ISC Class 12 Physics Question Paper Solution 2015

PART I (20 Marks)

*Answer **all** questions.*

Question 1

A. Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: **[5]**

(i) A **short** electric dipole (which consists of two point charges, +q and –q) is placed at the centre O and inside a **large** cube (ABCDEFGH) of length L, as shown in ***Figure 1***. The electric flux, emanating through the cube is:

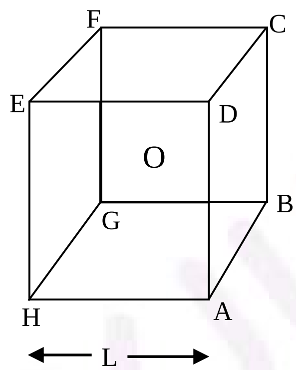


Figure 1

(a) $q/4\pi\epsilon_0 L$

(b) zero

(c) $q/2\pi\epsilon_0 Lm$

(d) $q/3\pi\epsilon_0 L$

(ii) The equivalent resistance between points **a** and **f** of the network shown in ***Figure 2*** is:

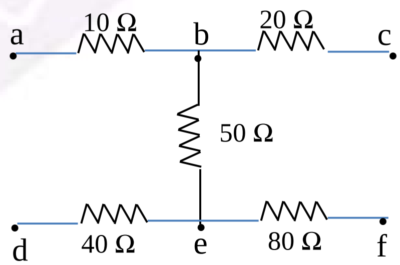


Figure 2

(a) 24 Ω

(b) 110 Ω

(c) 140 Ω

(d) 200 Ω

(iii) A moving electron enters a uniform and **perpendicular** magnetic field. Inside the magnetic field, the electron travels along:

(a) a straight line
(b) a parabola
(c) a circle
(d) a hyperbola

(iv) A fish which is at a depth of 12 cm in water ($\mu = \frac{4}{3}$) is viewed by an observer on the bank of a lake. Its **apparent depth** as observed by the observer is:

(a) 3 cm
(b) 9 cm
(c) 12 cm
(d) 16 cm

(v) If E_p and E_k represent potential energy and kinetic energy respectively, of an orbital electron, then, according to **Bohr's theory**:

(a) $E_k = -E_p/2$
(b) $E_k = -E_p$
(c) $E_k = -2E_p$
(d) $E_k = 2E_p$

B. Answer **all** questions given below **briefly** and to the point:

(i) What is meant by the term **Quantization of charge**?

(ii) A resistor **R** is connected to a cell of emf **e** and internal resistance **r.** Potential difference across the resistor **R** is found to be **V**. State the relation between **e**, **V**, **R** and **r**.

(iii) Three identical cells each of emf 2V and internal resistance 1Ω are connected in series to form a battery. The battery is then connected to a parallel combination of two identical resistors, each of resistance 6Ω. Find the current delivered by the battery.

(iv) State how **magnetic susceptibility** is **different** for the three types of magnetic materials, i.e. diamagnetic, paramagnetic and ferromagnetic materials.

(v) An emf of 2V is induced in a coil when current in it is changed from 0A to 10A in 0·40 sec. Find the **coefficient of self-inductance** of the coil.

(vi) How are electric vector $(\vec{E})$, magnetic vector $(\vec{B})$ and velocity vector $(\vec{c}\,)$ oriented in an electromagnetic wave?

(vii) State *any two* methods by which ordinary light can be polarised.

(viii) A monochromatic ray of light falls on a **regular prism.** What is the relation between angle of incidence and angle of emergence in the case of **minimum deviation**?

(ix) What type of lens is used to correct **long-sightedness**?

(x) State any one **advantage** of using a reflecting telescope in place of a refracting telescope.

(xi) State **Moseley's law**.

(xii) Wavelengths of the first lines of the **Lyman series**, **Paschen series** and **Balmer series**, in hydrogen spectrum are denoted by λ_L, λ_P, and λ_B, respectively. Arrange these wavelengths in **increasing order**.

(xiii) What is the **significance** of **binding energy per nucleon** of a nucleus of a radioactive element?

(xiv) Write any one **balanced** equation representing **nuclear fission**.

(xv) What is the difference between **analogue** signal and **digital** signal?

Comments of Examiners

(A) (i) Some candidates selected option 'c'. They could not apply Gauss' Law.

(ii) Many candidates thought that the given circuit was that of a balanced Wheatstone bridge.

(iii) Very few candidates could answer this question. They selected a (wrong) option 'b' i.e. 'a parabola'.

(iv) A few candidates gave option 'a' as they got confused between apparent depth and upward displacement.

(v) Many candidates gave wrong options, i.e. c, d, etc.

(B) (i) A number of candidates gave an incomplete statement. Some candidates could not identify elementary charge, i.e. charge of a proton (e).

(ii) Many candidates could not obtain the correct relation. They wrote two separate equations instead of one.

(iii) In this part, several candidates could not find the net emf, while some others were unable to find total internal resistance. A few candidates could not apply ohm's law.

(iv) Many candidates were unable to recall the correct values of magnetic susceptibility for the three magnetic materials.

(v) The expression for induced emf was not known to some candidates.

(vi) Some candidates wrote $\vec{C} = \vec{E} \times \vec{B}$, which is incorrect. Several others wrote $\vec{C} = \frac{\vec{E}}{\vec{B}}$, which is also wrong.

Suggestions for teachers

- Train students to read questions carefully, understand what is being asked for and then give relevant and to the point answers.
- Explain Gauss' Law and give practice in solving numericals based on it.
- Train student to find equivalent resistance of a few circuits in class.
- Explain the motion of a charged particle in a uniform and perpendicular magnetic field and why it is an arc of a circle.
- Explain the concept of real depth (R) and apparent depth (A).
- Derive an expression for total energy E_n of an electron in the nth orbit to kinetic energy E_k and potential energy E_p of the orbiting electron.
- Explain the meaning of the term: quantization.

(vii) Some candidates gave only one method of polarization of light instead of two as required. Several others gave two methods of polarization but they meant the same thing. They were unable to write two different methods of polarization of light.

(viii) Many candidates gave the expression $\delta = i + e - A$, instead of the correct answer i.e. $i = e$. Some candidates gave the prism formula.

(ix) Instead of the correct answer i.e. convex lens, a number of candidates gave the answer as 'concave lens'.

(x) A number of candidates were not able to answer correctly – they gave answers such as, it has greater magnifying power or that it is cheaper or it forms a clearer image.

(xi) Some candidates could not state Moseley's law correctly. They did not write 'K' X rays or characteristic X rays.

(xii) Many candidates could not arrange $\lambda_{L,} \lambda_P \,\&\, \lambda_B$ in the correct increasing order.

