PHYSICS

Paper – 1

(THEORY)

Three hours and a quarter

(The first 15 minutes of the examination are for reading the paper only.

Candidates must NOT start writing during this time).

Answer **all** *questions in Part I. From Part II, answer any four questions from Section A, any three questions from Section B and any two questions from Section C.*

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

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

Balanced equations must be given wherever possible and diagrams where they are helpful.

When solving numerical problems, all essential working must be shown.

In working out problems, use the following data:

Gas Constant R = 1.987 cal deg^{-1} mol^{-1} = 8.314 JK^{-1} mol^{-1} = 0.0821 dm^3 atm K^{-1} mol^{-1}

PART I (40 marks)

Answer **all** *questions.*

Question 1.

(a) ***Each question is followed by four possible choices of answers. Choose the correct answer and write it in your answer sheet.*** **[10]**

(i) When Si and Cu are cooled to a temperature of 300 K, the resistivity for

A Si increases and Cu decreases.

B Si decreases and Cu increases.

C Si increases and Cu increases.

D Si decreases and Cu decreases.

(ii) The magnetic field due to a small current element *dl* at a distance *r* and the element carrying a current *I* is

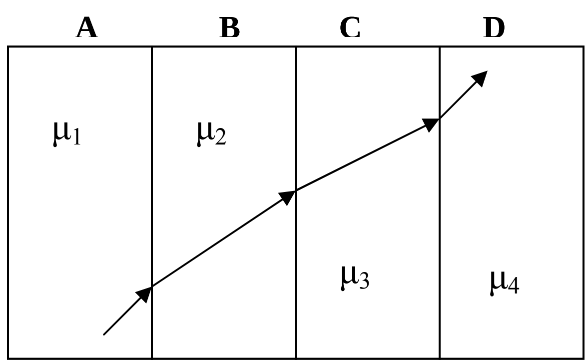
A $\frac{\mu_0 I}{4\pi}\frac{d\vec{l}x\vec{r}}{r}$.

B $\frac{\mu_0 I}{4\pi}\frac{Id\vec{l}x\vec{r}}{r^2}$.

C $\frac{\mu_0 I}{4\pi}\frac{d\vec{l}x\vec{r}}{r^3}$.

D $\frac{\mu_0 I}{4\pi}\frac{d\vec{l}x\vec{r}}{r^4}$.

(iii) A ray of light passes through four transparent media A, B, C and D with refractive indices μ_1, μ_2, μ_3, μ_4 respectively as shown in the figure given below. The refracting surfaces of all media are parallel to each other. If the rays inside the media A and D are parallel, then



A $\mu_1 = \mu_2 < \mu_3$.

B $\mu_1 < \mu_2 = \mu_3$.

C $\mu_1 < \mu_3 = \mu_4$.

D $\mu_2 > \mu_1 = \mu_4$.

(iv) If the distance between a point source of light and screen is halved, the intensity will become

A one quarter.

B half.

C two times.

D four times.

(v) When the mass of the nucleus of an atom is m and the sum of the masses of the nucleons in it is $m^{/}$ then

A $m<m'$.

B $m = m'$.

C $m>m'$.

D $m \leq m'$.

(vi) When an electric current is sent through a thermo-couple, its two junctions register a difference of temperature. This effect is called

A Thomson's effect.

B See-beck effect.

C Joules effect.

D Peltier effect.

(vii) The direction of magnetic moment of a magnetic dipole is

A along the axis from south to north.

B along the axis from north to south.

C at right angles to axis, directed towards it.

D at right angles to axis, directed away from it.

(viii) Susceptibility is positive and large for a

A ferromagnetic substance.

B non-magnetic substance.

C paramagnetic substance.

D diamagnetic substance.

(ix) The control rods in a nuclear reactor are made of

A graphite.

B uranium.

C cadmium.

D plutonium.

(x) Transistors are useful in equipments such as hearing aids and small radios receivers because they

A are inexpensive.

B can stand rough use.

C do not distort sound.

D consume little power.

(b) Complete the following statements by choosing the correct alternatives given in the bracket. **[6]**

(i) The magnification for a compound microscope is generally …………. but …….. for an astronomical telescope. (unity, less than unity, greater than unity, infinity)

(ii) The saturated photoelectric current depends upon ….... while the stopping voltage depends upon the ………of incident radiation. (intensity, wave length, frequency, velocity)

(iii) The wave particle duality of electromagnetic waves could be assured from …….. and ……. (polarization, Thomson's experiment, Brewster's law, photo electric effect)

(iv) In Fraunhofer's diffraction at a single slit, the diffraction pattern will be ……. if the slit is made narrower. (white, colourful, wider, narrower)

(v) Diodes and transistors are the basic circuit elements in …… and ….. respectively. (amplifiers, radio receivers, microphones, rectifiers)

(vi) In a transistor amplifier, the emitter-base junction is ….. biased and the base collector-junction is ….. biased. (forward, reversed, thickly, thinly)

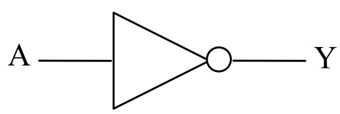
(c) Write True or False and give reasons for the false statements. **[4]**

(i) The wavelength of soft X-rays is smaller than that of hard X-rays.

