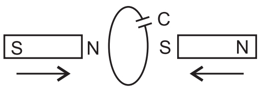
How is the speed of em-waves in vacuum determined by the electric and magnetic fields?

Q.3. Write the expression, in a vector form, for the Lorentz magnetic force $\vec{F}$ due to a charge moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ .What is the direction of the magnetic force?

Q.4. A light metal disc on the top of an electromagnet is thrown up as the current is switched on. Why? Give reason.

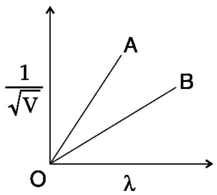
Or

Two bar magnets are quickly moved towards a metallic loop connected across a capacitor 'C' as shown in the figure. Predict the polarity of the capacitor.



Q.5. The radius of innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. What is the radius of orbit in the second excited state?

Q.6. Figure shows a plot of $\frac{1}{\sqrt{V}}$, where V is the accelerating potential, *vs.* the *de-Broglie* wavelength 'λ' in the case of two particles having same charge '*q*' but different masses m_1 and m_2. Which line (A or B) represents a particle of larger mass?



Q.7. State *two* characteristic properties of nuclear force.

Or

Two nuclei have mass number in the ratio 1 : 3. What is the ratio of their nuclear densities?

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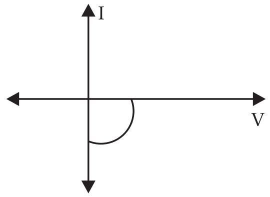
Q.8. The current in the forward bias is known to be more (~mA) than the current in the reverse bias (~μA). What is the reason, then, to operate the photodiode in reverse bias?

Or

Name the junction diode whose I-V characteristics are drawn here:



Q.9. What is the difference between an n-type and a p-type intrinsic semiconductor?

Q.10. What happens to the width of depletion layer of a p-n junction when it is (i) forward biased, (ii) reverse biased?

For question numbers 11, 12, 13 and 14, 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.***

Q.11. ***Assertion (A):*** The force with which two charges attract or repel each other are not affected by the presence of a third charge kept at a long distance.

Reason (R): Force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to other charges, taken one at a time.

Q.12. ***Assertion (A):*** The potential difference between two conductors of a capacitor is small.

Reason (R): A capacitor is so configured that it confines the electric field lines within a small region of space.

Q.13. ***Assertion (A):*** Combination of lenses helps to obtain diverging or converging lenses of desired magnification.

Reason (R): It enhances sharpness of the image.

Q.14. ***Assertion (A):*** In Young's double slit experiment, interference pattern disappears when one of the slits is closed.

Reason (R): Interference occurs due to superimposition of light waves from two coherent sources.

SECTION-B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub-parts from each question. Each question carries 1 mark.

Q.15. Capacitors & Capacitance

A capacitor is a system of two conductors separated by an insulator. These two conductors may be charged by connecting them to a battery. It may be noted that the charge is on one of the conductors—the total charge of the capacitor is zero.

The potential difference (V) is directly proportional to the charge (Q) and the ratio (Q/V) is a constant (C), which is called the **capacitance** of capacitor.

These capacitors can be combined in series, parallel and mixed combinations depending upon the requirement of specific values of capacitance.

(i) The magnitude of electric field E in the annular region of a charged cylindrical capacitor:

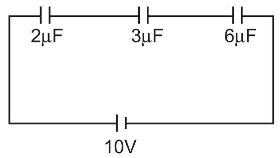
(a) is the same throughout.

(b) is higher near the outer cylinder than near the inner cylinder.

(c) varies as $\frac{1}{r^2}$ where r is the distance from the axis.

(d) varies as $\frac{1}{r^3}$ where r is the distance from the axis.

(ii) The charge on 3μF capacitor shown in the figure is:



(a) 2 μC

(b) 10 μC

(c) 6 μC

(d) 8 μC

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(*iii*) **Two identical capacitors are joined in parallel, charged to a potential V, separated and then connected in series, the positive plate of one is connected to the negative of the other. Which of the following is true?**

(*a*) The charges on the free plates connected together are destroyed.
(*b*) The energy stored in the system increases.
(*c*) The potential difference between the free plates is 2V.
(*d*) The potential difference remains constant.

(*iv*) **A parallel plate capacitor is made by placing n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C then the resultant capacitance is**

(*a*) nC (*b*) $\frac{C}{n}$ (*c*) $(n + 1)$C (*d*) $(n - 1)$C

(*v*) **A parallel plate air capacitor is charged to a potential difference of V volts. After disconnecting the charging battery the distance between the plates of the capacitor is increased using an insulating handle. As a result the potential difference between the plates**

(*a*) increases (*b*) decreases
(*c*) does not change (*d*) becomes zero

Q.16. **Huygens' Principle**

The corpuscular (particle) model of light was developed by Sir Isaac Newton; while in 1678, the Dutch physicist Huygens put forward the wave theory of light. The wave model of light could satisfactorily explain the phenomena of Reflection and Refraction. A locus of points, which oscillate in phase is called a **wavefront**, which is defined as a surface of constant phase. Huygens' principle is used to determine the shape of the wave front. The laws of reflection and refraction can be derived from Huygens' Principle.

