Total No. of Printed Pages—7

GB/M–06–33B

2006

PHYSICS

SECOND PAPER

Full Marks : 200

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer **all** questions

Use of non-programmable calculators allowed

GROUP—A

1. *(a)* Using Gauss' law in electrostatics, show that the electric intensity near a charged conducting surface in air is

$$\frac{\sigma}{\varepsilon_0} NC^{-1}$$

where σ is the surface density of charge and ε_0 is the absolute permittivity of free space in SI units. Show also that the force acting on a unit area of the surface is

$$\frac{\sigma^2}{2\varepsilon_0}$$

8+4=12

(b) Two identical spherical liquid drops, each having a radius of 2 mm and carrying a charge of 5×10^{-15} C coalesce to form a single drop. What is the potential at the surface of the new drop? [Given, $\varepsilon_0 = 8 \cdot 85 \times 10^{-12}$ SI units] 8

Or

What do you understand by the polarization of a dielectric? How does it explain the effect of inserting a dielectric slab between the plates of a given capacitor? 4+4=8

2. (a) Describe briefly, how an attracted disc electrometer can be used to measure potential difference. 6

(b) A small rectangular coil carrying current is placed in a uniform external magnetic field. Show that the potential energy of the coil is $U = -\vec{p}_m \cdot \vec{B}$, where $\vec{p}_m$ is the magnetic moment of the loop and $\vec{B}$ is the external magnetic field. 8

Or

Establish the relationship $\vec{B} = \mu_0(\vec{H} + \vec{M})$ in magnetostatics, where the symbols have their usual meanings.

(c) Derive an expression for the self-inductance of a long solenoid of length l, total number of turns n and radius r. 6

3. (a) Derive an expression for the magnetic field due to a circular loop of radius R carrying a current at any point on its axis other than its center. 12

(b) There are 1600 turns of mean radius 10 cm in a solenoid of length 20 cm with air inside. A current of 2 A is made to flow through it. Calculate the magnetic field on its axis at a distance of 10 cm inside from one end. What is the value of the field at one end? [Given, $\mu_0 = 4\pi \times 10^{-7}$ H/m] 6+2=8

Or

A long straight wire carries a current of 50 A. An electron is moving towards the wire with a velocity of 10^7 m/s. Find the force acting on the electron when it is at a distance of 5·0 cm from the wire. 8

4. Discuss the charging and discharging of a capacitor through a resistance. What is meant by time constant of the circuit?

A capacitor of capacitance 1 μF is discharged through a high resistance. The time taken for half the charge on the capacitor to leak is found to be 10 seconds. Compute the value of the resistance. 16+4=20

5. (a) What is meant by resonance in an a.c. circuit? What is a series resonant circuit? Derive an expression for the resonant frequency of the circuit. Why is it called an acceptor circuit? 2+2+4+2=10

Or

What do you understand by the quality factor Q of a circuit? Show that in a series resonant circuit the bandwidth is given by

$$\Delta f = \frac{R}{2\pi L}$$

where the symbols have their usual meanings. 2+8=10

(b) A 2 kΩ resistor, a 1 mH inductor and a 1 μF capacitor are connected in series across a 120 V, 60 Hz a.c. source. Calculate the impedance of the circuit. What will be the reading of an a.c. voltmeter connected across the resistor? 4+6=10

GROUP—B

6. (a) State and explain Einstein's photo-electric equation. Discuss how it was verified experimentally. 2+5+5=12

(b) Maximum energy of photoelectrons emitted by a metal surface is $3 \cdot 62 \times 10^{-12}$ erg, when the incident radiation is 3000 Å. When the incident radiation is 5000 Å, the maximum energy of photoelectrons is $0 \cdot 972 \times 10^{-12}$ erg. Calculate Planck's constant and the threshold wavelength of the metal. [Given, $c = 3 \times 10^8$ m/s] 8

Or

Give the construction and the working of a photovoltaic cell.

7. (a) Explain why there is a short wavelength limit in the continuous X-ray spectrum. Establish the relation between the minimum wavelength and the accelerating potential. 3+5=8

(b) State Moseley's law, giving clearly the meanings of the different terms in it. What is the contribution of Moseley's law in the perfection of the periodic table? 3+5=8

Or

Discuss briefly, what is meant by radioactive carbon dating. 8

(c) An X-ray tube operates at 50 kV and emits a continuous X-ray spectrum. Calculate the shortest wavelength of X-ray emitted. [Given $h = 6 \cdot 63 \times 10^{-34}$ J-s and $c = 3 \times 10^{8}$ m/s] 4

8. (a) Define the mean life of a radioactive substance. Show that the mean life is equal to the reciprocal of its decay constant. 3+7=10

(b) The activity of a radioactive substance decreases to 1/64 of its original value in 21 days. Calculate the half-life of the substance. 5

Or

The half-life of radium is 1590 years. In how many years will 1 gram of radium be reduced to 1 centigram?

(c) Discuss briefly the origin of solar energy. 5

9. (a) Distinguish between controlled and uncontrolled chain reactions in a nuclear fission reaction. What are the conditions for a self-sustained chain reaction? 4+4=8

(b) Explain the function of a moderator in a nuclear reactor. 4

(c) Write in short, the principle of a cyclotron or a bubble chamber. 4

(d) Distinguish between primary and secondary cosmic rays. 4

10. (a) Describe the working of a common emitter P-N-P transistor amplifier. 10

(b) A transistor is connected in common emitter configuration. The collector supply is 8 V and the voltage drop across a resistor of 800 Ω in the collector circuit is 0·5 V. If the current gain factor α is 0·96, find the base current. 5

(c) Mention briefly the salient features on account of which FM receivers are superior to AM receivers. 5

Or

Draw the block diagram of a superheterodyne FM receiver and mention the feature on which it is different from a superheterodyne AM receiver. 3+2=5

★★★