(xiii) A number of candidates defined binding energy per nucleon, instead of giving its physical significance.

(xiv) Quite a few candidates wrote unbalanced reactions or imaginary/unrealistic reactions. A few did not give the left hand side of the equation. In many cases, incorrect symbols were used.

(xv) Some candidates defined either analogue signal or digital signal but did not state the difference between the two. Many candidates did not state that digital signal has only two values.

- Explain when the formula $I = \frac{V}{R}$ should be used and when $I = \frac{E}{R+r}$ is to be used. Also emphasize that $E \neq V$ in general. Explain the difference between E and V.
- Explain the concept of cells in series and cells in parallel and how to find net emf and effective internal resistance in each case.
- Define diamagnetic, paramagnetic and ferromagnetic materials. Tabulate the difference in properties of these materials, with special reference to susceptibility; permeability and effect of temperature.
- Explain the phenomenon of self-induction, immediately after stating laws of electromagnetic induction.
- Explain with the help of a diagram that $\vec{E}$, $\vec{B}$ and $\vec{C}$ are always perpendicular to each other in an electromagnetic wave.
- In addition to explaining what is short sightedness and long sightedness, explain how they can be corrected, preferably with the help of diagrams.
- Ask students to learn and state the laws, theorems, principles as they are and not to distort them.
- Explain students the hydrogen spectrum systematically.
- Give practice to students in writing balanced equations and explain how atomic number and mass numbers are balanced.
- Explain the differences between 'analogue' and 'digital' signal with the help of labelled graphs.

MARKING SCHEME

Question 1.

A. (i) (b) OR Zero

(ii) (c) OR 140 (Ω)

(iii) (c) OR circle

(iv) (b) OR 9(cm)

(v) (a) OR $E_k = -E_{p/2}$

B. (i) Charge on a body is an integral or exact multiple of the **elementary charge** OR q =(±) ne (where n is an integer).

(ii) $V = \frac{eR}{r+R}$ OR $V = e - \frac{V}{R} r$ OR $V = e - \frac{e}{R+r} . r$

OR

Any other correct relation containing <u>all four</u> quantities, i.e. r, R, e and V.

(iii) 1A, with some working. $i = \frac{E}{R+r}$ OR $\frac{6}{3+3}$ OR circuit with correct values.

(iv) (Susceptibility) is small and negative for diamagnetic material OR $\chi < 0$

(Susceptibility) is small and positive for paramagnetic material OR $\chi > 0$

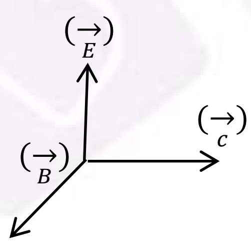
(Susceptibility) is very large and positive for ferromagnetic material OR $\chi >> 0$

(v) 0·08 H , with correct substitution/formula.

and other correct units

(vi) They are <u>mutually perpendicular</u> (to each other)/ orthogonal

OR



E, B & c in any order

(vii) Any two of the following:

(a) Using a polarizer or a Polaroid or a tourmaline lamina/crystal

(b) By reflection (at a surface of a transparent material)

(c) By double refraction / NICOL prism/dichroic/anisotropic/quartz/calcite

(d) Pile of glass plates/refraction

(e) By scattering

(f) Selective absorption

(viii) (They are) equal OR $i = e$ or $i_1 = i_2$ or by diagram

(ix) A convex lens or converging lens or diagram

(x) Image is free from spherical aberration OR

Image is free from chromatic aberration OR

Image is brighter/sharper/easier to install/less distorted (or free) /better quality.

(xi) $\sqrt{v}\ \alpha\ z$

[Where v : frequency of K X ray or

Frequency of (characteristic) X rays and

z = atomic number. OR

Statement: Square Root of the frequency of (K) X rays varies directly with atomic number (of the target element)]

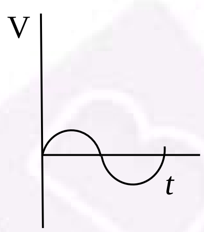
(xii) λ_L, λ_B and λ_p OR $\lambda_P > \lambda_B > \lambda_L$ or $\lambda_L < \lambda_B < \lambda_p$

(xiii) It gives us an idea of the stability of the nucleus.

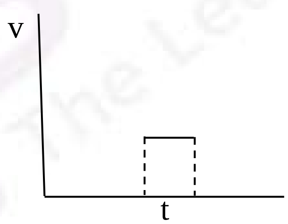
(xiv) ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{148}_{57}(La) + {}^{85}_{35}(Br) + 3\,{}^{1}_{0}n$

OR any other correct balanced equation

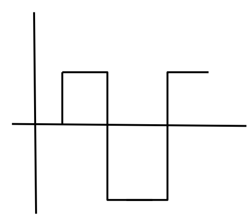
(xv)



Analogue signal



OR



Digital signal

Statement i.e. analogue signal has infinite number of values or many continuously varying values whereas digital signal has only two values.

OR Analogue – sinusoidal wave

Digital – square (pulse) or rectangular wave

PART II (50 Marks)

SECTION A

Question 2

(a) Derive an expression for intensity of electric field at a point in **broadside position** or on an **equatorial line** of an electric dipole. **[4]**

(b) Two point charges of 10C each are kept at a distance of 3m in vacuum. Calculate their electrostatic potential energy. **[1]**

<u>Comments of Examiners</u>

(a) Several candidates derived an expression for intensity of electric field E at a point in the end-on positon i.e. axial position, instead of that in the broad side position, as required. Some candidates did not understand/remember which derivation was to be given, hence, they wrote both the derivations. Many candidates could not draw the correct labelled diagram. A few candidates were not able to reach the last step.

(b) Many candidates used wrong formulae. Some used the formula for force/ intensity/ potential. In several cases the unit of energy i.e. J was not written.

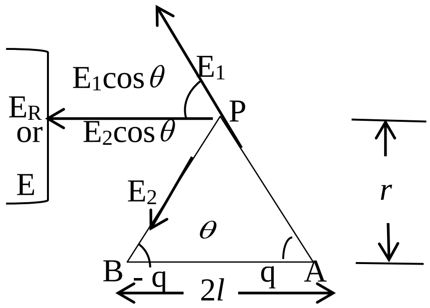
<u>Suggestions for teachers</u>

- Explain the meaning of the terms: end-on/axial position & broadside position.
- Show students how to draw correct labelled diagrams, specially directions of electric field intensity $\vec{E}$ at a point due to charges –q and + q.
- Make students practice these derivations. Instruct students to read the question carefully and write answer to the point. Self contradictory answers are not acceptable.
- Ask students to learn the formulae by heart and practice them at home.
- The importance of writing the unit along with the answer must be emphasised.

