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12F

SS4

PREBOARD EXAMINATION 2023-24

Subject: PHYSICS

SET 2

Maximum Marks: 70 **Time Allowed**: 3hours

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. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

v. $h = 6.63 \times 10^{-34}$ Js

vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$

[SECTION A]

1. We use alloys for making standard resistors because they have

(a) low temperature coefficient of resistance and high specific resistance.

(b) high temperature coefficient of resistance and low specific resistance

(c) low temperature coefficient of resistance and low specific resistance.

(d) high temperature coefficient of resistance and high specific resistance.

2. A fixed horizontal wire M carries 200 A current. Another wire N running parallel to M carries a current I and remains suspended in a vertical plane below M at a distance of 20 mm. Both the wires have a linear mass density of 10^{-2} kg/m. Therefore the current I is

(a) 20 A (b) 4.9 A (c) 49 A (d) 200 A

3. An ammeter reads up to 1 ampere. Its internal resistance is 0.81 ohm . To increase the range to 10A, the value of the required shunt is

(a) 0.9 ohm (b) 0.09 ohm (c) 0.03 ohm (d) 0.3 ohm

4. If a charge q is placed at the centre of the line joining two equal charges Q such that the system is in equilibrium, then the value of q is

(a) Q/2 (b) −Q/2 (c) Q/4 (d) −Q/4

5. Which of the following is not the property of an equipotential surface?

(a) They do not cross each other.

(b) The work done on an equipotential surface in carrying a charge from one point to another is zero.

(c) For a uniform electric field, they are concentric spheres.

(d) They can be imaginary spheres.

6. Three resistors having resistance values R_1, R_2 and R_3 are connected in series to a battery. Suppose R_1 carries a current of 2 A, R_2 has a resistance of 3 ohm and R_3 dissipates 6W of power. Then the voltage across R_3 is

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

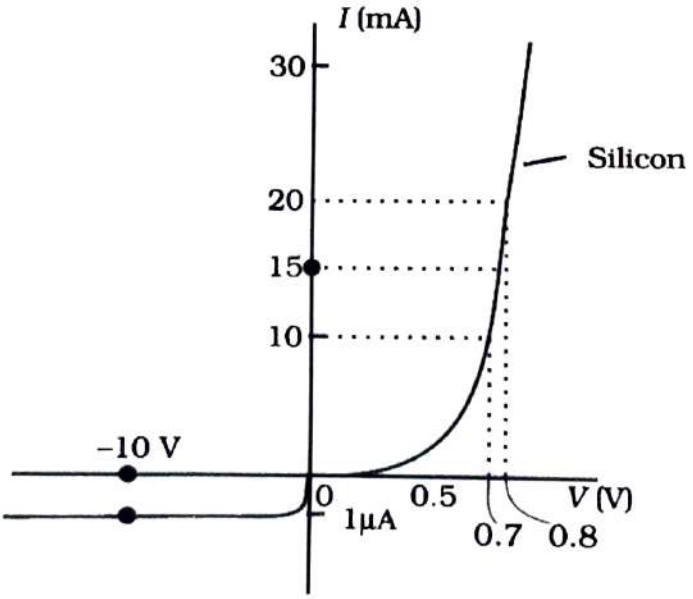
7. 64 drops each having the capacity C and potential V are combined to form a big drop. If the charge on the small drop is q, the charge on the big drop will be

(a) 2q (b) 4q (c) 16q (d) 64 q

8. Four identical cells each of emf E and internal resistance r are to be connected in series. Suppose if one of the cells is connected wrongly then the equivalent emf and effective internal resistance of the combination is

(a) $4E$ and $2r$ (b) $2E$ and $2r$ (c) $4E$ and $4r$ (d) $2E$ and $4r$.

9.