(*i*) **When a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our TV screen. This is because of .... between the direct signal and reflected signal. (Fill in the blank)**

(*a*) interference (*b*) diffraction
(*c*) polarisation of direct signal (*d*) Both (*b*) and (*c*)

(*ii*) **The refractive index of glass is 1.5 for light waves of λ = 6000 Å in vacuum. Its wavelength in glass is:**

(*a*) 2000 Å (*b*) 4000 Å (*c*) 1000 Å (*d*) 3000Å

(*iii*) **Spherical wavefronts, emanating from a point source, strike a plane reflecting surface. What will happen to these wave fronts, immediately after reflection?**

(*a*) They will remain spherical with the same curvature, both in magnitude and sign.
(*b*) They will become plane wave fronts.
(*c*) They will remain spherical, with the same curvature, but sign of curvature reversed.
(*d*) They will remain spherical, but with different curvature, both in magnitude and sign.

(*iv*) **Light propagates rectilinearly due to:**

(*a*) wave nature (*b*) wavelengths (*c*) velocity (*d*) frequency

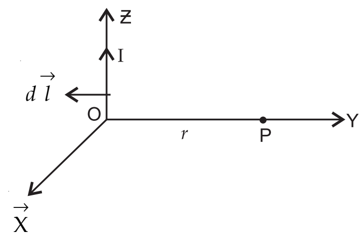
(*v*) **A plane wave passes through a convex lens. The geometrical shape of the wave-front that emerges is:**

(*a*) plane (*b*) diverging spherical
(*c*) converging spherical (*d*) none of these

SECTION-C

All questions are compulsory. In case of internal choice, attempt any one.

Q.17. State Biot-Savart law. A current I flows in a conductor placed perpendicular to the plane of the paper. Indicate the direction of the magnetic field due to a small element $\vec{dl}$ at point P situated at a distance $\vec{r}$ from the element as shown in the figure.



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Q.18. A parallel beam of light of 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Calculate the width of the slit.

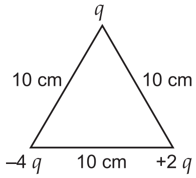
Q.19. Two point charges 20×10^{-6} C and -4×10^{-6} C are separated by a distance of 50 cm in air.

(*i*) Find the point on the line joining the charges, where the electric potential is zero.

(*ii*) Also find the electrostatic potential energy of the system.

Or

Calculate the work done to dissociate the system of three charges placed on the vertices of a triangle as shown.



Q.20. Mention the important considerations required while fabricating a *p-n* junction diode to be used as a Light Emitting Diode (LED). What should be the order of band gap of an LED if it is required to emit light in the visible range?

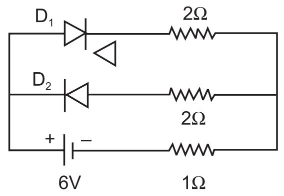
Q.21. Define self-inductance of a coil. Show that magnetic energy required to build up the current I in a coil of self inductance L is given by $\frac{1}{2}$ LI^2.

Q.22. ***Answer the following questions :***

(*i*) In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

(*ii*) When a tiny circular obstacle is placed in the path of light from a distance source, a bright spot is seen at the centre of the shadow of the obstacle. Explain, why?

Q.23. Assuming that the two diodes D_1 and D_2 used in the electric circuit shown in the figure are ideal, find out the value of the current flowing through 1 Ω resistor.



Q.24. A straight wire extending from east to west falls with a speed v at right angles to the horizontal component of the Earth's magnetic field. Which end of the wire would be at the higher electrical potential and why?

Or

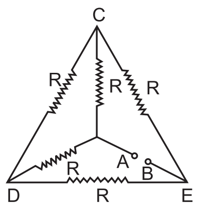
Where on the surface of Earth is the Earth's magnetic field perpendicular to the surface of the Earth?

Q.25. A ray of light passes through an equilateral prism in such a way that the angle of incidence is equal to the angle of emergence and each of these angles is 3/4 times the angle of the prism. Determine—(*i*) the angle of deviation and (*ii*) the refractive index of the prism.

SECTION-D

All questions are compulsory. In case of internal choices, attempt any one.

Q.26. Starting from the expression for the energy $W = \frac{1}{2} LI^2$, stored in a solenoid of self-inductance L to build up the current I, obtain the expression for the magnetic field B, area A and length l of the solenoid having n number of turns per unit length. Hence show that the energy density is given by $B^2/2\mu_0$.



Q.27. (*i*) Calculate the equivalent resistance of the given electrical network between points A and B.

(*ii*) Also calculate the current through CD and ACB, if a 10 V d.c. source is connected between A and B, and the value of R is assumed as 2 Ω.

Q.28. Define the terms—(*i*) 'cut-off voltage' and (*ii*) 'threshold frequency' in relation to the phenomenon of photoelectric effect.

Using Einstein's photoelectric equation show how the cut-off voltage and threshold frequency for a given photosensitive material can be determined with the help of a suitable plot/graph.

Or

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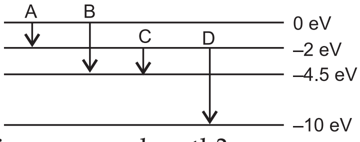
Sketch the graph showing variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies $\upsilon_A > \upsilon_B$.

(*i*) In which case is the stopping potential more and why?

(*ii*) Does the slope of the graph depend on the nature of the material used? Explain.

Q.29. (*a*) The energy levels of an atom are as shown here. Which of them will result in the transition of a photon of wavelength 275 nm?



(*b*) Which transition corresponds to emission of radiation of maximum wavelength?

Q.30. Draw a plot of potential energy of a pair of nucleons as a function of their separations. Mark the regions where the nuclear force is (*i*) attractive and (*ii*) repulsive. Write any *two* characteristic features of nuclear forces.

SECTION-E

All questions are compulsory. In case of internal choices, attempt any one.