MARKING SCHEME

Question 2.

(a)



$$E_1 = \frac{1}{4\pi\epsilon_o}\,\frac{q}{AP^2}$$

$$= \frac{1}{4\pi\epsilon_o}\,\frac{q}{(r^2+l^2)} \quad \text{OR} \quad K\,.\,\frac{q}{r^2+l^2}$$

$$E_2 = \frac{1}{4\pi\epsilon_o}\,\frac{q}{BP^2}$$

$$= \frac{1}{4\pi\epsilon_o}\,\frac{q}{(r^2+l^2)} \quad \text{OR} \quad K\,.\,\frac{q}{r^2+l^2}$$

$E = E_1 \cos\theta + E_2 \cos\theta$

OR $E_1 = E_2$

$E = 2\,E_1 \cos\theta$

$$E = 2.\frac{1}{4\pi\in_\circ}\frac{q}{r^2+l^2}.\frac{l}{(r^2+l^2)^{1/2}}$$

OR

$$= \frac{1}{4\pi\epsilon_o}\,\frac{p}{(r^2+l^2)^{3/2}} \quad \{q\times 2l = p\}$$

(b) $U = \frac{1}{4\pi\epsilon_o}.\frac{Q\,q}{r}$

Correct substitution (with or without formula) with correct result with proper unit.

i.e. $\underline{3\times10^{11}\text{ J}}$

Question 3

(a) Four capacitors, C_1, C_2, C_3 and C_4 are connected as shown in ***Figure 3*** below. Calculate **equivalent** capacitance of the circuit between points X and Y. **[3]**

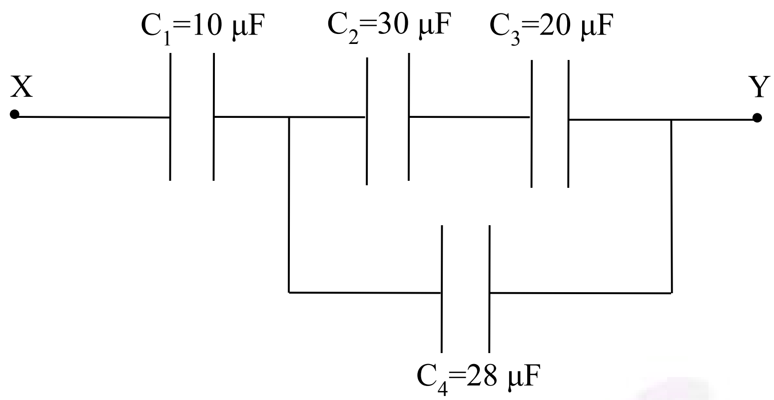


Figure 3

(b) Draw labelled graphs to show how **electrical resistance** varies with **temperature** for: **[2]**

(i) a metallic wire.

(ii) a piece of carbon.

<u>Comments of Examiners</u>

(a) Many candidates made conceptual errors, i.e. they were not clear as to which capacitors were in series and which were in parallel.

(b) (i) A number of candidates did not draw a straight line graph. Some did not label the axes or labelled them incorrectly.

(ii) Several candidates drew a straight line graph instead of a curve. The axes were interchanged by some candidates.

<u>Suggestions for teachers</u>

- Explain clearly the concept of capacitors in series and capacitors in parallel. Start with simple circuits and proceed to more and more complex ones.
- Tell students that the formulae for equivalent capacitors are inverse of those for resistors.
- Explain to students that resistance of a metallic wire increases uniformly with the increase in temperature. So, straight line graph moves upwards. For non-metals and semi-conductors, resistance decreases, and that too non-uniformly with the rise in temperature. Hence, a downward curve is almost like a parabola.
- Stress upon correct labelling of the axes.

MARKING SCHEME

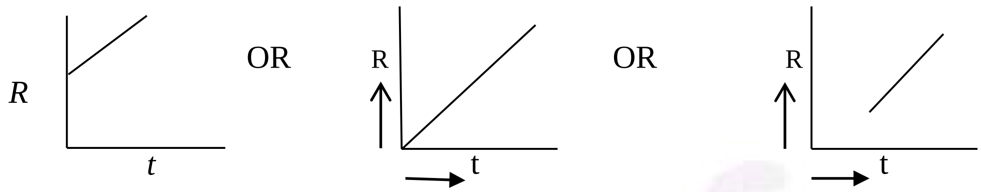
Question 3.

(a) (i) Equivalent capacitance of C_2 and C_3, $C_5 = 12\mu F$

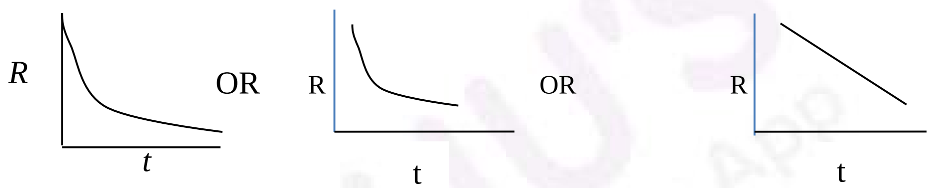
(ii) Equivalent capacitance of C_4 and C_5, $C_6 = 40\ \mu F$ $(C_6 = C_4 + C_5)$

(iii) Final equivalent capacitance $= 8\ \mu F$ $\left(C = \dfrac{C_1 C_6}{C_1 + C_6}\right)$

(b) (i)



(ii)



OR any other correct graph (showing correct behaviour)

Question 4

(a) Two resistors $R_1 = 400\ \Omega$ and $R_2 = 20\ \Omega$ are connected in **parallel** to a battery. If heating power developed in R_1 is 25 W, find the heating power developed in R_2. **[2]**

(b) With the help of a labelled diagram, show that the **balancing condition** of a **Wheatstone bridge** is: **[3]**

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$ where the terms have their usual meaning.

Comments of Examiners

(a) Some candidates seemed to have conceptual problems - instead of taking potential difference same, they took current as same and hence, ended with wrong result. Some candidates used wrong formulae, e.g. $P=V^2R$ instead of $P = \frac{V^2}{R}$.

(b) A number of candidates used symbols P, Q, R & S, instead of the given symbols i.e. R_1, R_2, R_3 & R_4. $I_g = 0$ in case of a balanced Wheatstone bridge, was not mentioned by a number of candidates. Some candidates did not apply Kirchoff's laws correctly.

Suggestions for teachers

– Tell students that in parallel, potential difference across resistors is same. Therefore, the formula $P = \frac{V^2}{R}$ is relevant. When resistors are in series, current I is same. Therefore $P = I^2 R$ is more relevant.

– Adequate practice should be given in solving such problems in class and ask students to practice more at home.

