PHYSICS

Paper – 1

(THEORY)

(Three hours)

*(Candidates are allowed additional 15 minutes for **only** reading the paper.*
They must NOT start writing during this time.)

Answer **all** *questions in* ***Part I*** *and* **six** *questions from* ***Part II****, choosing* **two** *questions from* ***each of*** *the Sections* ***A, B*** *and* ***C****.*

All working, including rough work, should be done on the same sheet as, and adjacent to, the rest of the answer.

The intended marks for questions or parts of questions are given in brackets [ ].

(Material to be supplied: Log tables including Trigonometric functions.)

A list of useful physical constants is given at the end of this paper.

PART I

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 body has a positive charge of 8×10^{-19}C. It has:

(A) an excess of 5 electrons (B) a deficiency of 5 electrons

(C) an excess of 8 electrons (D) a deficiency of 8 electrons

(ii) ***Figure 1*** below shows five dc sources (cells). Their emfs are shown in the figure.

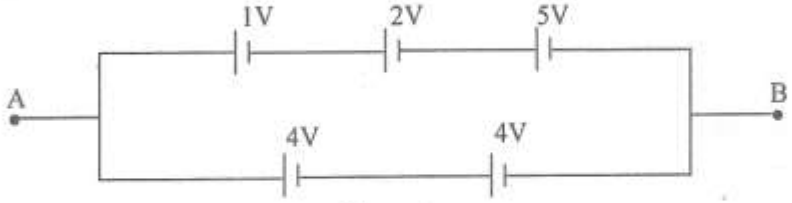


Figure 1

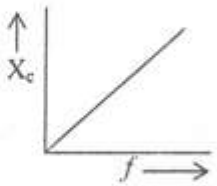
Emf of the battery AB is:

(A) 8V (B) 16V

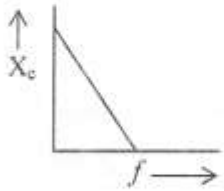
(C) 4V (D) 2V

(iii) Which one of the following graphs in ***Figure 2*** represents variation of reactance 'X_c' of a capacitor with frequency 'f' of an ac supply:

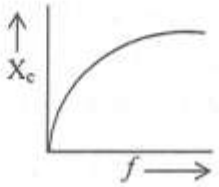
(A)



(B)



(C)



(D)

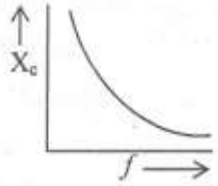


Figure 2

(iv) White light is passed through sodium vapours contained in a thin walled glass flask and the transmitted light is examined with the help of a spectrometer. The spectrum so obtained is:

(A) Absorption spectrum

(B) Solar spectrum

(C) Band spectrum

(D) Continuous spectrum

(v) Binding energy of a nucleus is of the order of:

(A) Electron volt (eV) (B) Kilo electron volt (KeV)

(C) Mega electron volt (MeV) (D) a joule (J)

B. Answer **all** questions briefly and to the point: **[15]**

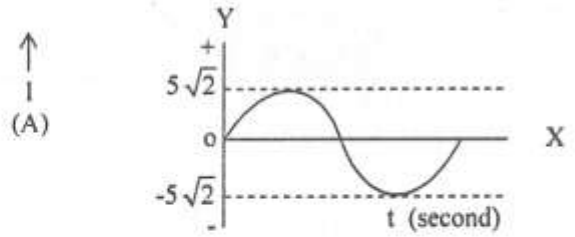
(i) A point charge of 5×10^{-6} C experiences a force of 2×10^{-3} N when kept in a uniform electric field of intensity E. Find E.

(ii) Which conservation principle is involved in Kirchoff's **first law** of electric circuits?

(iii) Write an expression of magnetic flux density **'B'** at a point in end - on position or an axial position of a magnetic dipole. (Derivation **not** required.)

(iv) In a moving coil galvanometer, what is meant by a **radial** magnetic field?

(v) Variation of alternating current 'I' with time 't' is shown in the graph below:



What is the **rms** value of this current?