Q.31. (*a*) State the working principle of a potentiometer. With the help of the circuit diagram, explain how a potentiometer is used to compare the emfs of two primary cells. Obtain the required expression used for comparing the emfs.

(*b*) Write *two* possible causes for one sided deflection in a potentiometer experiment.

Or

(*i*) Define the term drift velocity.

(*ii*) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistivity of a conductor depend?

(*iii*) Why alloys like constantan and manganin are used for making standard resistors?

Q.32. Derive an expression for the impedance of a series LCR circuit connected to an AC supply of variable frequency.

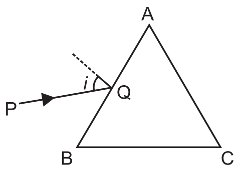
Plot a graph showing variation of current with the frequency of the applied voltage. Explain briefly how the phenomenon of resonance in the circuit can be used in the tuning mechanism of a radio or a TV set.

Or

(*a*) Explain with the help of a labelled diagram, the principle and working of a transformer. Deduce the expression for its working formula.

(*b*) Name any *four* causes of energy loss in an actual transformer.

Q.33. (*a*) A ray 'PQ' of light is incident on the face AB of a glass prism ABC (as shown in the figure) and emerges out of the face AC. Trace the path of the ray. Show that $\angle i + e = \angle A + \angle\delta$. where δ and e denote the angle of deviation and angle of emergence respectively. Plot a graph showing the variation of the angle of deviation as a function of angle of incidence. State the condition under which $\angle\delta$ is minimum.



(*b*) Find out the relation between the refractive index (μ) of the glass prism and $\angle A$ for the case when the angle of prism (A) is equal to the angle of minimum deviation (δ_m). Hence obtain the value of the refractive index for angle of prism A = 60°.

Or

(*a*) (*i*) "Two independent monochromatic sources of light cannot produce a sustained interference pattern". Give reason.

(*ii*) Light waves each of amplitude 'a' and frequency 'ω', emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by $y_1 = a \cos \omega t$ and $y_2 = a \cos(\omega t + \phi)$ where ϕ is the phase difference between the two, obtain the expression for the resultant intensity at the point.

(*b*) In Young's double slit experiment, using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$.

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Answer Sheet

S	A	M	P	L	E							P	A	P	E	R		

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PHYSICS

SECTION – A

1. *No*, it does not, because the charge resides only on the surface of the conductor.

2. **Name:** *X-rays*

Use: In medical diagnosis to look for broken bones; treatment study of crystal structure.

Or

Speed of electromagnetic waves in vacuum is determined by the ratio of the peak values of electric and magnetic field vectors.

i.e., $C = \frac{E_0}{B_0}$

3. $\vec{F} = q(\vec{V} \times \vec{B})$ **...[*q* is the magnitude of the moving charges**

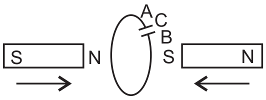
This force is normal to both the directions of velocity $\vec{V}$ and magnetic field $\vec{B}$.

4. Because of Eddy Current.

If the upper force of the core of the electromagnet acquires north polarity, then according to Lenz's Law, the lower face of the disc will also acquire north polarity. Due to the force of repulsion between the lower face (N-pole) of the core of the electromagnet, the disc jumps upto a certain height.

Or

When both magnets move towards the loop, the A side plate of capacitor will be positive while the lower plate B is negative, making the induced current in a clockwise direction.



5. $r = n^2 \times 5.3 \times 10^{-11}$ m

$\therefore$ Radius of second excited state ($n = 3$) is:

$r = (3)^2 \times 5.3 \times 10^{-11}$ m $= 9 \times 5.3 \times 10^{-11}$ m $= \mathbf{4.77 \times 10^{-10}}$ **m**

6. As $\lambda = \frac{h}{\sqrt{2mqV}}$ because slope $\propto = \frac{1}{\sqrt{m}}$.

Slope of line B > Slope of line A

$$\frac{1}{\sqrt{m_B}} > \frac{1}{\sqrt{m_A}} \quad \Rightarrow \quad \sqrt{m_B} < \sqrt{m_A} \quad \therefore \quad m_B < m_A$$

$\therefore$ Line B represents a particle of smaller mass, will have greater slope which is represented by the graph 'B'.

7. (*i*) Nuclear forces are the strongest force in nature.

(*ii*) They are saturated forces.

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(*iii*) They are charge independent.

Or

Since nuclear density is independent of the mass number, the ratio of nuclear densities will be 1 : 1.

[Hint: Radius of nucleus, $R = R_0A^{1/3}$

Density $= \frac{Mass}{Volume} = \frac{mA}{\frac{4}{3}\pi R^3} = \frac{mA}{\frac{4}{3}\pi(R_0A^{1/3})^3} = \frac{mA}{\frac{4}{3}\pi(R_0^3A)} = \frac{m}{\frac{4}{3}\pi R^3}$

8. The fractional increase in majority carriers is much less than the fractional increase in minority carriers. Consequently, the fractional change due to the photo-effects on the minority carrier dominated reverse bias current is more easily measurable than the fractional change in the majority carrier dominated forward bias current.

Or

Solar Cell

9.

n-type semiconductor	*p-type semiconductor*
The electron density (n_e) is much greater than the hole density (n_h), *i.e.*, $n_e >> n_h$.	The hole density (n_h) is much greater than the electron density (n_e), *i.e.*, $n_h >> n_e$.

10. (*i*) In forward biased, the width of depletion layer of a *p-n* junction *decreases*.
(*ii*) In reverse biased, the width of depletion layer of a *p-n* junction *increases*.