– Train students to read questions slowly and carefully. Advise them to use data (including symbols) given in the question bases and not their own.

– Derivations must be learnt by heart logically by the candidates and practiced, along with properly drawn and labelled diagrams.

MARKING SCHEME

Question 4.

(a) $$\frac{P_1}{P_2} = \frac{R_2}{R_1}$$

i.e. $\frac{25}{P_2} = \frac{20}{400}$ Correct substitution (in formula)

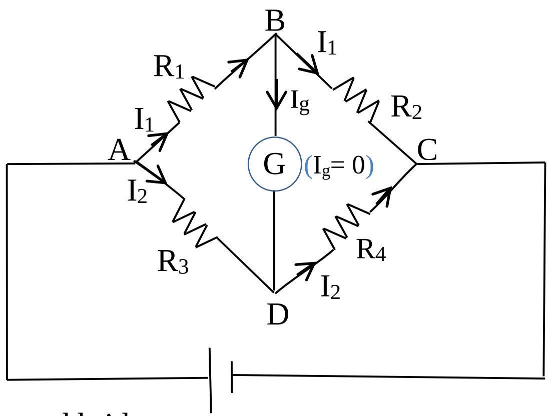
$\therefore P_2 = 500$ W

OR

$V = \sqrt{PR}$ OR $\sqrt{25 \times 400} = 100$ V

$P = \frac{V^2}{R}$ OR $\frac{100\times100}{20} = 500$ W

(b)



(Correct labelled diagram compulsory)

For a balanced bridge

$I_g = 0 \quad \therefore \; V_B = V_D$

$$\left.\begin{aligned} V_A - V_B &= I_1 R_1 \\ V_B - V_C &= I_1 R_2 \\ V_A - V_D &= I_2 R_3 \\ V_D - V_C &= I_2 R_4 \end{aligned}\right]$$

$$\therefore \left.\begin{aligned} I_1 R_1 &= I_2 R_3 \\ I_1 R_2 &= I_2 R_4 \end{aligned}\right]$$

On dividing, we get $\frac{\boldsymbol{R_1}}{\boldsymbol{R_2}} = \frac{\boldsymbol{R_3}}{\boldsymbol{R_4}}$

(or any other correct method)

Question 5

(a) A 10m long uniform metallic wire having a resistance of 20Ω is used as a potentiometer wire. This wire is connected in series with another resistance of 480Ω and a battery of emf 5V having neglegible internal resistance. If an unknown emf ***e*** is balanced across 6m of the potentiometer wire, calculate: **[3]**

(i) the potential gradient across the potentiometer wire.

(ii) the value of the unknown emf ***e***.

(b) (i) Explain the term ***hysteresis***. **[2]**

(ii) Name **three elements** of the earth's magnetic field which help in defining **earth's magnetic field** completely.

Comments of Examiners

(a) (i) Many candidates did not take resistance of the wire into account while calculating current and hence arrived at a wrong answer for potential gradient (k). Some did not write the correct unit of potential gradient (k).

(ii) Many candidates did not realise/know that unknown e = k × balancing length.

(b) (i) A number of candidates drew the B-H loop i.e. hysteresis curve, instead of defining the term hysteresis.

(ii) Instead of giving the three elements, B_H, θ & δ which define earth's magnetic field completely, some candidates gave only two components. A few candidates gave the answer as, geographical meridian, magnetic meridian, etc.

Suggestions for teachers

- The topic of potentiometer must be taught highlighting how emf of a cell is balanced against a potential difference across the balancing length.
- Students may be taken to the physics laboratory to show the use of potentiometer by making all connections. They must be taught how to get the balance point.
- Students must be trained to write relevant answers: writing a correct answer to the point, is an art which can gradually be developed amongst students.
- While teaching the chapter of Earth's magnetic field, explain to students how the knowledge of B_H, θ & δ helps us in knowing earth's magnetic field at that place completely.

MARKING SCHEME

Question 5.

(a) (i) $\mathbf{I_p = \frac{E}{R_s+R_p+r}}$

Or $= \frac{\mathbf{5}}{\mathbf{480+20}}$ $= 0{\cdot}01$ A

(ii) k $= \frac{V_p}{L}$ or $\frac{I_pR_p}{L}$ or $\frac{0.2}{10} = 0{\cdot}02$ $\underline{\text{Vm}^{-1}}$

e = $(\boldsymbol{V_{AC}})$ ***or*** k×L or $0{\cdot}02 \times 6 =$ 0.12V

(b) (i) The phenomenon in which magnetic flux density /(B) lags behind magnetising field intensity/ (H) is called hysteresis.

(ii) B_H (Horizontal component of earth's magnetic field)

$\boldsymbol{\delta}$ (angle of dip) and

$\boldsymbol{\theta}$ (angle of declination)

Question 6

(a) Obtain an expression for **magnetic flux density** B at the centre of a circular coil of radius **R**, having **N** turns and carrying a current **I**. **[3]**

(b) A coil of self inductance 2•5H and resistance 20Ω is connected to a battery of emf 120V having internal resistance of 5 Ω. Find: **[2]**

(i) The **time constant** of the circuit.

(ii) The current in the circuit in **steady state**.

Comments of Examiners

(a) Several candidates used Ampere Circuital Law to find magnetic flux density. Many candidates did not derive the expression for magnetic flux density B at the centre of a circular coil having N turns. Some derived the formula of B along the axis and then got B at the centre of the coil.

(b) (i) Some candidates did not know the formula of time constant. A few used an incorrect formula. Several candidates used the formula of A.C circuits. In many cases, the correct unit was not given.

(ii) A number of candidates did not consider internal resistance to calculate steady current. In some cases, the unit was missing. Several candidates did not understand the meaning of 'steady state current'.

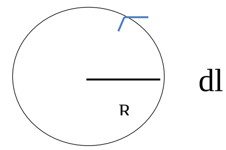
Suggestions for teachers

- Students should be explained distinctly the application of Biot Savart's Law and Ampere Circuital Law.
- While explaining growth of current or decay of current in an LR circuit; specially with their graphs, concept of time constant should be introduced. It should be defined both ways. It may also be shown that $\tau = \frac{L}{R}$ has unit and dimension of time.
- Tell students that steady state current i.e. final current can be found by applying ohm's law i.e. $I = \frac{E}{R+r}$.

MARKING SCHEME

Question 6.