(ii) No electrons are emitted if the incident radiation has a frequency less than a threshold frequency.

(iii) The resistivity of a semi-conductor increases with rise in temperature.

(iv) The Boolean expression for the logic gate given below is Y = A.



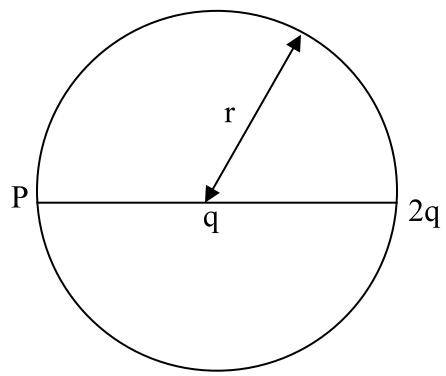
(d) Match the items of column A with the items in column B. Rewrite the correct pairs in your answer sheet. **[4]**

Column A	**Column B**
(i) Chromatic aberration	(a) Michelson's experiment
(ii) Conservation of energy	(b) uranium fuel
(iii) Null deflection method	(c) Coolidge tube
(iv) Source of electromagnetic waves	(d) Fraunhoffer lines
(v) Nuclear fission	(e) photoelectric effect
(vi) Nuclear fusion	(f) astronomical telescope
(vii) Diffraction	(g) tangent galvanometer
(viii)Detection of current	(h) hydrogen bomb
	(i) half-life
	(j) voltmeter

(e) Answer the following questions.

(i) What is the effect of polarization in a capacitor due to the introduction of a dielectric medium in between the plates?

(ii) The figure given below represents a circle of radius r with a point P and charge $2q$ at the ends of a diameter and the charge q located at the centre. Find the expression for the net electrostatic potential at P. **[2]**



(iii) Derive the expression for the velocity of the electron in the nth Bohr orbit. **[2]**

(iv) A radioactive nuclide 'Z' undergoes a series of decays according to the scheme,

$Z \xrightarrow{\alpha} Z_1 \xrightarrow{\beta} Z_2 \xrightarrow{\alpha} Z_3 \xrightarrow{\gamma} Z_4$

If the mass number and the atomic number of 'Z' are 180 and 72 respectively, what are the corresponding numbers for Z_4? **[2]**

(v) Derive the relation to calculate the maximum frequency of the LCR circuit at the condition of resonance. **[2]**

(vi) State *two* postulates of Huygen's wave theory. **[2]**

(vii) How can we predict the age of archeological specimen on the basis of radioactivity? **[1]**

(viii) Compare alpha, beta and gamma particles on the basis of any *two* properties. **[3]**

PART II

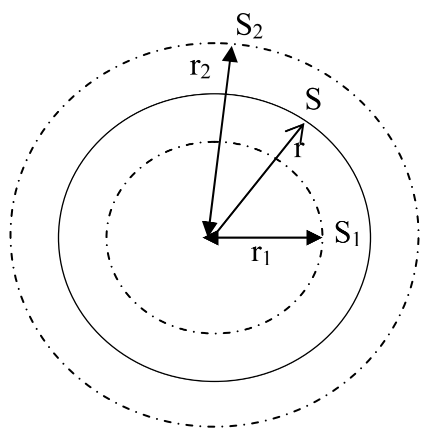
SECTION A (28 marks)

Answer any **four** *questions.*

Question 2.

(a) Modify Coulomb's law to express the dielectric constant of a medium in terms of electrostatic force. **[2]**

(b) Define Gauss theorem. A hollow sphere *S* of radius *r* encloses σ charge per unit area. There are concentric spheres S_1 with radius $r_1 < r$ and S_2 with radius $r_2 > r$ as shown in the figure given below. Apply Gauss's theorem to sketch the intensity distribution curve for the system given below. **[3]**



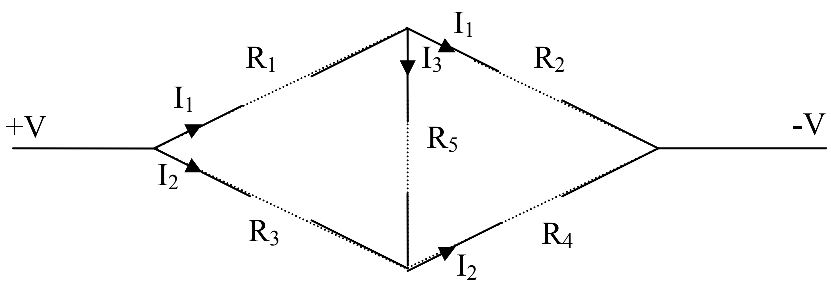
(c) A capacitor of capacitance 4μF is charged to 100V and then discharged through a resistor. What is the heat produced in the resistor? **[2]**

Question 3.