11. **(*b*)** Both A and R are true but R is Not the correct explanation of A.
[Hint: Force of any charge due to other charges is the vector sum of all the forces on that charge due to other charges, taken one at a time. The individual forces are unaffected due to the presence of other charges. This is the principle of superimposition of charges.

12. **(*a*)** Both A and R are true and R is the correct explanation of A.
[Hint: Even though the field may have considerable strength, the potential difference between two conductors of a capacitor is small, because the field lines are confined within a small region of space.

13. **(*b*)** Both A and R are true but R is Not the correct explanation of A.

14. **(*a*)** Both A and R are true and R is the correct explanation of A.

SECTION – B

15. **(*i*)** **(*c*)** varies as $\frac{1}{r^2}$ where r is the distance from the axis.

(*ii*) **(*b*)** 10 μC ***[Hint:*** $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ ***and*** $q = CV$

(*iii*) **(*c*)** The potential difference between the free plates is 2V. ***[Hint:*** $V = V_1 + V_2 = V + V = 2V$

(*iv*) **(*d*)** $(n - 1)C$ ***...[Hint:*** $C_{eq} = (n - 1)C$

(*v*) **(*a*)** increases

16. **(*i*)** **(*a*)** interference

(*ii*) **(*b*)** 4000 ***[Hint:*** $\mu = \frac{c}{\lambda} = \frac{\lambda v}{\lambda g} \therefore \lambda g = \frac{\lambda v}{\mu} = \frac{6,000}{1.5} = 4,000$

(*iii*) **(*c*)** They will remain spherical, with the same curvature, but sign of curvature reversed.

(*iv*) **(*a*)** wave nature

(*v*) **(*c*)** converging spherical

SECTION – C

17. ***Biot-Savart law and its applications :*** Biot-Savart law states that "*the magnitude of the magnetic field dB at any point due to a small current element dl is given by*

$$dB = \frac{\mu_0}{4\pi} Idl \frac{\sin\theta}{r^2}.$$

...where [I is the magnitude of current; *dl* is the length of element; θ is the angle length of between the element and the line joining the element to the point of observation; r is the distance of the point from the element.

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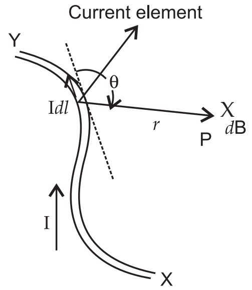
In vector form, $d\vec{B} = \frac{\mu_0}{4\pi} I \frac{\left(d\vec{l} \times \vec{r}\right)}{r^3}$



Its S.I. unit is tesla. Its direction is perpendicular to the plane in which $d\vec{l}$ and $\vec{r}$ lie

Since, $dB \propto I \left(d\vec{l} \times \vec{r}\right)$

dB is the direction given by $\left(dl\hat{k} \times r\hat{j}\right)$

i.e., $-dlr\ \hat{i}$ is along the negative x-axis.

18. **Given.** λ = 500 nm = 500 × 10^{-9}m, D = 1, x_n = 2.5 mm = 2.5 × 10^{-3} m, n = 1

As we know, $\frac{x_n d}{D} = n\lambda$

$$d = \frac{n\lambda D}{x_n}$$

$$\therefore \quad d = 1 \times (500 \times 10^{-9}) \times \frac{1}{2.5 \times 10^{-3}} = \mathbf{2 \times 10^{-4}\ m}$$

19. (*i*) Here q_1 = 20 × 10^{-6} C, q_2 = –4 × 10^{-6} C and AB = 50 cm = 0.50 m = 0.5m

Let AP = x then PB = 0.5 – x

Potential at P due to charge $q_1 = \frac{Kq_1}{AP}$

Potential at P due to charge $q_2 = \frac{Kq_2}{PB}$

$\because$ Potential at P = 0 $\Rightarrow \frac{Kq_1}{AP} + \frac{Kq_2}{PB} = 0$

$\Rightarrow \frac{Kq_1}{AP} = -\frac{Kq_2}{PB}$ $\Rightarrow \frac{q_1}{AP} = -\frac{q_2}{PB}$

$\Rightarrow \frac{20 \times 10^{-6}}{x} = -\frac{(-4 \times 10^{-6})}{0.5 - x}$ $\Rightarrow \frac{20}{x} = \frac{4}{0.5 - x}$

$\Rightarrow 10 - 20x = 4x$ $\Rightarrow 24x = 10$ $\therefore x = \frac{10}{24} = \mathbf{\frac{5}{12}}$ m

(*ii*) $U = \frac{Kq_1q_2}{r} = \frac{9 \times 10^9 (20 \times 10^{-6})(4 \times 10^{-6})}{50 \times 10^{-2}} = \mathbf{1.45\ J}$

Or

Initial P.E. of the three charges

$$u_i = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r} + \frac{q_2q_3}{r} + \frac{q_1q_3}{r}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q(-4q)}{r} + \frac{(-4q) \times 2q}{r} + \frac{q \times 2q}{r}\right]$$

$$= -\frac{1}{4\pi\varepsilon_0} \cdot \frac{10q^2}{r} = \frac{-9 \times 10^9 \times 10 \times (1.6 \times 10^{-10})^2 \text{J}}{0.10}$$

$$= \frac{-9 \times 10^9 \times 10 \times 2.56 \times 10^{-20} \times 100}{10} = -23.04 \times 10^{-9} = \mathbf{-2.304 \times 10^{-8}\ J}$$

Final P.E, $u_f = 0$

$\therefore$ Work required to dissociate the system of three charges, W = $u_f - u_i$ = **–2.304 × 10^{-8} J**

20. ***The important considerations required while fabricating a p-n junction diode to be used as a Light Emitting Diode (LED) are:***

(*i*) The Light Emitting efficiency is maximum.