(vi) Which electromagnetic radiation has wavelength greater than that of X rays and smaller than that of visible light?

(vii) How did **Fresnel** construct a biprism in order to study **interference of light**?

(viii) State **Brewster's** law of polarisation of light.

(ix) A thin convex lens (L_1) of focal length 80 cm and a thin concave lens (L_2) of focal length *f* are kept co-axially, 20 cm apart as shown in ***Figure 3*** below. When a narrow and **parallel** beam of light is incident on the convex lens, beam emerging from the concave lens is also a **parallel** beam. Find *f*.

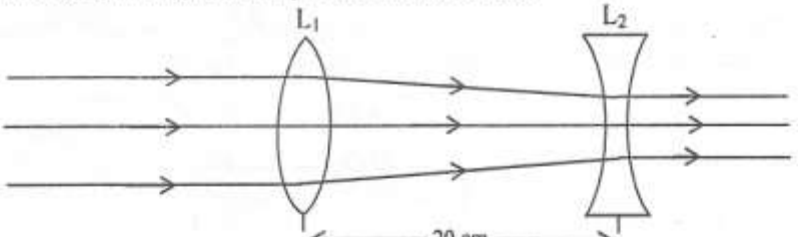


Figure 3

(x) What condition must be satisfied by two thin lenses kept in contact so that they form an achromatic doublet, i.e. a combination free from chromatic aberration?

(xi) Threshold frequency of a certain metal for photo-electric emission is 5×10^{14} Hz. Calculate its work function.

(xii) What conclusion was drawn by **Rutherford** based on **Geiger-Marsden's** experiment on scattering of alpha particles?

(xiii) Write a balanced nuclear reaction showing emission of a β^- particle by $^{234}_{90}$Th.

(Symbol of daughter nucleus formed in the process is Pa.)

(xiv) What is the essential difference between the working of a nuclear reactor and that of a fission bomb?

(xv) State one important use of a **Zener** diode.

PART II

Answer **six** *questions in this part, choosing* **two** *questions*

from ***each*** *of the Sections* ***A, B*** *and* ***C.***

SECTION A

Answer any **two** *questions*

Question 2

(a) Three point charges $Q_1 = 25\,\mu C$, $Q_2 = 50\,\mu C$ and $Q_3 = 100\,\mu C$, are kept at the corners A, B and C respectively of an equilateral triangle ABC having each side equal to 7·5m. Calculate the total electrostatic potential energy of the system. **[4]**

(b) Obtain an expression for equivalent capacitance C, when three capacitors having capacitance C_1, C_2 and C_3 are connected in **series**. **[3]**

(c) When a potential difference of 3V is applied between the two ends of a 60 cm long metallic wire, current density in it is found to be $1\times10^{-7}\ Am^{-2}$. Find conductivity of the material of the wire in SI system. **[2]**

Question 3

(a) In the circuit shown in ***Figure 4*** below, E is a battery of emf 6V and internal resistance 1Ω. Find the reading of the ammeter A, if it has negligible resistance: **[4]**

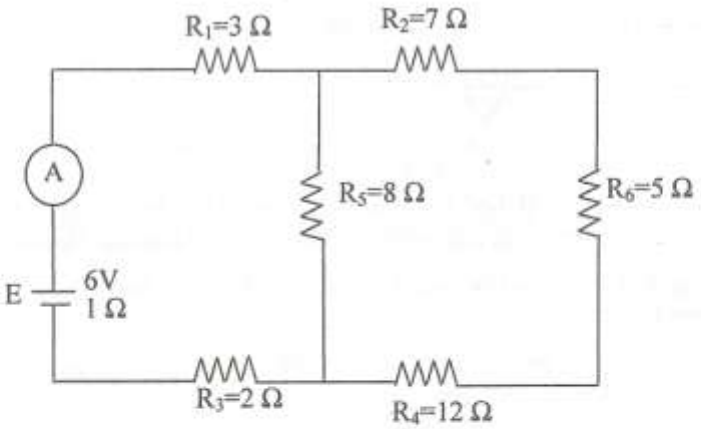


Figure 4

(b) With the help of a neatly drawn and labelled diagram, obtain balancing condition of a **Wheatstone** bridge. **[3]**