(a) $dB = \frac{\mu_O}{4\pi} \cdot \frac{I.dl}{R^2}$

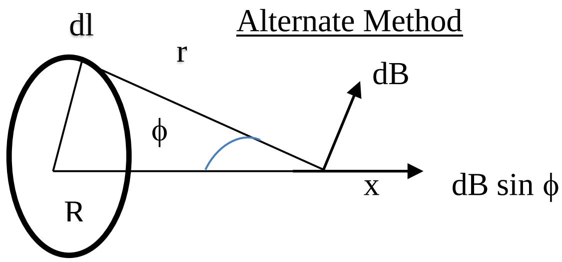


$B = \int_o^l dB$ or $B = \Sigma\Delta\ B$

$B = \left(\frac{\mu_O}{4\pi}\right) \frac{2\pi NI}{R}$ OR

$B = \frac{\mu_O NI}{2R}$ with some working

<u>Alternate Method</u>



$dB = \frac{\mu_\circ}{4\pi} \cdot \frac{idl \sin\theta}{r^2}$

$dB = \frac{\mu_\circ}{4\pi} \cdot \frac{idl}{r^2}$ $(\theta=90^0)$

$B = \int dB \sin \phi$

$= \frac{\mu_\circ}{4\pi} \frac{2i\pi R^2}{(x^2+R^2)^{3/2}}$

For centre $x=0$

$B = \frac{\mu_\circ Ni}{2R}$

(b) Time constant = $\frac{L}{R} / \frac{2\cdot5}{20}$ $= 0\cdot125$ s OR $\frac{L}{R+r} / \frac{2.5}{25} = 0.1$s

(Steady state current) $I = \frac{E}{R+r} / \frac{120}{20+5} = 4\cdot8$ A

Question 7

(a) ***Figure 4*** below shows a capacitor C, an inductor L and a resistor R, connected in series to an a.c. supply of **220 V.** **[4]**

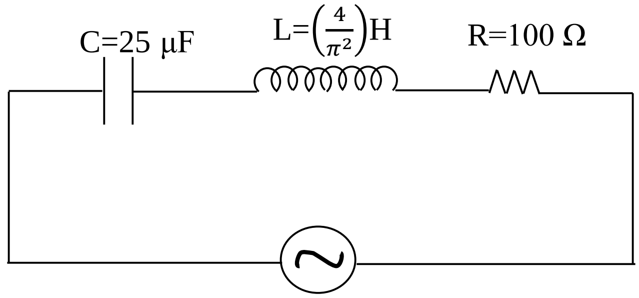


Figure 4

Calculate:

(i) The **resonant frequency** of the given CLR circuit.

(ii) Current flowing through the circuit.

(iii) Average power consumed by the circuit.

(b) In a series LCR circuit, what is the **phase difference** between $\mathbf{V_L}$ and $\mathbf{V_C}$ where V_L is the potential difference across the inductor and V_C is the potential difference across the capacitor? **[1]**

<u>Comments of Examiners</u>

(a)(i) A number of candidates found the value of ω_0 not of f_0. Some candidates did not convert microfarad to farad.

(ii) Several candidates did not write the current with appropriate unit.

(iii) Many candidates used the incomplete/incorrect formula to calculate average power conumed by the circuit P = V.I. A few candidates did not write the unit of power i.e. watt.

(b) Many candidates wrote the answer as '90°' as they thought it was phase difference between I and V_L or I and V_C. Several candidates used the wrong formula $\tan\theta = \frac{V_L - V_C}{V_R}$. Some candidates did not give the correct unit of θ.

<u>Suggestions for teachers</u>

– Explain the difference between angular frequency 'ω' and frequency 'f' and thus derive formula of f_0. Solve a few numericals based on it.

– Emphasize that, at resonance, impedance (Z) = resistance (R).

Hence, $I = \frac{V_T}{Z} \longrightarrow I = \frac{V_T}{R}$.

– Stress upon writing the units.

MARKING SCHEME

Question 7.

(a) (i) Resonant frequency

$$f_o = \frac{1}{2\pi\sqrt{\frac{4}{\pi^2}\times 25\times 10^{-6}}}$$ Correct substitution with or without formula

$f_o = 50\ \text{H}_z$ correct answer with unit

(ii) $I = \frac{\boldsymbol{V_T}}{\boldsymbol{Z}} = \frac{220}{100} = 2{\cdot}2\ (A)$ OR $I = \frac{V}{z}\ /\ \frac{220}{z}\ /\ \frac{220}{\sqrt{(\chi_L + \square\ \chi_C)^2 + R^2}}$

(iii) $\langle P\rangle = V_T\ I$ or $I^2 R\ /\ (2{\cdot}2)^2 \times 100 = 484\ (W)$

(b) 180^o or π (radian)

OR

V_L & V_C shown clearly on phasor diagram.

SECTION B

*Answer any **three** questions.*

Question 8

(a) On the basis of **Huygen's Wave theory of light**, show that angle of reflection is equal to angle of incidence. You must draw a labelled diagram for this derivation. **[4]**

(b) State any one difference between **interference of light** and **diffraction of light**. **[1]**

Comments of Examiners

(a) Some of the errors made by candidates in this part were as follows:
- Correct diagrams were not drawn;
- The arrows were not marked;
- Angles 'i' and 'r' were not marked correctly;
- Wavefronts were not shown or not marked/labelled;
- The rays were not perpendicular to the relevant wave fronts;
- Congruency of triangles was not proved correctly and completely.
- Derived the formula of refraction.

(b) Some candidates did not know the correct difference between interference of light and diffraction of light.

Suggestions for teachers
- Train the students to draw correct and completely labelled diagrams.
- Tell the students that a ray is perpendicular to the wavefront.
- Tell students that there are many methods to prove $\angle r = \angle i$ and give them the simplest of all.
- Ask the students to practice these diagrams and derivations.
- Since both interference of light and diffraction of light involve superposition of waves, the difference between the two must be brought out clearly.

MARKING SCHEME

Question 8.

(a) Correct diagram with at least one arrow, an incident or reflected ray Or mentioned wave fronts i and r marked

Proof of 2 triangles as congruent (angle between ray and wave front is 90°, either shown on diagram or written mathematically)

Proving r = i

(b) Any one difference

Interference of light requires two coherent sources (slits), diffraction of light requires only one source.

OR

Many bright and dark fringes are obtained in interference

A few bright and dark fringes are obtained in diffraction OR

All bright fringes are equally bright in interference.

They are of decreasing intensities in diffraction. OR

Intensity curves diagram but axes may not be marked OR

Interference – Fringes may or may not be of equal widths

Diffraction – Fringe width varies

Question 9

(a) Laser light of wavelength 630 nm is incident on a pair of slits which are separated by 1·8mm. If the screen is kept 80 cm away from the two slits, calculate: **[3]**

(i) fringe separation i.e. fringe width.

(ii) distance of 10^{th} bright fringe from the centre of the interference pattern.