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(*ii*) The reverse breakdown voltage of LEDs are very low. Care should be taken that high reverse voltages do not appear across them.

(*iii*) The semiconductor used for fabrication of visible LEDs must have a band gap of 1.8 eV (spectral range of visible light is from about 0.4 μm to 0.7 μm *i.e.* from about 3 eV to 1.8 eV).

21. The self-inductance of a coil may be defined as the induced emf set up in the coil due to a unit rate of change of current through it.

Let I be the current through the inductor L at any instant *t*.

The current rises at the rate *dI/dt*, so the induced emf is $e = -L\frac{dI}{dt}$

Work done against the induced emf in small time *dt* is

$$dW = |e|\, I dt = LI\frac{dI}{dt}\, dt = LIdI$$

Total work done in building up the current from 0 to I in

$$W = \int dW = \int_0^I LIdI = L\int_0^I IdI = L\left[\frac{I^2}{2}\right]_0^I = \frac{1}{2}LI^2$$

This work done is stored as the magnetic field energy U in the inductor.

$$\therefore\ U = \frac{1}{2}LI^2$$

22. (*i*) ***Diffraction from each slit is related to interference pattern in a double slit experiment in the following ways:***

- The intensity of minima for diffraction is never zero, while for interference it is generally zero.
- All bright fringes for diffraction are not of uniform intensity, while for interference, these are of uniform intensity.

(*ii*) Waves from the distant source are diffracted by the edge of the circular obstacle and these diffracted waves interfere constructively at the centre of the obstacle's shadow producing a bright spot.

23. Since the diodes used are ideal, the diode D_1 in forward bias will conduct the current in forward direction, while diode D_2 in reverse bias will not allow any current to flow.

As such, 2 Ω with D_1 and 1 Ω are in series, the net resistance of the circuit will be 2 Ω + 1 Ω = 3 Ω,

$$\therefore\ I = \frac{6V}{3\Omega} = 2A$$

Hence, the value of the current flowing through 1Ω resistor 2A.

24. West end of the wire must be at higher electric potential. According to *Fleming's Right Hand rule, "the direction of induced emf is from West to East".*

Or

At poles of the Earth. The Earth's magnetic field is perpendicular to the surface of the Earth.

25. **Given.** $\angle A = 60^\circ$ and $\angle e = \angle r$

$$\angle e = \angle r = \frac{3}{4} \times 60^\circ = 45^\circ$$

We know, that $\delta + A = i + e$ $\Rightarrow$ $\delta = i + e - A$ $\therefore\ \delta = 45^\circ + 45^\circ - 60^\circ = \mathbf{30^\circ}$

(*i*) Angle of deviation = **30°**

(*ii*) $$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}} \Rightarrow \mu = \frac{\sin\frac{60^\circ+30^\circ}{2}}{\sin\frac{60^\circ}{2}}$$

$$\Rightarrow \mu = \frac{\sin 45^\circ}{\sin 30^\circ} = \frac{1/\sqrt{2}}{1/2} \Rightarrow \mu = \frac{1}{\sqrt{2}} \times 2 = \sqrt{2} = 1.41$$

∴ Refractive index of prism = **1.41**

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SECTION – D

26. *Given.* $W = \frac{1}{2}LI^2$

We know that, $e = -N\frac{d\phi}{dt}$. Also, $e = -L\frac{dI}{dt}$

From these two equations, we get

$$L = \frac{Nd\phi/dt}{dI/dt} = \frac{N\phi}{I} \quad ...[(N = n \times l)$$

$$\Rightarrow \quad L = \frac{N(\vec{B}.A)}{I} = \frac{N(\mu_0 nI)A}{I}$$

$$\Rightarrow \quad L = \frac{nl(\mu_0 nI)A}{I} = \mu_0 n^2 Al$$

Since magnetic energy $= \frac{1}{2}LI^2 = \frac{1}{2}(\mu_0 n^2 Al)I^2$

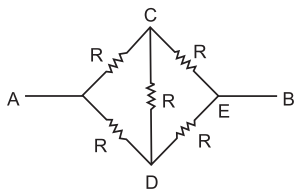
$\Rightarrow$ Expression for magnetic energy $= \frac{1}{2}(\mu_0 n^2 I^2 Al)$

$$\text{Energy density} = \frac{\text{Energy}}{\text{Volume}}$$

$$= \frac{1}{2}\frac{\mu_0^2 n^2 I^2 (Al)}{\mu_0 (Al)} \quad ...[V = Al$$

$$= \frac{1}{2}\frac{(\mu_0 nI)^2}{\mu_0} \qquad \therefore \quad \text{Energy density} = \mathbf{\frac{B^2}{2\mu_0}}$$

27. (*i*) Equivalent circuit of the given problem is shown in the given diagram. The simplified circuit is equivalent to a balanced **wheatstone bridge.**

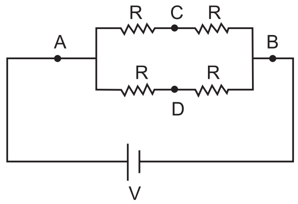


Hence there will be no current in arm CD, $I_{CD} = 0$.