(c) State **any two** differences between **Peltier effect** and **Joule effect**. **[2]**

Question 4

(a) *Figure 5* below shows a point P near a long conductor XY carrying a current I. MN is a short current carrying conductor, kept at the point P, parallel to the conductor XY. [2]

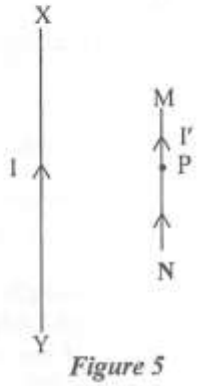


Figure 5

(i) What is the direction of magnetic flux density **'B'** at the point P due to the current flowing through XY?

(ii) What is the direction of the force experienced by the conductor MN due to the current flowing through XY?

(b) What are **four** different types of energy losses in a transformer? State how to reduce/minimize **any one** of them. [3]

(c) A 50 μ F capacitor, a 30 Ω resistor and a 0·7 H inductor are connected in series to an ac supply which generates an emf 'e' given by e = 300 Sin(200t) Volt. Calculate **peak value** of the current flowing through the circuit. [4]

SECTION B

Answer any **two** *questions*

Question 5

(a) On the basis of **Huygen's** wave theory, prove **Snell's law** of refraction of light. Draw a neat and labelled diagram. (Postulates of Huygen's wave theory not required). [4]

(b) In **Young's** double slit experiment using monochromatic light of wavelength 600 nm, interference pattern was obtained on a screen kept 1·5 m away from the plane of the two slits. Calculate the distance between the two slits, if fringe separation/fringe width was found to be 1·0 mm. [2]

(c) Draw a labelled graph to show variation in intensity of diffracted light with angular position, in a single slit diffraction experiment. [2]

Question 6

(a) You are provided with a narrow and parallel beam of light. State how you will determine **experimentally**, whether it is a beam of ordinary (unpolarised) light, partially polarised light or completely polarised light. [3]

(b) For any prism, show that refractive index of its material is given by: [3]

$$\text{n or } \mu = \frac{Sin\left(\frac{A+\delta m}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

where the terms have their usual meaning.

(c) ***Figure 6*** below shows a parallel beam of monochromatic light incident on a convex spherical surface, radius of curvature R = 30 cm, which separates glass (refractive index = 1·6) from air. Find the position of the image formed due to refraction of light at this single spherical surface. [2]

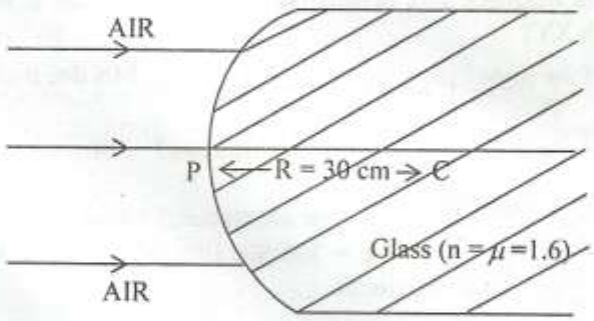


Figure 6

Question 7

(a) (i) What is meant by: [3]

(A) Spherical aberration?

(B) Chromatic aberration?

(ii) How can spherical aberration be reduced/minimized? Suggest any one method.

(b) A compound microscope consists of an objective of focal length 2 cm and an eye piece of focal length 5 cm. When an object is kept 2·4 cm from the objective, final image formed is virtual and 25 cm from the eye piece. Determine magnifying power of this compound microscope in this set up i.e. in normal use. [3]

(c) (i) Define ***Resolving Power*** of a simple astronomical telescope. [2]

(ii) State **one** advantage of a reflecting telescope over refracting telescope.

