QUESTION PAPER-2
PHYSICS

Time Allowed : 3.00 Hours **Maximum Marks : 70**

General Instructions :

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study based questions of four marks each and Section E contains three long answer questions of five marks each.
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.
7. You may use the following values of physical constants where ever necessary

i. $c = 3 \times 10^8$ m/s ii. $m_e = 9.1 \times 10^{-31}$ kg

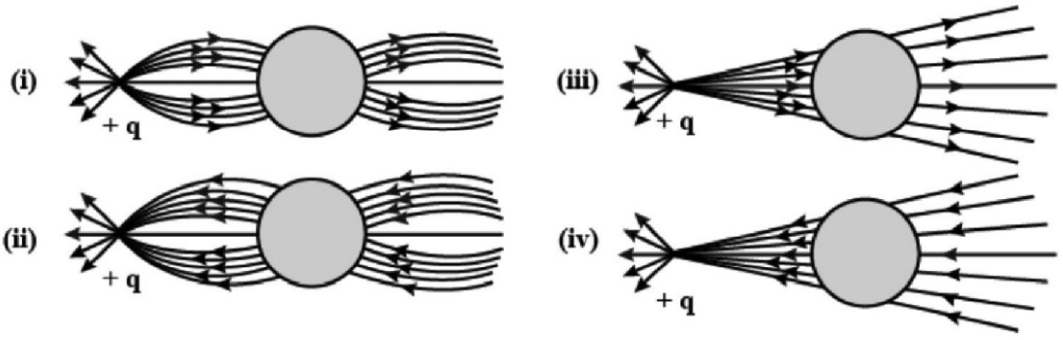
iii. $e = 1.6 \times 10^{-19}$ C iv. $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

v. $h = 6.63 \times 10^{-34}$ Js vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. A point positive charge is brought near an isolated conducting sphere (Fig. given below). The electric field is best given by



(a) Fig (i) (b) Fig (ii) (c) Fig (iii) (d) Fig (iv)

2. An electric dipole of length 2 cm is placed at an angle of 30° with an electric field 2×10^5 N/C. If the dipole experiences a torque of 8×10^{-3} Nm, the magnitude of either charge of the dipole, is

(a) 4 μC (b) 7 μC

(c) 8 mC (d) 2 mC

3. Photons of energy 3.2 eV are incident on a photosensitive surface. If the stopping potential for the emitted electrons is 1.5 V, the work function for the surface is

(a) 1.5 eV (b) 1.7 eV (c) 3.2 eV (d) 4.7 eV

4. Which of the following statement is not correct according to Rutherford model ?

(a) Most of the space inside an atom is empty.

(b) The electrons revolve around the nucleus under the influence of coulomb force acting on them.

(c) Most part of the mass of the atom and its positive charge are concentrated at its centre.

(d) The stability of atom was established by the model.

5. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true ?

(a) The elctron will be accelerated along the axis.

(b) The electron path will be circular about the axis.

(c) The electron will experience a force at 45° to the axis and hence execute a helical path.

(d) The electron will continue to move with uniform velocity along the axis of the solenoid.

6. A magnet of magnetic moment m is cut into two equal parts. The two parts are placed perpendicular to each other so that their north poles touch each other. The resultant magnetic moment is

(a) $\sqrt{2}m$ (b) $\frac{m}{\sqrt{2}}$ (c) $\sqrt{3}m$ (d) $\frac{m}{\sqrt{3}}$

7. If an ammeter is to be used in place of a voltmeter, then we must connect with the ammeter a

(a) low resistance is parallel (b) low resistance in series

(c) high resistance is parallel (d) high resistance in series

8. A paramagnetic sample shows a net magnetisation of 8 Am^{-1} when placed in an external magnetic field of 0.6 T and a temperature of 4 K. When the same sample is placed in an external magnetic field of 0.2 T at a temperature of 16 K, the magnetisation will be

(a) $\frac{32}{3}$ Am^{-1} (b) $\frac{2}{3}$ Am^{-1} (c) 6 Am^{-1} (d) 2.4 Am^{-1}

9. The output of a step-down transformer is measured to be 24 V when connected to a 12 watt light bulb. The value of the peak current is

(a) $\frac{1}{\sqrt{2}}$ A (b) $\sqrt{2}$ A (c) 2 A (d) $\frac{2}{\sqrt{2}}$ A

10. Electromagnetic waves used as a diagnostic tool in medicine are

(a) X-rays (b) ultraviolet rays (c) infrared radiation (d) ultrasonic waves

11. A square of side L meters lies in the X-Y plane in a region, where the magnetic field is given by $B = B_0\left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)T$, where B_0 is constant. The magnitude of flux passing through the sqaure is

(a) $2B_0L^2$ Wb (b) $3B_0L^2$ Wb (c) $4B_0L^2$ Wb (d) $\sqrt{29}\,B_0L^2$ Wb

12. In Bohr's model of hydrogen atom, the total energy of the electron in n^{th} discrete orbit is proportional to

(a) n (b) $\frac{1}{n}$ (c) n^2 (d) $\frac{1}{n^2}$

13. **Assertion (A) :** Photoelectric effect demonstrates the wave nature of light.