(b) Show graphically the intensity distribution in **Fraunhofer's single slit diffraction experiment**. Label the axes. **[2]**

Comments of Examiners

(a) (i) A number of candidates used incorrect formula. Some did not know the correct meaning of the symbols i.e. 'D' and 'd', hence they interchanged them. Some candidates did not convert 'nm' to 'm' as well as 'cm' to 'm'.

(ii) Several candidates used wrong formula to find the distance of the 10th bright fringe. Some candidates used nλ for calculating distance. A few did not write the unit, along with the answer.

(b) Many candidates did not label the graph or labelled it incorrectly. Some candidates could not draw the correct shape of the graph. In some cases, the height of the secondary maxima was high.

Suggestions for teachers

– Students must be asked to learn the formulae with proper understanding of all the symbols used. All quantities must be brought to SI system before substituting them in the formula.
– Give adequate practice to students in solving numerical problems based on formula, X_n and β.
– Students should be taught how to draw a correct labelled graph of relative intensity vs θ. Tell them that central maxima has highest peak (maximum intensity) and secondary peaks become smaller and smaller.

MARKING SCHEME

Question 9.

(a) (i) Fringe width $\beta = \frac{\lambda D}{d}$ formula with correct understanding of terms D & d

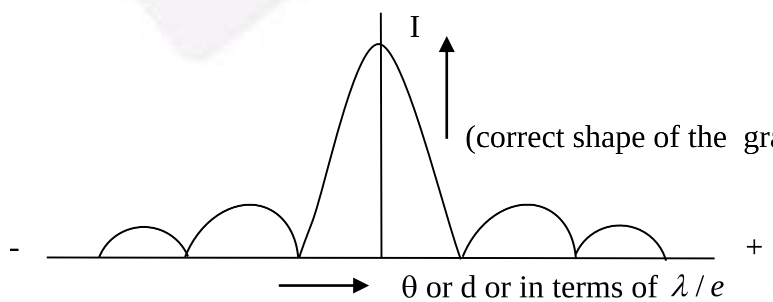
OR $\beta = \frac{630\times10^{-9}\times0{\cdot}8}{1{\cdot}8\times10^{-3}}$

β = 280×10^{-6} m Correct value of fringe width with other appropriate units is also acceptable

(ii) $X_{(10)} = (10\,\beta) = 10 \times 280 \times 10^{-6}$

$= 2{\cdot}8 \times 10^{-3}$ m OR correct substitution in $X_n = \frac{n\lambda D}{d}$

(b)



(correct shape of the graph with proper labelling)

Question 10

(a) A point object **O** is placed at a distance of 15cm from a convex lens **L** of focal length 10cm as shown in ***Figure 5*** below. On the other side of the lens, a convex mirror **M** is placed such that its distance from the lens is equal to the focal length of the lens. The final image formed by this combination is observed to **coincide** with the object **O**. Find the **focal length** of the **convex mirror**. **[3]**

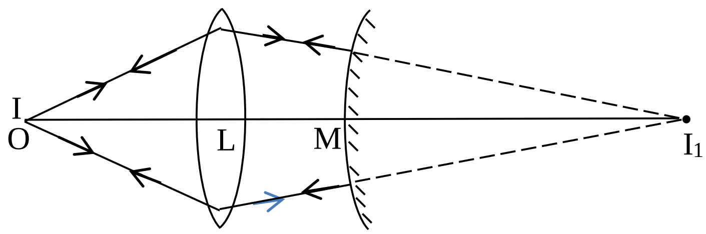


Figure 5

(b) What is **chromatic aberration**? How can it be minimised or eliminated? **[2]**

<u>Comments of Examiners</u>

(a) In the lens portion, some candidates could not apply the correct sign convention, hence, they got wrong value of v. In the mirror part, a number of candidates could not identify its centre of curvature. Some were not aware of the relation R = 2f for a spherical mirror.

(b) A number of candidates were confused between spherical aberration and chromatic aberration and hence they described the former instead of the latter. While defining chromatic aberration, some candidates did not mention white light as incident light. A few candidates wrote 'stops' should be used to reduce chromatic aberration.

<u>Suggestions for teachers</u>

– Teach any one sign convention to students. Using it, solve as many numericals as possible. Then ask them to solve/practice few more problems. (It should be accompanied by a proper ray diagram). After solving numericals on spherical mirrors and lenses, solve a few involving lens- mirror combination.

– Various terms in physics should not only be defined but also explained so that students are able to recall them in the examination.

MARKING SCHEME

Question 10.

(a) Using lens formula for convex lens:

$$\frac{1}{15}+\frac{1}{v}=\frac{1}{10}$$ (Any sign convention may be followed by the candidate)

$\therefore v = 30$ (cm) (negative value of v will not be accepted.

$2f = R = v - 10$

$2f = 30 - 10$

OR

$\therefore f = 10$ cm

(b)	It is that defect of image in which coloured images are formed by a lens when an object is illuminated with white light. OR by diagram with arrows with atleast one incident ray marked with white /polychromatic light. It can be minimised by combining a convex lens with a suitable concave lens OR by satisfying the condition: $\frac{\omega}{f} + \frac{\omega'}{f'} = 0$ OR using achromatic doublet/achromatic combination of lenses.

Question 11

(a) Draw a labelled ray diagram of an image formed by a **compound microscope**, when the final image lies at the **least distance of distinct vision (D)**. **[3]**

(b) With regard to an **astronomical telescope** of **refracting** type, state how you will increase its: **[2]**

(i) magnifying power

(ii) resolving power

<u>Comments of Examiners</u>

(a) Some candidates could not show the correct formation of the final image. In some cases, the diagram was not labelled fully, or arrows were not put on the rays of light.

(b) (i) A few candidates used the wrong formula to increase M of telescope.

(ii) Many candidates did not know how to increase resolving power of a telescope.

<u>Suggestions for Teachers</u>

– Give practice to students in drawing ray diagrams of compound microscope, astronomical telescope. Putting arrows on the rays must be stressed upon.

– Derive the expresion of magnifying power (M) of an astronomical telescope i.e. M = f_o/f_e. Then explain to students that M can be increased by either increasing the focal length of objective lens(f_o) or by decreasing the focal length of eyepiece lens (f_e).

– After explaining the concept of resolving power, tell students how it can be increased/decreased. Factors affecting resolving power of a telescope must be stated clearly.

MARKING SCHEME

Question 11.

(a) First lens (marked as objective) with at least two rays from an object with an arrow on one of them. with I_1 correctly formed.

Second lens (marked as Eye piece) with two emergent rays with an arrow on one of them, with I_2 correctly formed.