The V-I characteristic of a diode is shown in the figure. The ratio of the resistance of the diode at I = 15 mA to the resistance at V = -10 V is

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

10. A long straight wire of circular cross section of radius 'a' carries a steady current I. The current is uniformly distributed across its cross section. The ratio of magnitudes of magnetic field at a point distant a/2 above the surface of wire to that of a point distant a/2 below its surface is

(i) 4 :1 (ii) 1:1 (iii) 4: 3 (iv) 3 :4

11. In a Young's double slit experiment, the path difference at a certain point on the screen between two interfering waves is $\frac{1}{8}$th of the wavelength. The ratio of intensity at this point to that at the centre of a bright fringe is close to

(i) 0.80 (ii) 0.74 (iii) 0.94 (iv) 0.85

12. The photoelectric work function for a metal surface is 4.14 eV. The threshold wavelength for this is about

(i) 4125 Å (ii) 2062.5 Å (iii) 3000Å (iv) 6000 Å

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.

b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

c) If Assertion is true but Reason is false.

d) If both Assertion and Reason are false.

13. **Assertion (A)**: For the radiation of a frequency greater than the threshold frequency, photoelectric current is proportional to the intensity of the radiation.

Reason (R) : Greater the number of energy quanta available, greater is the number of electrons absorbing the energy quanta and greater is number of electrons coming out of the metal.

14. **Assertion (A)**: The applied voltage (in forward bias of a p-n junction) mostly drops across the depletion region and the voltage drop across the p side and n side of the junction is negligible.

Reason (R): The resistance of the depletion region is large compared to resistance of n or p side.

15. **Assertion (A) :** If the electrons in an atom were stationary then they would fall into the nucleus.

Reason (R) : The electrostatic force of attraction acts between negatively charged electrons and positive nucleus.

16. **Assertion (A)** : The de Broglie wavelength of an electron is ~~smallest~~ largest as compared to that of a proton and an alpha particle (if they have the same kinetic energy).

Reason (R) : The de Broglie wavelength is inversely proportional to $(mass)^{\frac{1}{2}}$.

[SECTION B]

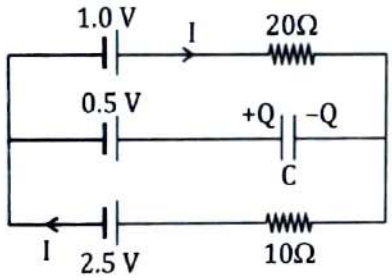
17. What is the shape of the wavefront in each of the following cases?

(a) light diverging from a point source.

(b) light emerging out of a convex lens when a point source is placed at its focus.

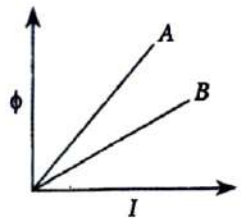
18. Using Bohr's atomic model derive an expression for the radius of nth orbit of the revolving electron in a hydrogen atom.

19. In the circuit given below, what is the potential difference across the terminals of the capacitor?

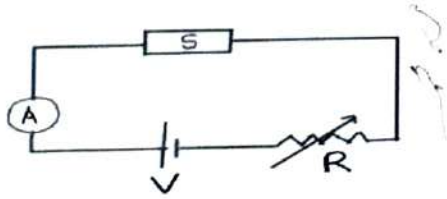


20. **a**). Define the term 'self-inductance' of a coil. Write its SI. unit.

b). A plot of magnetic flux (ϕ) versus current (I) is shown in the figure for two inductors A and B. Which of the two has a larger value of self inductance?