Reason (R) : The number of photoelectrons is proportional to the velocity of incident light.

(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 but (R) is true

14. **Assertion (A) :** When the temperature of a semiconductor is increased, then its resistance decreases.

Reason (R) : The energy gap between valence and conduction bands is very small for semiconductors.

(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 but (R) is true

15. **Assertion (A) :** Electric field is always normal to equipotential surfaces and along the direction of decreasing order of potential.

Reason (R) : Negative gradient of electric potential is electric field.

(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 but (R) is true

16. **Assertion (A) :** In a telescope, objective lens has greater focal length than eye piece but in a microscope objective has smaller focal length than eye piece. By inverting a telescope, a microscope cannot be formed.

Reason (R) : The difference in focal lengths of objective and eye lens in telescope is much larger than in microscope.

(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 but (R) is true

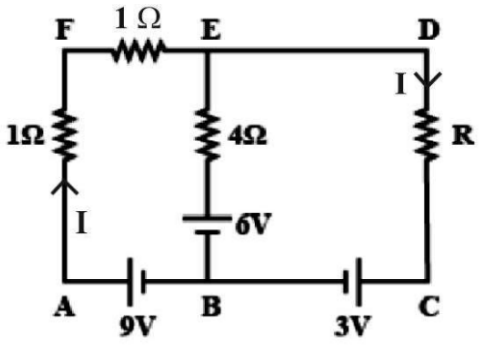
SECTION-B

17. Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. Differentiate between a half-wave and a full-wave rectifier.

18. Light of wavelength 488 nm is produced by an Argon Laser which is used in the photoelectric effect. When light from this spectral line is incident on the cathode the stopping potential of photoelectrons is 0.38V. Find the work function of the cathode material.

19. An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of minimum deviation of the prism, when kept in a medium of refractive index $\frac{4\sqrt{2}}{5}$.

20. Using Kirchoff's rules determine the value of unknown resistance R in the circuit so that no current flows through 4 Ω resistance. Also find the potential difference between A and D.



21. (a) State the condition under which a large magnification can be achieved in an astronomical telescope.

(b) Give two reasons to explain why a reflecting telescope is preferred over a refracting telescope.

OR

(a) Explain briefly how the focal length of convex lens changes with increase in wavelength of incident light.

(b) What happen to the focal length of convex lens when it is immersed in water ? Refractive index of the material of lens is greater than that of water.

SECTION-C

22. (i) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$?

(ii) Show that the density of nucleus over a wide range of nuclei is constant independent of mass number A.

OR

Calculate the energy in fusion reaction

${}_1^2H + {}_1^2H \rightarrow {}_2^3He + n,$ where BE of ${}_1^2H = 2.23$ meV and of ${}_2^3He = 7.73$ meV

23. A charge Q is distributed over the surfaces of two concentric hollow spheres of radii r and R (R >> r), such that their surface charge densities are equal. Derive the expression for the potential at the common centre.

24. If the frequency of the incident radiation on the cathode of a photo-cell is doubled, how will the following change:

(i) The kinetic energy of the electrons?

(ii) Photoelectric current?

(iii) Stopping potential?

Justify your answer.

25. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds at a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27° C ? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is 1.7×10^{-4} per °C.

26. Two identical coils P and Q each of radius R are lying in perpendicular planes such that they have a common centre. Find the magnitude and direction of magnetic field at the common centre of the two coils, if they carry currents equal to I and $\sqrt{3}$ I respectively.

27. Electromagnetic waves of wavelengths λ_1, λ_2 and λ_3 are used in radar systems, in water purifiers and in remote switches of TV, respectively.

(a) Identify the electromagnetic waves, and (b) Write one source of each of them.

28. Derive expression for self inductance of a long air-cored solenoid of length ℓ, cross-sectional area A and having number of turns N.

SECTION-D

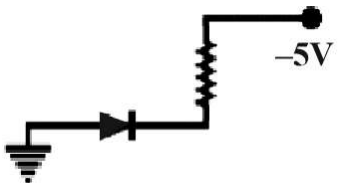
(Case Study based questions)

29. **Biasing of Diode-** When the diode is forward biased, it is found that beyond forward voltage $V = V_k$, called knee voltage, the conductivity is very high. At this value of battery biasing for p-n junction,the potential barrier is overcome and the current increases rapidly with increase in forward voltage.

