Time : 3 hrs | Max. Marks : 70

General Instructions

1. All questions are compulsory. There are 33 questions in all.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. **Section A** contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, **Section B** has two case based questions of 4 marks each, **Section C** contains nine short answer questions of 2 marks each, **Section D** contains five short answer questions of 3 marks each and **Section E** contains three long answer questions of 5 marks each.
4. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

SECTION-A

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

1. When yellow light is incident over a metal surface, no electrons are emitted while green light can emit electrons. What will happen, if red light is incident over the surface?

2. Name any one method by which eddy currents can be minimised in the metal core of transformer on which coils are wound.

   Or

   Find the self-inductance of a coil, in which magnetic flux of 40 mWb is produced when 2A current flows through it.

3. When a ray is refracted from one medium to another, the wavelength changes from 6000 Å to 4000 Å. Find the critical angle for the interface.

4. A *p-n* junction photodiode is fabricated from a semiconductor with a band gap of 2.8 eV. Upto which wavelength it can detect a light?

5. A magnet of magnetic moment 2.5 A-m^2, weighs 66g. If the density of the material of the magnet is 7500 kg m^{-3}, then find the intensity of magnetisation.

* You are advised to attempt this sample paper without referring the solutions given here. However, cross check your solutions with the solutions given at the end of paper after you complete the paper.

Or

An electron moves in a circular path of radius 15 cm in a magnetic field of 4 G. Find the velocity of the electron in this field.

6. On bombarding U^{235} by slow neutron, 200MeV energy is released. If the power output of atomic reactor is 1.6 MW, then what is the rate of fission?

Or

If the orbital radius of the electron in a hydrogen atom is 4.7×10^{-11} m. Compute the kinetic energy of the electron in hydrogen atom.

7. In photoelectric effect, if the intensity of light is doubled, then what will be the change in maximum kinetic energy of photoelectrons?

8. When a charged capacitor is disconnected from a battery and if its plates are separated further, then find the change in its potential energy.

9. What is the frequency range of visible rays?

10. A p-n junction diode is forward biased. Write the effect on its potential barrier.

Or

Draw the I-V characteristics of a illuminated photodiode.

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.

11. Assertion If a proton and an α-particle enter a uniform magnetic field perpendicularly with the same speed, the time period of revolution of α-particle is double than that of proton.

Reason In a magnetic field, the period of revolution of a charged particle is directly proportional to the mass of the particle and inversely proportional to the charge of particle.

12. Assertion If the inner solenoid was much shorter than (and placed well inside) the outer solenoid, then we could still have calculated the flux linkage $N_1\phi_1$.

Reason The inner solenoid is effectively immersed in a uniform magnetic field due to the outer solenoid.

13. Assertion Propagation of light through an optical fibre is due to total internal reflection taking place at the core-clade interface.

Reason Refractive index of the material of the core of the optical fibre is greater than that of air.

14. Assertion Photocell is also called electric eye.

Reason Photocell can see the things placed infront of it.

SECTION-B

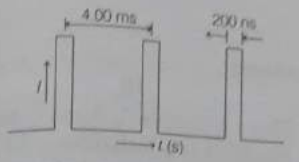
Questions 15 and 16 are case study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carriers 1 mark.

Electric Pulse

15. We define average current as $I_{av} = \frac{\Delta Q}{\Delta t}$ and instantaneous current as $I = \frac{dQ}{dt}$.

Obviously, $Q = \int I dt$. Further, electric energy delivered per unit time by a source, i.e. power, $P = \frac{\Delta E}{\Delta t}$, where ΔE is the energy delivered by the source in time Δt.

In a certain accelerator, electrons emerge with energies of 40.0 MeV (1MeV $= 1.60 \times 10^{-13}$ J). The electrons do not emerge in steady stream, but in pulses that repeat 250 times per second.



This corresponds to a time between each pulse of 4.00 ms in figure. Each pulse lasts for 200 ns and the electrons in the pulse constitute a current of 250 mA. The current is zero between the pulses. While the pulse is ON, the current is constant.

(i) Which of the following relation is correct for conductivity σ of solid conductor?

(a) $\sigma = \frac{ne^2}{m}\tau$ (b) $\sigma = \frac{2ne^2}{m}\tau$

(c) $\sigma = \frac{ne^2}{2m}\tau$ (d) $\sigma = \frac{ne^2}{4m}\tau$

(ii) The charge delivered by the acceleration per pulse is

(a) 5.00×10^{-6} C (b) 5.00×10^{-8} C

(c) 10.00×10^{-8} C (d) 10.00×10^{-6} C

(iii) The number of electrons delivered per pulse is

(a) 6×10^{11} (b) 6×10^{9}

(c) 3.13×10^{11} (d) 3.13×10^{18}

(iv) The average current delivered by the acceleration is

(a) 12.5 A (b) 12.5 mA

(c) 12.5 μA (d) 1.25 A

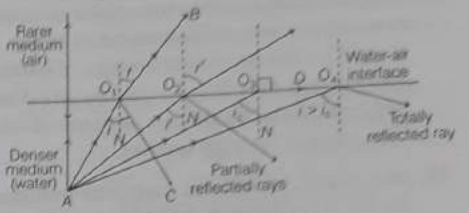
(v) The maximum power delivered by the electron beam is

(a) 100 W (b) 10 kW

(c) 1MW (d) 10 MW

Total Internal Reflection

16. Total internal reflection is the phenomenon of reflection of light into denser medium at the interface of denser medium with a rarer medium. Light must travel from denser to rarer and angle of incidence in denser medium must be greater than critical angle (i_c) for the pair of media in contact, we can show $\mu = \frac{1}{\sin i_c}$.