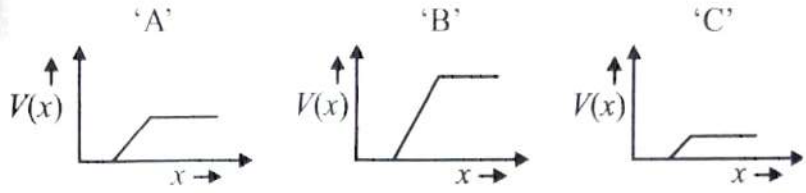


21. The diagram shows a piece of pure semiconductor S in series with a variable resistor R and a source of constant voltage V. Should the value of R be increased or decreased to keep the reading of the ammeter constant, when semiconductor S is heated? Justify your answer



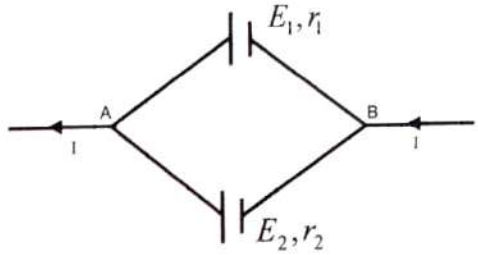
OR

The graph of potential barrier versus width of depletion region for an unbiased diode is shown in graph A. In comparison to A, graphs B and C are obtained after biasing the diode in different ways. Identify the type of biasing in B and C and justify your answer.



[SECTION C]

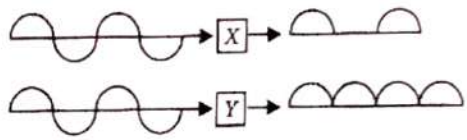
22. Two cells of emfs E_1 and E_2 having internal resistances r_1 and r_2 respectively are connected in parallel as shown in the figure. Deduce the expressions for the equivalent emf and equivalent internal resistance of a cell which can replace the combination between the points A and B. Also find the potential difference between the points A and B.



23. An a.c. signal is fed into two circuits 'X' and 'Y' and the corresponding output in the two cases have the waveforms as shown in figure.

(**a**) Identify the circuits 'X' and 'Y'.

(**b**) Briefly explain the working of circuit Y.



24. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion?

25. (**a**) Plot a graph for angle of deviation as a function of angle of incidence for a triangular prism.

(**b**) Derive the relation for the refractive index of the prism in terms of the angle of minimum deviation and angle of prism.

OR

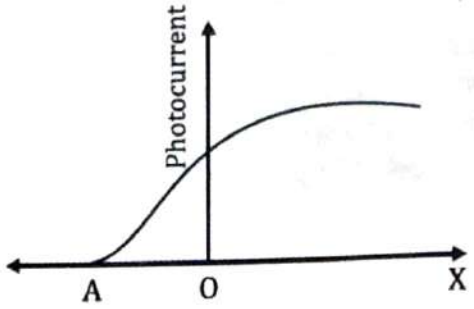
25. Obtain lens maker's formula using the expression

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$$

Here the ray of light propagating from a rarer medium of refractive index (n_1) to a denser medium of refractive index (n_2) is incident on the convex side of spherical refracting surface of radius of curvature R.

26. Using Biot-Savart law derive the expression for the magnetic induction due to a current carrying circular coil at a point along its axis.

27. The graph shows the variation of photocurrent for a photosensitive metal



(**a**) What do X and A on the horizontal axis represent?

(**b**) Draw the graph for three different values of frequencies υ_1, υ_2 and υ_3 ($\upsilon_3 > \upsilon_2 > \upsilon_1$) of incident radiation for the same intensity.

(**c**) Draw this graph for three different values of intensities of incident radiation I_1, I_2 and I_3 ($I_3 > I_2 > I_1$) having the same frequency.

28. (**a**) Electromagnetic waves with wavelength

(i) λ_1 is suitable for radar systems used in aircraft navigation.
(ii) λ_2 is used to kill germs in water purifiers.
(iii) λ_3 is used to improve visibility in runways during fog and mist conditions.

Identify and name the part of the electromagnetic spectrum to which these radiations belong. Also arrange these wavelengths in ascending order of their magnitude.

(**b**). A capacitor consists of two parallel plates, with an area of cross-section of 0.001 m^2, separated by a distance of 0.0001 m. If the voltage across the plates varies at the rate of 10^8 V/s, determine the value of displacement current through the capacitor.

[SECTION D]

Case Study Based Questions.