When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

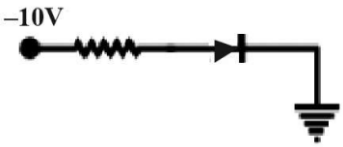
(i) In which of the following figures, the p-n diode is forward biased.

(a)

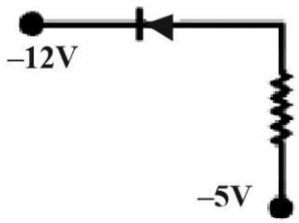


(b)

(c)



(d)



(ii) Based on the V-I characteristics of the diode, we can classify diode as

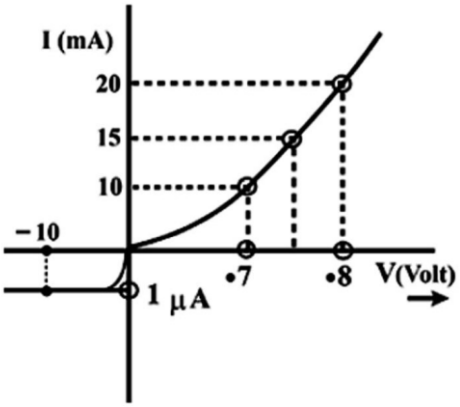
(a) bi-directional device

(b) ohmic device

(c) non-ohmic device

(d) passive element

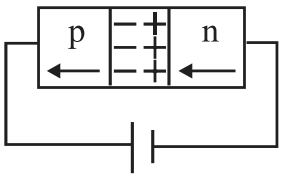
(iii) The V-I characteristic of a diode is shown in the figure. The ratio of forward to reverse bias resistance is

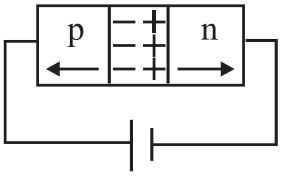


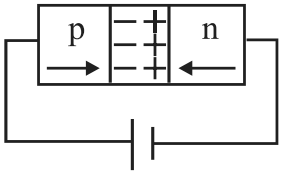
(a) 100 (b) 10^6 (c) 10 (d) 10^{-6}

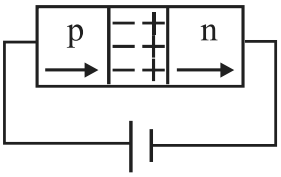
OR

In the case of forward biasing of a p-n junction diode, which one of the following figures correctly depicts the direction of conventional current (indicated by an arrow mark) ?

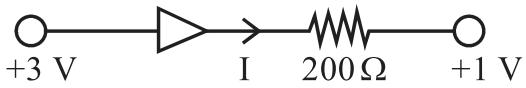
(a) 

(b) 

(c) 

(d) 

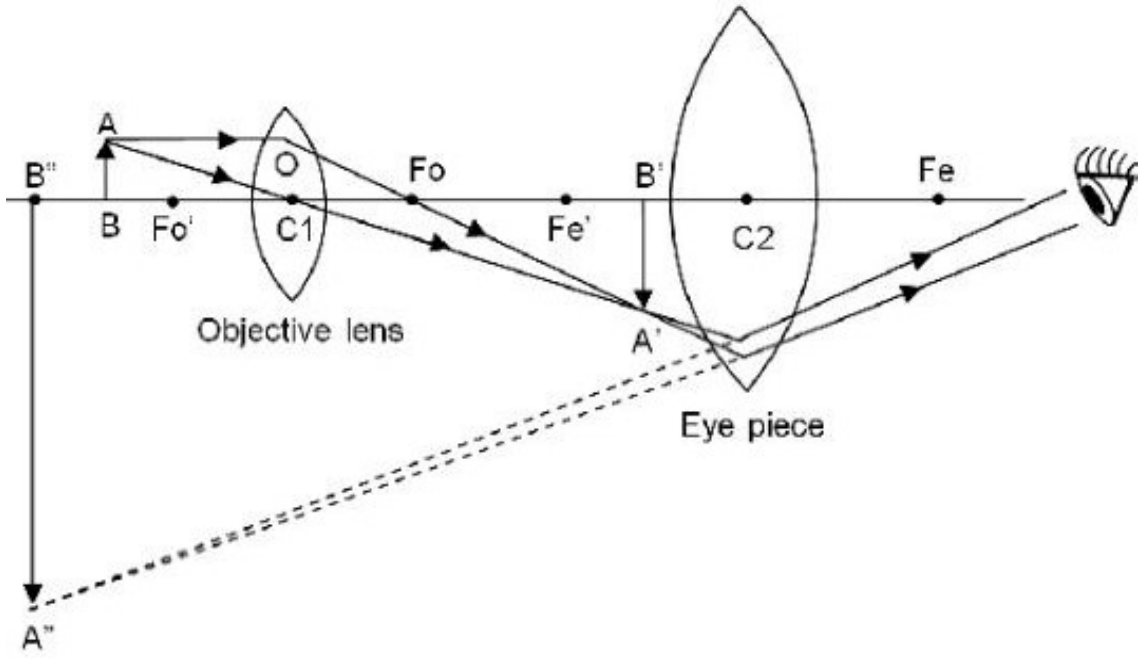
(iv) If an ideal junction diode is connected as shown, then the value of the current I is