Marking of f_o, f_e, u_o, u_e, D, v_0 and β (any five marked correctly)

(b) (i) Magnifying power can be increased by either increasing focal length.

of objective lens i.e. f_o OR

by decreasing focal length of eyepiece i.e. f_e

(ii) Resolving power can be increased by increasing the diameter / aperture

Or size of the objective lens

SECTION C

*Answer any **three** questions.*

Question 12

(a) In an experiment of **photoelectric effect**, the graph of maximum kinetic energy E_K of the emitted photoelectrons versus the frequency $\boldsymbol{\nu}$ of the incident light is a straight line **AB** as shown in ***Figure 6*** below: **[3]**

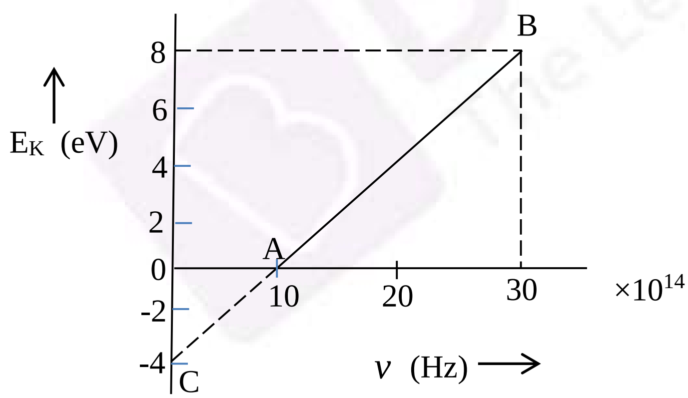


Figure 6

Find:

(i) Threshold frequency of the metal.

(ii) Work function of the metal.

(iii) Stopping potential for the photoelectrons emitted by the light of frequency $\boldsymbol{\nu} = 30\times10^{14}$ Hz.

(b) (i) State how **de-Broglie wavelength** (λ) of moving particles varies with their linear momentum (p). **[2]**

(ii) State any one phenomenon in which moving particles exhibit wave nature.

<u>Comments of Examiners</u>

(a)(i) Some candidates did not read the given graph correctly. They thought ν_o was '10' and not 10 x10^{14} Hz. Some calculated the values of ν_o from the data, instead of just reading its value from the graph.

(ii) Many candidates were unaware of the fact that y intercept of the graph gives us the value of work function of the metal.

(iii) Many candidates gave wrong unit of stopping potential. They wrote 'eV'in place of volt.

(b)(i) A number of candidates gave wrong relationship between λ and p. Some drew a wrong graph between λ and p.

(ii) Several candidates gave the answer as 'reflection' or 'refraction' instead of 'diffraction' and 'interference'.

<u>Suggestions for teachers</u>

– Explain the graph of E_{max} Vs frequency (ν) of incident radiation.

– Train students how to read the graph and use it to determine:
- Threshold frequency
- Work function
- Planck's constant.

– State and explain the de Broglie Hypothesis and give the mathematical relation $\lambda = \frac{h}{p}$. Tell students that when $y \;\alpha\; \frac{1}{x}$, graph of y Vs x is a rectangular hyperbola.

MARKING SCHEME

Question 12.

(a) (i) Threshold frequency $(\nu_o) = 10 \times 10^{14}$ Hz

(ii) $W = (h\nu_o)$

$= 6{\cdot}6 \times 10^{-34} \times 10 \times 10^{14}$

$= 6{\cdot}6 \times 10^{-19}$ J = 4.125 eV

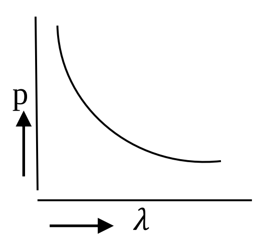
(iii) $E_K = 8 \times 1{\cdot}6 \times 10^{-19}$ J = 8eV

$$V_s = \frac{8\times1{\cdot}6\times10^{-19}}{1{\cdot}6\times10^{-19}}$$

V_s = 8·0V

(b) (i) Either

$\lambda \;\alpha\; \frac{1}{p}$ OR



OR

(de Broglie) wavelength varies inversely with the linear momentum

(ii) Electron Diffraction /diffraction/G P Thomson/ Davisson-Germer Experiment /Interference.

Question 13

(a) On the basis of **Bohr's** theory, derive an expression for the **radius** of the **nth** orbit of an electron of hydrogen atom. **[3]**

(b) Using the constants given on page 8 of this Paper, find the **minimum wavelength** of the emitted X rays, when an **X ray tube** is operated at 50 kV. **[2]**

Comments of Examiners

(a) Some candidates were unable to recall the correct equations i.e. $mvr = \frac{nh}{2\pi}$ and $\frac{mv^2}{r} = \left(\frac{1}{4\pi\epsilon_o}\right)\ \frac{Ze^2}{r^2}$

Many candidates derived the correct formula of radius, but forgot to write z = 1 for hydrogen atom.

(b) A number of candidates did not use the correct formula. Some did not convert 50kV to volt. A few candidates did not write the correct unit, after using the short cut formula, $\lambda_{min} = \frac{12400}{V}$.

Suggestions for teachers

- Ask candidates to learn derivations by heart and also to practice them.
- Tell students that the answer must be written as per the question, so, reading the questions carefully is very important.

MARKING SCHEME

Question 13.

(a)

$$mv\boldsymbol{r} = \frac{\mathbf{nh}}{\mathbf{2\pi}} \quad OR$$

$$m^2v^2r^2 = \frac{n^2h^2}{4\pi^2} \quad \text{----------------------- (i)}$$

$$\frac{mv^2}{r} = \left(\frac{1}{4\pi\epsilon_o}\right)\ \frac{Ze^2}{r^2} \quad \text{----------------------- (ii)}$$

Dividing (i) by (ii) $r = \frac{n^2h^2\epsilon_o}{\pi m Z e^2}$

for $\underline{Z = 1}$

$$r = \frac{n^2h^2\epsilon_o}{\pi m e^2}$$

(b)

$$\lambda_{min} = \left(\frac{\boldsymbol{hc}}{\boldsymbol{eV}}\right)$$

$$= \frac{\mathbf{6{\cdot}6\times10^{-34}\times3\times10^{8}}}{\mathbf{1{\cdot}6\times10^{-19}\times50000}}$$

Correct result with proper unit

$\lambda_{mi} = 0{\cdot}248\times10^{-10}$ m (or equivalent)

$$\lambda = \frac{hc}{E}$$

$$\lambda = \frac{12375}{EorV} A^\circ$$

$$\lambda = \frac{12375}{50000}$$

=0.2475 A° (or 0.248) A°

Question 14

(a) (i) Define **half life** of a radioactive substance. **[3]**

(ii) Using the equation $N = N_o e^{-\lambda t}$, obtain the relation between **half life** (T) and **decay constant** (λ) of a radioactive substance.