Read the following paragraph and answer the questions that follow.

29. Diamagnetic substances are those which have a tendency to move from stronger to weaker part of the external magnetic field and an external magnet repels a diamagnetic substance. When a bar of diamagnetic material is placed in an extremal magnetic field, the field lines are repelled or expelled and the field inside the material is reduced. Copper, bismuth, gold, mercury, diamond, and nitrogen are some examples of diamagnetic substances.

Each electron in an atom orbiting around the nucleus is equivalent to a current carrying loop and thus possesses orbital angular moment. Diamagnetic substances are the ones in which the resultant magnetic moment of all the electrons in an atom is zero. When a magnetic field is

applied, those electrons having orbital magnetic moment in the same direction slow down and those in the opposite direction speed up. Thus, the substance develops a net magnetic moment in a direction opposite to that of the applied magnetic field and hence the repulsion. Diamagnetism is independent of temperature changes.

The most exotic diamagnetic materials are super conductors. These are metals cooled to very low temperatures and exhibit perfect conductivity and perfect diamagnetism. This phenomenon was discovered by Meissner.

1. An example of a diamagnetic substance is

   (a) Aluminium (b) Copper (c) Iron (d) Nickel

2. Diamagnetic substances are

   (a) feebly attracted by an external magnet

   (b) strongly attracted by an external magnet

   (c) feebly repelled by an external magnet

   (d) strongly repelled by an external magnet

3. The magnetic dipole moment of a diamagnetic atom is

   (a) greater than 1 (b) 1 (c) between 0 and 1 (d) equal to zero,

4. Which of the following is true?

   (a) Diamagnetism increases with temperature.

   (b) Diamagnetism decreases with temperature.

   (c) Diamagnetism is independent of temperature changes.

   (d) Iron is a diamagnetic substance.

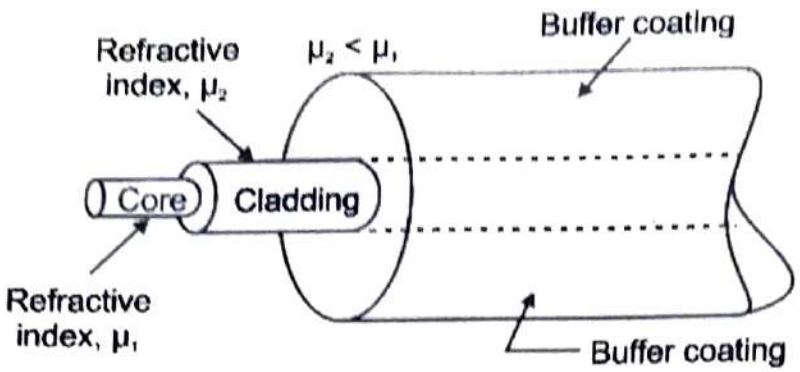
OR

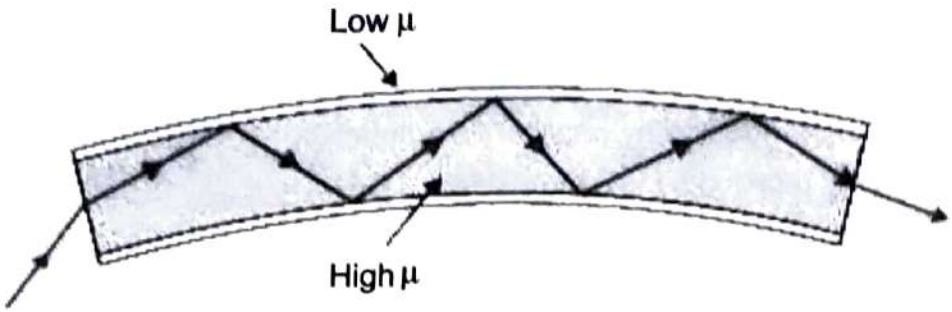
4. A superconductor acts as a perfect diamagnetic material. This phenomenon is called as

   (a) Hall effect (b) Meissner effect (c) Curie's law (d) Langevin effect.

ad the following paragraph and answer the questions that follow.