(a) 0.013 A (b) 0.02 A

(c) 0.01 A (d) 0.1 A

30. **Compound Microscope-** A compound microscope consists of two converging lenses. One of them, of smaller aperture and smaller focal length is called objective and the other of slightly larger aperture and slightly larger focal length is called eye-piece. Both the lenses are fitted in a tube with an arrangement to vary the distance between them. A tiny object is placed in front of the objective at a distance slightly greater than its focal length. The objective produces the image of the object which acts as an object for the eye-piece. The eye piece, in turn produces the final magnified image.



(i) In a compound microscope the images formed by the objective and the eye-piece are respectively.

(a) virtual, real (b) real, virtual (c) virtual, virtual (d) real, real

(ii) The magnification due to a compound microscope does not depend upon

(a) the aperture of the objective and the eye-piece

(b) the focal length of the objective and the eye-piece

(c) the length of the tube

(d) the colour of the light used

(iii) Which of the following is not correct in the context of a compound microscope?

(a) Both the lenses are of short focal lengths.

(b) The magnifying power increases by decreasing the focal lengths of the two lenses.

(c) The distance between the two lenses is more than $(f_0 + f_e)$.

(d) The microscope can be used as a telescope by interchanging the two lenses.

(iv) A compound microscope consists of an objective of 10X and an eye-piece of 20X. The magnification due to the microscope would be

(a) 2 (b) 10 (c) 30 (d) 200

OR

The focal lengths of objective and eye-piece of a compound microscope are 1.2 cm and 3.0 cm respectively. The object is placed at a distance of 1.25 cm from the objective. If the final image is formed at infinity, the magnifying power of the microscope would be

(a) 100 (b) 150 (c) 200 (d) 250

SECTION-E

31. (a) Draw a ray diagram to show the image formation by a combination of two thin convex lenses in contact. Obtain the expression for the power of this combination in terms of the focal lengths of the lenses.
(b) A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is $\frac{3}{4}$th of the angle of prism. Calculate the speed of light in the prism.

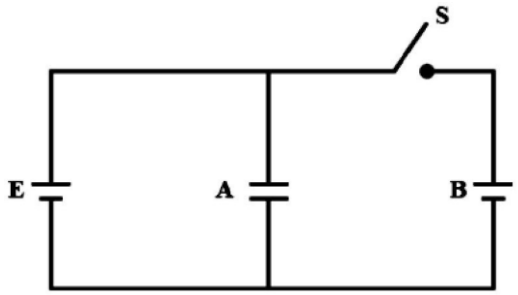
OR

A parallel beam of monochromatic light falls normally on a narrow slit and the light, coming out of the slit, is obtained on a screen, kept behind, parallel to the slit plane. What kind of pattern do we observe on the screen and why? How does the
(a) angular width
(b) linear width of the principal maximum, in this pattern change when the screen is moved, parallel to itself, away from the slit plane?
State two points of difference between this pattern and the interference pattern observed in the Young's double slit experiment.

32. The capacitance of a parallel plate capacitor is 50 pF and the distance between the plates is 4 mm It is charged to 200 V and then the charging battery is removed. Now a dielectric slab (k = 4) of thickness 2 mm is placed.
Determine-
(a) final charge on each plate
(b) final potential difference between the plates
(c) final energy in the capacitor and
(d) energy loss.

OR

Two identical pararallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introducion of the dielectric.



33. An ac voltage $V = V_0 \sin\omega t$ is applied to a pure inductor L. Obtain an expression for the current in the circuit.
Prove that the average power supplied to an inductor over one complete cycle is zero.

OR

(a) Describe, with the help of a suitable diagram, the working principle of a step-up transformer. Obtain the relation between input and output voltages in terms of the number of turns of primary and secondary windings and the currents in the input and output circuits.
(b) Given the input current 15 A and the input voltage of 100 V for a step-up transformer having 90% efficiency, find the output power and the voltage in the secondary if the output current is 3 A.