(b) With the help of a suitable **example** and an **equation**, explain the term ***pair production***. **[2]**

Comments of Examiners

(a)(i) Many candidates could not recall the correct definition of half-life. Some defined average life instead of half life.

(ii) Some candidates derived the formula $N=N_oe^{-\lambda t}$ which was actually given in the question. Some wrote log 2 instead of $\log_e 2$ or *ln* 2. Many candidates used 't' in place of T or $T_{1/2}$.

(b) Some candidates were confused between pair production and pair annihilation. Many candidates were unable to write a correct and balanced equation. Some candidates used wrong symbols. Several candidates could not draw the correct diagram for pair production. Many used a photon, instead of gamma ray photon.

Suggestions for teachers

– Tell students that definitions must be learnt correctly.
– Derive the relation between T and λ in class. Tell students that T is a constant whereas t can have any value - 't' cannot be used for half life.
– Pair production is a rare phenomenon in which matter is created from energy. It must be explained correctly with the help of a diagram and a balanced equation, making use of correct symbols.

MARKING SCHEME
Question 14.

(a) (i) It is that time in which a quantity of a radioactive substance becomes half.
OR
It is that time in which half of the given number of nuclei disintegrate.

(ii) Substitute $N = \frac{\mathbf{N_o}}{\mathbf{2}}$ and $t = T$
OR
$\frac{\mathbf{N_o}}{\mathbf{2}} = N_o\ e^{-\lambda T}$
$\lambda T = \log_e 2$ or $\ln 2$

(b) It is that phenomenon in which a pair of an electron and a positron is produced from a gamma ray photon.

$$\gamma \longrightarrow {}^{o}_{1}e + {}^{o}_{-1}e$$

Correct Diagram

Question 15

(a) Draw a labelled diagram of a **full wave rectifier**. Show how output voltage varies with time, if input voltage is a **sinusoidal** voltage. **[3]**

(b) What is a NAND gate? Write its truth table. **[2]**

<u>Comments of Examiners</u>

(a) Some common errors made by candidates in this part were:
- A.C. input voltage was not shown;
- Complete circuit was not drawn;
- Resistor in output circuit was not shown;
- The circuit was not labelled;

Many candidates could not show correctly how output voltage varies with time. Some candidates did not label the axes of the graph.

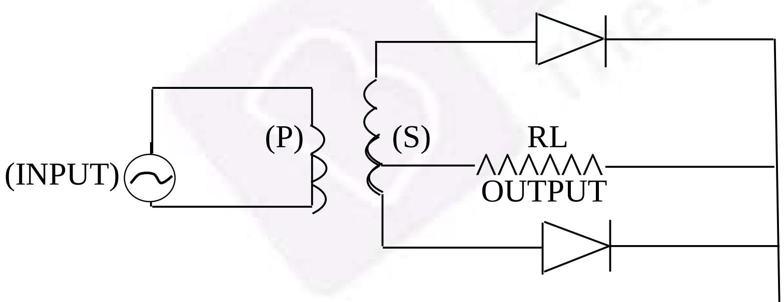
(b) Instead of defining what a NAND gate is (a combination of AND gate a NOT gate or an AND gate followed by a NOT gate), some candidates simply said that it is a universal gate. A number of candidates gave incomplete truth table whereas some candidates gave wrong truth table.

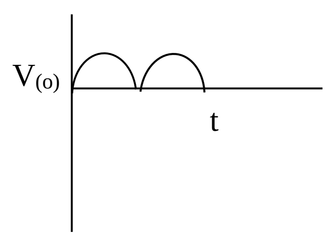
<u>*Suggestions for teachers*</u>
- Working of full wave rectifier must be clearly explained with the help of a labelled circuit diagram. Variation of input and output signals with time must also be shown correctly with the help of labelled diagrams.
- Students should be asked to practice drawing the diagram and graphs of input and output voltages.
- Give students correct definition and symbols of various basic gates as well NOR gate, NAND gate, etc. encourage them to understand the truth tables of each one of them logically.

MARKING SCHEME

Question 15.

(a)





(b) It is a combination of an AND gate and a NOT gate or it is a negated/ inverted or complement of on AND gate.

TRUTH table of NAND gate

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

GENERAL COMMENTS

(a) Topics found difficult by candidates in the Question paper:

- Equivalent resistance of a circuit.
- Equivalent capacitance of a given circuit.
- Mosley's law
- Potentiometer.
- Hysteresis.
- Time constant of an LR circuit.
- Lens mirror combination.
- Resolving power of a telescope.
- Polarisation of light.
- Reflection of light by Huygens theory.
- Drawing and use of labelled graphs.
- Elements of earth's magnetic field.
- Derivation of E in broad side position of an electric dipole.
- Derivation of B at the Centre of a circular coil of N turns.
- Drawing a ray diagram of a compound microscope.

(b) Concepts between which candidates got confused:

- Capacitors in series and parallel.
- Resistors in series and parallel
- Cells in series and parallel
- Ordinary electric circuit and Wheatstone bridge.
- End on position and broad side position of an electric dipole.
- Biot-savart's law and Ampere's circuital law.
- Long-sightedness and short sightedness.
- Reflection of light and refraction of light by Huygens's wave theory.
- Spherical aberration and chromatic aberration.
- Pair production and pair annihilation.
- Interference of light and diffraction of light.
- LR dc circuit and LR ac circuit.
- Electrostatic potential and potential energy.
- Magnetic susceptibility of paramagnetic, ferromagnetic and diamagnetic materials.
- Effect of temperature on resistance of metals and nonmetals.

(c) Suggestions for candidates:

- Learn various laws, principles, and terms. Try to understand them, rather than learning them by rote. Build up the concept and develop them with the help of examples, diagrams, numerical, etc. If need be, take the help of reference books.
- Study regularly, not just before the examination.
- Practice what you have learnt, theory, graphs, diagrams, numerical etc.
- Make a list of all the formulae in each chapter and learn these formulae, along with the meaning of each and every symbol.
- Make a list of derivations in each chapter. Lay more emphasis on understanding the derivations logically and step wise. Learn them and practice them regularly.
- During the Examination, read each and every question carefully and then write the answer to the point.
- In ray optics, arrows must be given to the rays.
- While solving a numerical problem, read the question carefully and write the given data. See if all given quantities are in same system i.e. S.I system. If not, make proper conversions e.g. cm $\longrightarrow$ m, $\mu F \longrightarrow F$ & eV to J. Then write the relevant formula, substitute the known quantities in it and solve for the unknown. Write the answer with proper unit.
- Be careful with vector quantities as they have directions.