$V_C = V_D$

$R_{AB} = \frac{2R}{2}$ = **RΩ**

(*ii*) Being a balanced wheatstone bridge,



$I_{CD} = 0$

$V = 10$ volt

$R = 2\Omega$

$V_{AB} = 10$ volt

$R_{ACB} = 4\Omega \qquad \therefore \quad I_{ACB} = \frac{10}{4}$ = **2.5A**

28. (*i*) **Cut-off voltage.** The value of the retarding potential at which the photo electric current becomes zero is called cut-off or stopping potential for the given frequency of the incident radiation.

(*ii*) **Threshold frequency.** The minimum value of the frequency of incident radiation below which the photoelectric emission stops altogether is called threshold frequency.

According to *Einstein's photo electric* equation, maximum K.E. of a photo electron is given by $K_{max} = h\nu - W_0$

If V_0 is the stopping potential, then

$K_{max} = eV_0$

$$\therefore \quad eV_0 = h\nu - W_0 \Rightarrow V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e} \quad ...(i)$$

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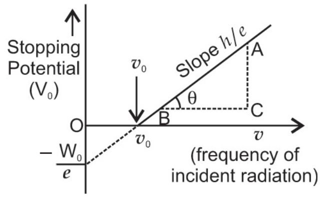
We compare this equation with the straight line equation,

$y = mx + c$

Clearly, Slope of $V_0 - v$ graph = $\frac{h}{e}$

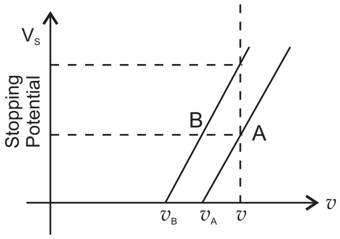
V_0 is the threshold frequency

and $-\frac{W_0}{e}$ is the cut-off or stopping voltage.



Or

Graph:



(i) For material B, because from the graph for the same value of 'v', stopping potential is more for material 'B' $\left[V_0 = \frac{h}{e}(v - v_0)\right]$.

$\therefore$ V_0 is higher for lower value of v_0.

(ii) No, it does not depend on the nature of material used. As slope is given by $\frac{h}{e}$ which is constant.

29. (a) 275 nm corresponds to utraviolet radiation.

Using $E = \frac{hC}{\lambda}$ and $h = 4.14 \times 10^{-15}$ eV

$$\lambda = \frac{hC}{E} = \frac{4.14 \times 10^{-15} eV \times 3 \times 10^8}{E} = \frac{12.42 \times 10^{-7}}{E}$$

$$\lambda_A = \frac{hC}{E} = \frac{12.42 \times 10^{-7}}{2} = 6.21 \times 10^{-7}\text{m} = \mathbf{621\ nm}$$

$$\lambda_B = \frac{12.42 \times 10^{-7}}{4.5} = \frac{24.84 \times 10^{-7}}{9} = 2.76 \times 10^{-7} = \mathbf{276\ nm}$$

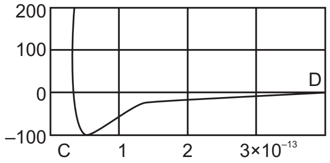
$\therefore$ λ_B corresponds to 276 nm.

$$\lambda_C = \frac{12.42 \times 10^{-7}}{2.5} = \frac{24.84 \times 10^{-7}}{5} = 4.968 \times 10^{-7}\text{ m} = \mathbf{496.8\ nm}$$

$$\lambda_D = \frac{12.42 \times 10^{-7}}{8} = 1.552 \times 10^{-7} = \mathbf{155.2\ nm}$$

(b) The maximum wavelength of the emission corresponds to the radiation due to the transition A.

30. The graph indicates that the attractive force between the two nucleons is strongest at a separation r_0 = 1 fm. For a separation greater than r_0, the force is attractive and for separation less than r_0, the force is strongly repulsive.



Two characteristic features of nuclear forces :

1. Strongest interaction
2. Short-range force
3. Charge independent character

(Any two)

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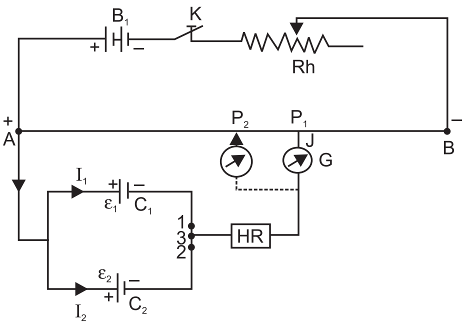
31. (*a*) ***Principle.*** *The basic principle of a potentiometer is that "When a constant current flows through a wire of uniform cross-sectional area and composition, the potential drop across any length of the wire is directly proportional to that length."* $v \propto l$.

Comparison of emfs of two cells. First of all the ends of potentiometer are connected to a battery B_1, key K and rheostat R*h* such that the positive terminal of battery B_1 is connected to end A of the wire. This completes the primary circuit.

Now the positive terminals of the cells C_1 and C_2 whose emfs are to be compared are connected to A and the negative terminals to the jockey J through a two-way key and a galvanometer, as shown in the figure. This is the secondary circuit.

Method:



(*i*) By closing key K, a potential difference is established and rheostat is so adjusted that when jockey J is made to touch at ends A and B of wire, the deflection in galvanometer is on both sides. Suppose in this position the potential gradient is *k*.