(i) In total internal reflection,

(a) light ray travelling through a denser medium is completely reflected back to denser medium

(b) light ray travelling through a denser medium is completely refracted to rarer medium

(c) light ray is partially reflected back to denser medium and partially refracted to rarer medium

(d) light ray is absorbed completely by denser medium

(ii) Total internal reflection of a light ray travelling from denser medium to rarer medium occurs only when angle of incidence is

(a) 45°

(b) 90°

(c) acute

(d) more than a certain value

(iii) Critical angle for water-air interface is 48.6°. What is the refractive index of water?

(a) 1 (b) 3/2 (c) 4/3 (d) 3/4

(iv) Light is travelling from air to water at $\angle i = 50°$, which is greater than critical angle for air-water interface. What fraction of light will be totally reflected?

(a) 100% (b) 50%

(c) 25% (d) None of these

(v) Critical angle for glass-air interface where refractive index μ of glass is 3/2 is

(a) 41.8° (b) 60° (c) 30° (d) 44.3°

SECTION-C

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

17. A germanium p-n junction diode is connected to a battery with milliammeter in series. What should be the minimum voltage of battery, so that current may flow in the circuit? What happens, if the diode is now made of silicon? Give reason for your answer.

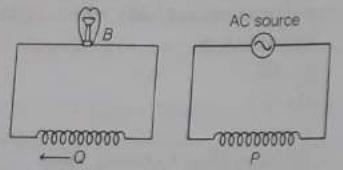
18. In a region of uniform magnetic induction $B = 10^{-2}$ T, a circular coil of radius 30 cm and resistance $\pi^2\Omega$ is rotated about an axis which is perpendicular to the direction of B and which forms a diameter of the coil. If the coil rotates at 200 rpm, find the amplitude of the alternating current induced in the coil.

Or

A coil Q is connected to low voltage bulb B and placed near another coil P as shown in the figure. Give reasons to explain the following observations.

(i) The bulb B lights.

(ii) Bulb gets dimmer, if the coil Q is moved towards left.



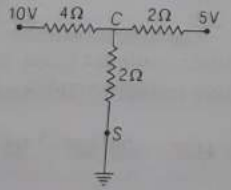
19. Suppose that, the electric field part of an electromagnetic wave in vacuum is

$$\mathbf{E} = (3.1\ \text{N/C})\cos[(1.8\ \text{rad/m})y + 5.4\times 10^{8}\ \text{rad/s})t]\hat{i}$$

(i) What is the direction of propagation?

(ii) What is the wavelength λ ?

20. As the switch S is closed in the circuit shown in figure below, then find current passed through it



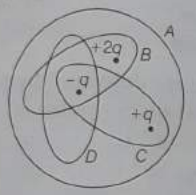
Or

Three materials A, B and C have electrical conductivities σ, 2σ and 2σ, respectively. Their number densities of free electrons are n, $2n$ and n, respectively. For which material, is the average collision time of free electrons maximum ?

21. Write some important properties of electric field lines.

Or

Rank the Gaussian surfaces as shown in the figure. In order of increasing electric flux, starting with the most negative.



22. (i) Which lens is used as a magnifying lens?

(ii) Raghav's grandfather was using spectacles of power -1D for distant vision. Now, he also needs to use reading glass of $+0.2$D. Explain it.

23. Define the term electric power and write and define its SI unit.

24. Two wavelengths of sodium light 590 nm, 596 nm are used in turn to study the diffraction taking place at a single slit aperture 2×10^{-4} cm. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of first maximum of the diffraction pattern obtained in the two cases.

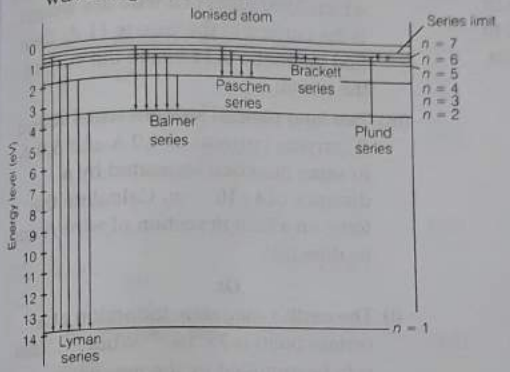
25. The mass of a nucleus is less than the sum of the masses of constituent neutrons and protons. Comment.