(a) Write *one* evidence to show that Ohm's law is not universally accepted.
A p.d of 10V is applied across a conductor of resistance 1 kΩ. Find the approximate number of free electrons flowing through the conductor in one minute. **[3]**

(b) Name the physical quantity whose SI unit is Newton Coulomb^{-1}.

(c) Study the diagram given below. Using the conditions, $I_3 = 0$ and internal resistance of the source is negligible, establish an important relation between the resistance R_1, R_2, R_3 and R_4. **[3]**



Question 4.

(a) What is the relation between the temperatures of cold junctions, the neutral temperature and the temperature of inversion of a thermocouple? **[2]**

(b) Write down *two* major factors that contribute to joules heating effect. **[2]**

(c) Derive an expression for the torque acting on a bar-magnet when placed at an angle θ with the direction of an uniform magnetic field. Hence define the magnetic dipole moment of that bar magnet. **[3]**

Question 5.

(a) Give a neat sketch of the deflection magnetometer in which the tangent law in magnetism is strictly applied. Demonstrate how tangent law is utilized in this device. **[3]**

(b) Define magnetic permeability. **[1]**

(c) Derive the expression for the magnetic field at the centre of a circular current-carrying coil of radius *r*. **[3]**

Question 6.

(a) Deduce with the help of a diagram the expression for a force per unit length experienced by two wires of infinite length when current flows in the same direction.

(b) Explain the phenomenon of mutual induction. Derive the relation to calculate its coefficient. Write *one* application where it is used. **[3]**

Question 7.

(a) How does the term electric resistance differ from impedance? With the help of a suitable vector diagram produce an expression for the impedance in an LCR series circuit. **[3]**

(b) A resistor of $50\,\Omega$, an inductor of $\frac{20}{\pi}$ H and a capacitor of $\frac{5}{\pi}$ μF are connected in series to an A.C voltage source of 50 Hz. Find the impedance of the circuit. **[3]**

(c) Explain power factor. **[1]**

SECTION B (18 marks)

Answer any **three** *questions.*

Question 8.

(a) Draw a labeled diagram of an octagonal mirror set-up made by Michelson in between mount Antonio and mount Wilson. (Explanation of the experiment is not required.) Apply a condition on the above set-up to calculate the velocity of light. **[3]**

(b) Sketch the experimental set-up by Young's for getting the interference pattern. Write *two* conditions to have interference patterns. **[3]**

Question 9.

(a) In an interference pattern, construct any conditions for the bandwidth to be zero and infinite.

(b) 'It is observed that light waves cannot be longitudinal at all.' Justify the statement on the basis of a relevant phenomenon. **[2]**

(c) Define Fraunhoffer diffraction. How is the diffraction from a single slit related with the interference? **[2]**

Question 10.

(a) With the help of a diagram apply the conditions observed in a angle of minimum deviation position to modify Snell's relation in terms of A and δ_{min} . **[4]**

(b) Draw the ray diagram to show whether it is possible to produce a real image in a denser medium through a convex surface for an object being kept in the rarer medium. **[2]**

Question 11.

(a) The radii of curvature of a double convex lens is 15 cm and 30 cm. Its refractive index is 1.5. Find the focal length of the lens. **[2]**

(b) Define chromatic aberration in lenses. Give the condition for achromatism. **[2]**

(c) Define luminous intensity. Name the unit in which it is measured. **[2]**

SECTION C (14 marks)

Answer any **two** *questions.*

Question 12.

(a) State the laws of photoelectricity. **[3]**

(b) Differentiate between the mass defect and binding energy. **[2]**

(c) Calculate de Broglie's wavelength for an electron moving with the velocity $10^6 ms^{-1}$. **[2]**

Question 13.

(a) Describe Rutherford's atomic theory and state its major failure. Apply Bohr's postulates to rectify the above theory. **[4]**

(b) Translate energy-mass equivalence to express the binding energy of a nucleus. **[1]**

(c) Calculate the energy equivalent of 1 a.m.u in MeV. **[2]**

Question 14.

(a) A certain radioactive substance has a half-life period of 30 months. What is the disintegration constant? **[2]**

(b) Define intrinsic semi-conductors. Explain briefly how to convert an intrinsic semi-conductor into a n-type extrinsic semi-conductor. **[2]**

(c) Draw a circuit diagram of a transistor as an amplifier (common emitter) and write the expression for voltage gain. **[3]**

[PHYSICAL CONSTANTS]

Planck's constant	$h = 6.63 \times 10^{-34}$ J.s
Electron charge	$e = 1.6 \times 10^{-19}$ C
1 electron volt	$1\ eV = 1.60 \times 10^{-19}$ J
Speed of electromagnetic wave	$C = 3.00 \times 10^{8}\ ms^{-1}$
Energy equivalent of	$1u = 931$ MeV
Mass of an electron	$m_e = 9.10 \times 10^{-31}$ kg
	$1u = 1.66 \times 10^{-27}$ kg