Optical fibres: Now-a-days optical fibres are extensively used for transmitting audio and video signals through long distances. Optical fibres too make use of the phenomenon of total internal reflection. Optical fibres are fabricated with high quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflections along the length of the fibre and finally comes out at the other end. Since light undergoes total internal reflection at each stage, there is no appreciable loss in the intensity of the light signal. Optical fibres are fabricated such that light reflected at one side of inner surface strikes the other at an angle larger than the critical angle. Even if the fibre is bent, light can easily travel along its length. Thus, an optical fibre can be used to act as an optical pipe.





1. Which of the following statement is not true?
   (a) Optical fibres make use of the phenomenon of total internal reflection.
   (b) The refractive index of the material of the core is less than that of the cladding.
   (c) An optical fibre can be used to act as an optical pipe.
   (d) There is no appreciable loss in the intensity of the light signal while propagating through an optical fibre.

2. What is the condition for total internal reflection to occur?
   (a) The angle of incidence must be equal to the critical angle.
   (b) The angle of incidence must be less than the critical angle.
   (c) The angle of incidence must be greater than the critical angle.
   (d) The ray must be travelling from rarer medium to denser medium.

3. The critical angle for diamond (refractive index = 2) is
   (a) About 20° (b) 60° (c) 45° (d) 30°

4. Optical fibres are used extensively to transmit
   (a) Optical Signals (b) Electric current (c) Sound waves (d) Heat energy

OR

4. An endoscope is employed by a physician to view the internal parts of a body organ. It is based on the principle of
   (a) Refraction (b) Reflection (c) Total internal reflection (d) Dispersion

[SECTION E]

31. (a) Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device.

(b) A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

OR

31. In a series LCR circuit with L = 10.0 H, C = 40 μF, R = 60 Ω connected to a variable frequency 240 V source, calculate

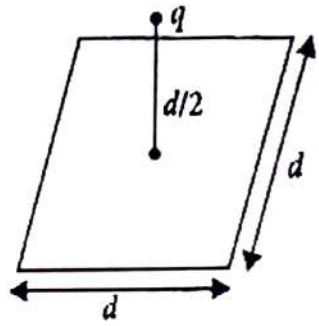
(i) the angular frequency of the source which drives the circuit at resonance.

(ii) the current at the resonating frequency,

(iii) the rms potential drop across the inductor at resonance.

32. (a) Define electric flux. Is it a scalar or a vector quantity?

(b) (i) A point charge q is at a distance of $d/2$ directly above the centre of a square of side d, as shown in the figure. Use Gauss law to obtain the expression for the electric flux through the square.



(ii) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

(c) Using Gauss's law obtain the expression for the electric field due to a uniformly charged thin spherical shell of radius R at a point outside the shell. Draw a graph showing the variation of electric field with r, for $r > R$ and $r < R$.

OR

32. (a) Draw equipotential surfaces for (i) an electric dipole (ii)two identical positive charges.

(b) In a parallel plate capacitor with air between the plates each plate has an area of $6 \times 10^{-3} m^2$ and the separation between the plates is 3 mm.

(i) Calculate the capacitance of the capacitor.

(ii) If the capacitor is connected to 100V supply then what would be the charge on each plate?

(iii) How would charge on the plate be affected if a 3 mm thick mica sheet of dielectric constant K=6 is inserted between the plates while the voltage supply remains connected

33. **(a)** Draw a ray diagram depicting the formation of the image by an astronomical telescope in normal adjustment and derive an expression for angular magnification.

(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope? Give reason.

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

OR

33. **(a)** Draw a ray diagram for the formation of image by a compound microscope when the final image is formed at the least distance of distinct vision and obtain an expression for its angular magnification in this adjustment.

(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct a compound microscope?

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1