SECTION-D

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

26. Hydrogen spectrum consists of discrete bright lines in a dark background and it is specifically known as hydrogen emission spectrum.There is one more type of hydrogen spectrum that exists where we get dark lines on the bright background, which is known as absorption spectrum.

Line spectra of the hydrogen atom is given below, whose series limit corresponds to the wavelength for $n = \infty$.



By using above spectra, write the expression for the series limit for all the series obtained.

Or

(i) Using Bohr's second postulate of quantisation of orbital angular momentum, show that the circumference of the electron in the nth orbital state in H-atom is n-times the de-Broglie wavelength associated with it.

(ii) The electron in H-atom is initially in the third excited state. What is the maximum number of spectral lines which can be emitted when it finally moves to the ground state?

27. A circular coil of 200 turns and radius 10 cm is placed in a uniform magnetic field of 0.5 T, parallel to the plane of the coil. If the current in the coil is 3 A, then calculate the

(i) total torque on the coil,

(ii) total force on the coil and

(iii) average force on each electron in the coil, due to the magnetic field.

Assume the area of cross-section of the wire to be 10^{-5} m^2 and the free electron density is 10^{29} m^{-3}.

28. What are extrinsic semiconductors? On the basis of valence band model, explain how can a pure semiconductor of Ge or Si be converted into n-type semiconductor?

29. (i) How does the choke coil help in the working of tubelight?

(ii) What is the effective resistance of a choke coil?

(iii) How can one reduces high frequency alternating current? What should be changed to reduce low frequency AC ?

30. Describe a photo-cell and mention few of its applications.

Or

What are the observations made from the expression of de-Broglie wavelength?

SECTION-E

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

31. (i) A point charge is placed at the centre of spherical gaussian surface. How will the electric flux ϕ change, if

(a) the sphere is replaced by a cube of same or different volume?

(b) a second charge is placed near and outside the original sphere?

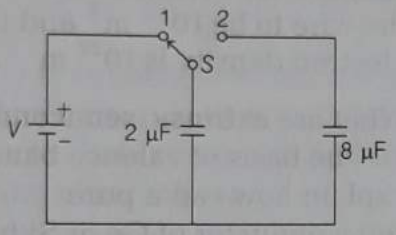
(c) the original charge is replaced by an electric dipole?

(ii) Two point charges $q_A = 3\mu$C and $q_B = -3\mu$C are located 20 cm apart in vacuum. What is the electric field and its direction at the mid-point O of the line AB joining the two charges?

Or

(i) A molecule of a substance has a permanent electric dipole moment of magnitude 10^{-29} C-m. A mole of this substance is polarised (at low temperature) by applying a strong electrostatic field of magnitude 10^6 Vm^{-1}. The direction of the field is suddenly changed by an angle of 60°. Calculate the heat released by the substance in aligning its dipoles along the new direction of the field.

(ii) A capacitor of 2 μF is charged as shown in the figure. When the switch *S* is turned to position 2, then find the percentage of its stored energy dissipated.

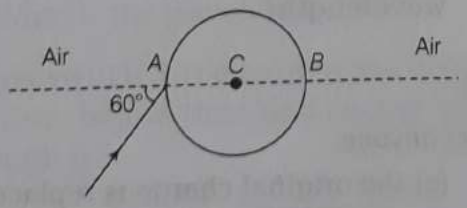


32. (i) Use the lens equation to deduce algebraically that an object placed with in the focus of a convex lens produces a virtual and enlarged image.

(ii) What do you understand by sign convention in measuring distances for lenses? Write it in your own words.

Or

(i) A ray of light falls on a transparent sphere with centre *C* as shown in the figure. The ray emerges from the sphere parallel to the line *AB*. Find the angle of refraction of *A*, if the refractive index of material of sphere is $\sqrt{3}$. Also draw the refracted ray in the given figure.



(ii) The image obtained with a convex lens is erect and its length is four times the length of the object.

If the focal length of the lens is 20 cm, calculate the object and image distances.

33. (i) A solenoid of length 0.5 m has a radius of 1 cm and is made up of 500 turns. It carries a current of 5A. What is the magnetic field inside the solenoid?

(ii) A toroid has a core of inner radius 0.25 m and outer radius 0.26 m around which 3500 turns of a wire are wound. If the current in the wire is 11 A, then find magnetic field inside the core of the toroid.

(iii) Two long parallel straight wires *A* and *B* carrying currents of 4.0 A and 5.0 A in same direction separated by a distance of 4×10^{-2} m. Calculate the force on a 0.20 m section of wire *A* and its direction.

Or

(i) The earth's magnetic induction at a certain point is 7×10^{-5} Wbm^{-2}. This is to be annulled by the magnetic induction at the centre of a circular conducting loop of radius 5 cm. Find the required current in the loop.

(ii) Is it possible to have a magnetic field configuration with three poles?

Also, if magnetic monopoles existed, how would Gauss's law of magnetism be modified?

(iii) A solenoid has core of a material with relative permeability 400. The windings of the solenoid are insulated from the core and carry a current of 2A.

If the number of turns is 1000 per metre, calculate (a) *H* and (b) *M*.