(*ii*) Now plug is inserted between the terminals 1 and 3 so that cell C_1 is included in the secondary circuit and jockey J is slided on the wire at P_1 (say) to obtain the null point. The distance of P_1 from A is measured. Suppose this length is l_1 *i.e.* $AP_1 = l_1$

$\therefore$ The emf of cell C_1, $\varepsilon_1 = kl_1$ ...(*i*)

(*iii*) Now plug is taken off between the terminals 1 and 3 and inserted in between the terminals 2 and 3 to bring cell C_2 in the circuit. Jockey is slided on wire and null deflection position P_2 is noted. Suppose distance of P_2 from A is l_2 *i.e.* $AP_2 = l_2$

$\therefore$ The emf of cell C_2, $\varepsilon_2 = kl_2$ ...(*ii*)

Dividing (*i*) by (*ii*), we get $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$ ...(*iii*)

Thus emfs of cells may be compared. Out of these cells if one is standard cell, then the emf of other cell may be calculated.

(*b*) ***Causes for one sided deflection:***

(*i*) Potential difference between the ends of the potentiometer wire is less than the emf of the cell in the secondary circuit.

(*ii*) The positive side of the driving cell is connected to the negative terminal of the cell in the secondary circuit.

Or

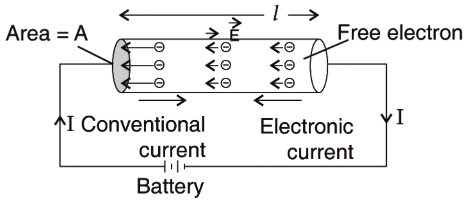
(*i*) Drift velocity may be defined as the average velocity gained by the free electrons of a conductor in the opposite direction of the externally applied field.

(*ii*) ***Relaxation time.*** The average time that elapses between two successive collisions of an electron is called relaxation time.

$$\vec{V}_d = \vec{a}\,\tau = -e\frac{\vec{E}}{m}\tau$$ **...where [$\vec{V}_d$ is called drift velocity of electrons.**

Suppose a potential difference V is applied across a conductor of length '*l*' and of uniform cross-section A, then Electric field E set up inside the conductor is given by:

$$E = \frac{V}{l}$$



Under the influence of field $\vec{E}$, the free electrons begin to drift in the opposite direction $\vec{E}$ with an average drift velocity V_d.

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Let the number of electrons per unit volume or electron density = n
Charge on an electron = e
Number of electrons in length l of the conductor = n × volume of conductor = nAl
Total charge contained in length l of the conductor, $q = enAl$
According to the electrons which enter the conductor at the right end will pass through the conductor at the left end in time,

$$t = \frac{distance}{velocity} = \frac{l}{V_d}$$

Current, $I = \frac{q}{t} = \frac{enAl}{l / v_d} = enAv_d$

$$I = enAv_d \qquad \therefore \qquad v_d = \frac{eE\tau}{m} = \frac{eV\tau}{ml}$$

$$I = enAv_d = enA.\frac{eV\tau}{ml}$$

$$\frac{v}{I} = \frac{ml}{ne^2\tau A} \qquad \therefore \qquad R = \frac{ml}{ne^2\tau A}$$ ...where [R is electrical resistivity

$$R = \rho\frac{l}{A}, \quad \text{or} \quad \rho = \frac{AR}{l} \qquad \therefore \qquad \rho = \frac{Aml}{ne^2\tau Al} = \frac{m}{ne^2\tau}$$

(*iii*) Because constantan and manganin show very weak dependence of resistivity on temperature.

32. Let an alternating current $I = I_m \sin \omega t$ be passing through a network of network of L, C and R creating a potential difference of $V = V_m \sin(\omega t \pm \phi)$ where ϕ is the phase difference.
Then the power consumed is

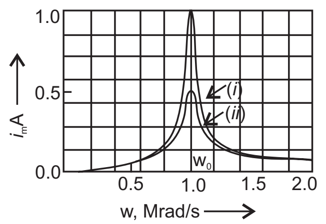
$$P = VI = V_m I_m \sin(\omega t \pm \phi) \sin \omega t$$
$$= V_m I_m (\sin \omega t \cos\phi \pm \cos \omega t \sin \phi) \sin \omega t$$
$$= V_m I_m \left(\sin^2 \omega t \cos\phi \pm \frac{1}{2}\sin 2\omega t \sin \phi\right)$$

$$P_{av} = \frac{\int_0^T P dt}{\int_0^T dt} = \frac{V_m I_m}{T}$$ $$...\left[\because \int \sin 2\omega t \cos\phi dt + \frac{1}{2}\int \sin\phi \sin 2\omega t\, dt\right.$$

$$P_{av} = \frac{V_m I_m}{T}\left[\frac{T}{2}\cos\phi + 0\right]$$ $$...\left[\because \int_0^T \sin^2 \omega t\, dt = \frac{T}{2} \text{ and } \int_0^T \sin 2\omega t\, dt = 0\right.$$

$$P_{av} = \frac{V_m I_m}{2}\cos\phi \quad \Rightarrow \quad \mathbf{P_{av} = V_{rms} I_{rms} \cos \phi}$$ $$...\left[\because V_{rms} = \frac{V_m}{\sqrt{2}} \text{ and } I_{rms} = \frac{I_m}{\sqrt{2}}\right.$$

Resonant circuit can be used in the tuning mechanism of a radio or a TV set.
The antenna of a radio accepts signals from many broadcasting stations. The signals picked up in the antenna act as a source in the tuning circuit of the radio, so the circuit can be driven at many frequencies. But to hear one particular radio station, we tune the radio. In tuning, we vary the capacitance of a capacitor in the tuning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received. When this happens, the amplitude of the current with the frequency of the signal of the particular radio station in the circuit is maximum.