SECTION C

Answer any **two** *questions*

Question 8

(a) Electrons having a velocity $\vec{v}$ of $2\times10^{6}ms^{-1}$ pass undeviated through a uniform electric field $\vec{E}$ of intensity $5\times10^{4}Vm^{-1}$ and a uniform magnetic field $\vec{B}$. [2]

(i) Find the magnitude of magnetic flux density B of the magnetic field.

(ii) What is the direction of $\vec{B}$, if $\vec{v}$ is towards right and $\vec{E}$ is vertically downwards in the plane of this paper?

(b) Monochromatic light of wavelength 198 nm is incident on the surface of a metal, whose work function is 2·5 eV. Calculate the **stopping potential.** [3]

(c) Energy levels of **H** atom are given by: [3]

$$E_n = -\frac{13.6}{n^2}\ eV,$$

where n is Principal Quantum number. Calculate the wavelength of electromagnetic radiation emitted by hydrogen atom resulting from the transition: $n = 2$ to $n = 1$.

Question 9

(a) (i) What is ***Compton effect*** ? [3]

(ii) In Coolidge X-Ray tube (Modern X-Ray tube) how will you vary:

(1) intensity of emitted X-Rays?

(2) penetrating power of emitted X-Rays?

(b) Complete the following table for a radioactive element whose half life is 5 minutes. Assume that you have 32 g of this element at start, i.e. at $t = 0$. [3]

Time 't' in minutes	0	5	10	15	20	25
Amount of radioactive element left in grams	32					

Now, using this data, plot the "**decay curve**".

(c) Calculate the energy released when an electron **annihilates** a positron. [2]

Question 10

(a) Draw a labelled **energy band diagram** for a solid which is an **insulator.** What is the main difference between this diagram and that of a semi-conductor? [3]

(b) ***Figure 7*** below shows the circuit of an electronic device: [3]

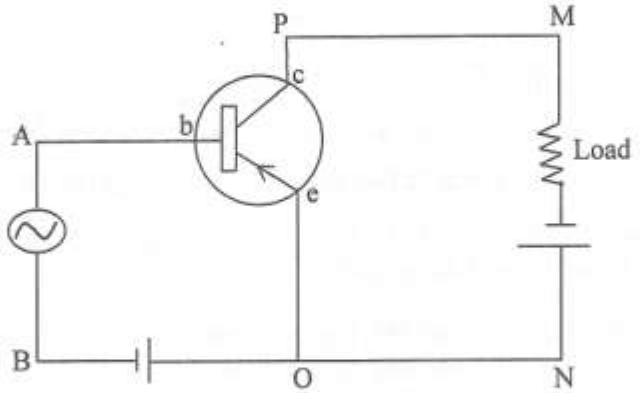


Figure 7

(i) Which electronic device: a rectifier, an amplifier or an oscillator does the above circuit represent?

(ii) State where the input voltage is applied and where the output voltage is available.

(iii) Compare the output voltage of this circuit with its input voltage.

(c) Prepare a truth table for the combination of gates shown in ***Figure 8*** below: [2]

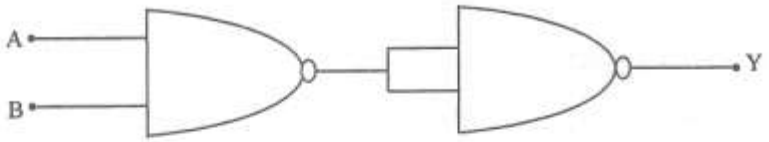


Figure 8

Useful Constants and Relations:

1.	Speed of Light in vacuum	(c)	$= 3.0 \times 10^{8}\ ms^{-1}$
2.	Planck's Constant	(h)	$= 6.6 \times 10^{-34}\ Js$
3.	Charge of an electron	(-e)	$= -1.6 \times 10^{-19} C$
4.	Constant for Columb's law	$\left(\frac{1}{4\pi \epsilon_o}\right)$	$= 9 \times 10^{9}\ mF^{-1}$
5.	Mass of an electron	(m_e)	$= 9 \times 10^{-31}\ kg$
6.	1 electron volt	(1eV)	$= 1.6 \times 10^{-19} J$
7.		(1nm)	$= 10^{-9} m$