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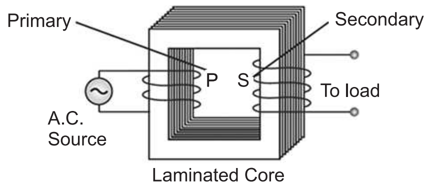
Or

(*a*) ***Principle.*** It is a device which converts high voltage a.c. into low voltage a.c. and *vice versa.* It is based upon the principle of *mutual induction.* When alternating current passes through a coil, an induced emf is set up in the neighbouring coil.



Construction. A transformer consists of two coils of many turns of insulated copper wire wound on a closed laminated iron core. One of the coils known as Primary 'P' is connected to A.C. supply. The other coil known as Secondary 'S' is connected to the load.

Working. When an alternating current passes through the primary, the magnetic flux through the iron core changes which does two things. It produces emf in the primary and an induced emf is also set up in the secondary. If we assume that the resistance of primary is negligible, the back emf will be equal to the voltage applied to the primary.

$$\therefore \quad V_P = -N_P \frac{d\phi}{dt} \text{ and } V_S = -N_S \frac{d\phi}{dt}$$

...where [N_P and N_S are number of turns in the primary and secondary respectively. Vp and Vs are their respective voltages.

$$\therefore \quad \frac{V_S}{V_P} = \frac{N_S}{N_P}$$

This ratio $\frac{N_s}{N_P}$ is called the turns ratio.

In a step-up transformer: $N_S > N_P$ $\quad\therefore\quad$ $V_S > V_P$

In a step-down transformer: $N_S < N_P$ $\quad\therefore\quad$ $V_S < V_P$

(*b*) ***Four causes of energy loss:***

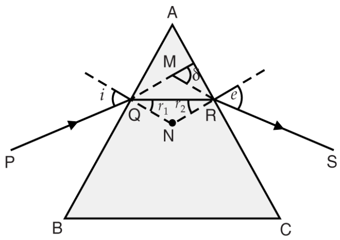
(*i*) Magnetic flux loss

(*ii*) Hystersis loss

(*iii*) Iron loss

(*iv*) Losses due to the resistance of primary and secondary coils.

33. (*a*) The figure shows the passage of light through a triangular prism ABC. The angles of incidence and refraction at the first face AB are i and r_1, while the angle of incidence (from glass to air) at the second face AC is r_2 and the angle of refraction or emergence e. The angle between the emergent ray RS and the direction of the incident ray PQ is called the angle of deviation δ.



In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles.

Therefore, the sum of the other angles of the quadrilateral is 180°.

$$\angle A + \angle QNR = 180°$$

From the triangle QNR,

$$r_1 + r_2 + \angle QNR = 180°$$

Comparing these two equations, we get

$$r_1 + r_2 = A$$

The total deviation δ is the sum of deviations at the two faces, $\delta = (i - r_1) + (e - r_2)$ that is

$$\delta = i + e \text{ or } \angle i + \angle e = \angle A + \delta \qquad ...(i)$$

A plot between the angle of deviation and angle of incidence is shown in the figure. In general, any given value of δ, except for $i = e$, corresponds to two values i and hence of e. This, in fact, is expected from the symmetry of i and e in equation (*i*) above, *i.e.*, δ remains the same if i and e are interchanged.

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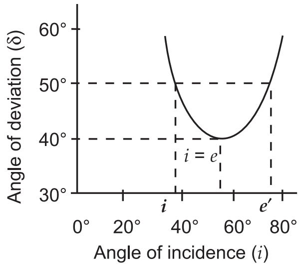
Physically, this is related to the fact that the path of ray in the given diagram can be traced back, resulting in the same angle of deviation. At the minimum deviation d_m, the refracted ray inside the prism becomes parallel to its base. We have,

$\delta = d_m$.

When angle of incidence (i) and angle of emergence (e) are equal, *i.e.*, $\angle i = \angle e$



(*b*) We know that for a prism

$$\mu = \frac{\text{Sin}\left(\frac{A + d_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Given, $\angle A = \angle d_m$

$$\mu = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin A}{\sin\frac{A}{2}} = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$= 2\cos\frac{A}{2} = 2\cos 30^\circ = 2 \times \frac{\sqrt{3}}{2}$$

$$= \sqrt{3} = 1.732$$ ...[Given A = 60°

Or

(*a*) (*i*) Two independent monochromatic sources of light cannot produce a sustained interference pattern. The phase difference between these two sources will continuously vary; and the positions of maxima and minima will change with time.

(*ii*) $y_1 = a\cos\omega t$, and $y_2 = a\cos(\omega t + \phi)$

$$y = (y_1 + y_2) = a[\cos\omega t + \cos(\omega t + \phi)] = 2a\cos\left(\frac{\phi}{2}\right)\cos\left(wt + \frac{\phi}{2}\right)$$

The resultant amplitude is $A = 2a\cos\left(\frac{\phi}{2}\right)$

and hence intensity $(I) = 4a^2\cos^2\left(\frac{\phi}{2}\right) = \mathbf{4I_0\cos^2\left(\frac{\phi}{2}\right)}$

(*b*) $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

Let I_0 be the intensity of either source, then

$$I_1 = I_2 = I_0$$

and $I = 2I_0(1 + \cos\phi) = 4I_0\cos^2\frac{\phi}{2}$

When $p = \lambda$, $\phi = 2\pi$

$$\therefore \quad I = 4I_0\cos^2\frac{\phi}{2} = 4I_0\cos^2\pi = 4I_0 = K$$

When $p = \frac{\lambda}{3}$, $\phi = \frac{2\pi}{3}$

$$\therefore \quad I = 4I_0\cos^2\frac{\pi}{3} = 4I_0 \times \frac{1}{4} = \mathbf{I_0 = \frac{K}{4}}$$

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