candidates must write the code on the title page of the answer-book.

- please check that this question paper contains 11 printed pages.
- code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- please check that this question paper contains 30 questions.
- please write down the serial number of the question before attempting it.
- 15 minutes time has been allotted to read this question paper. the question paper will be distributed at 10.15 a.m. from 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer script during this period.

भौतिक विज्ञान (सैद्धान्तिक)

PHYSICS (Theory)

निर्धारित समय : 3 घण्टे

Time allowed : 3 hours

[अधिकतम अंक : 70

[ Maximum marks : 70

सामान्य निर्देश :

(i) सभी प्रश्न अनिवार्य हैं।

(ii) इस प्रश्न-पत्र में कुल 30 प्रश्न हैं। प्रश्न 1 से 8 तक के प्रश्न अति-लघुउत्तम प्रश्न हैं और प्रत्येक एक अंक का है।

(iii) प्रश्न 9 से 18 में प्रत्येक प्रश्न दो अंक का है, प्रश्न 19 से 27 में प्रत्येक प्रश्न तीन अंक का है तथा प्रश्न 28 से 30 में प्रत्येक प्रश्न चार अंक का है।

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(iv) प्रश्न-पत्र में सम्प्रभु पर कोई विकल्प नहीं है। तथापि, दो अंकों वाले एक प्रश्न में, तीन अंकों वाले एक प्रश्न में और यांचे अंकों वाले तीनों प्रश्नों में आंतरिक चयन प्रदान किया गया है। ऐसे प्रश्नों में आपको दिये गए चयन में से केवल एक प्रश्न ही करना है।

(v) कैल्कुलेटर के उपयोग की अनुमति नहीं है। तथापि यदि आवश्यक हो तो आप लघुगणकीय सारणी का उपयोग कर सकते हैं।

(vi) जहाँ आवश्यक हो आप निम्नलिखित भौतिक नियमों के मानों का उपयोग कर सकते हैं:

\[ c = 3 \times 10^8 \text{ m/s} \]
\[ h = 6.63 \times 10^{-34} \text{ Js} \]
\[ e = 1.6 \times 10^{-19} \text{ C} \]
\[ \mu_0 = 4\pi \times 10^{-7} \text{ T mA}^{-1} \]
\[ \frac{1}{4\pi \varepsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{C}^{-2} \]
\[ m_e = 9.1 \times 10^{-31} \text{ kg} \]

**General Instructions:**

(i) All questions are compulsory.

(ii) There are 30 questions in total. Question Nos. 1 to 8 are very short answer type questions and carry one mark each.

(iii) Question Nos. 9 to 18 carry two marks each, Question Nos. 19 to 27 carry three marks each and Question Nos. 28 to 30 carry five marks each.

(iv) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the choices in such questions.

(v) Use of calculators is not permitted. However, you may use log tables if necessary.

(vi) You may use the following values of physical constants wherever necessary:

\[ c = 3 \times 10^8 \text{ m/s} \]
\[ h = 6.63 \times 10^{-34} \text{ Js} \]
\[ e = 1.6 \times 10^{-19} \text{ C} \]
\[ \mu_0 = 4\pi \times 10^{-7} \text{ T mA}^{-1} \]
\[ \frac{1}{4\pi \varepsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{C}^{-2} \]
\[ m_e = 9.1 \times 10^{-31} \text{ kg} \]

1. किसी धातु में इलेक्ट्रॉनों का निम्न विभाजन से उच्च विभाजन की ओर अवस्था होता है, क्या इसका तात्पर्य यह है कि धातु के सभी इलेक्ट्रॉन एक ही दिशा में गति कर रहे हैं?

When electrons drift in a metal from lower to higher potential, does it mean that all the free electrons of the metal are moving in the same direction?
2. The horizontal component of the earth’s magnetic field at a place is $B$ and angle of dip is $60^\circ$. What is the value of vertical component of earth’s magnetic field at equator?

3. Show on a graph, the variation of resistivity with temperature for a typical semiconductor.

4. Why should electrostatic field be zero inside a conductor?

5. Name the physical quantity which remains same for microwaves of wavelength $1\text{ mm}$ and UV radiations of $1600\text{ Å}$ in vacuum.

6. Under what condition does a biconvex lens of glass having a certain refractive index act as a plane glass sheet when immersed in a liquid?

7. Predict the directions of induced currents in metal rings 1 and 2 lying in the same plane where current $I$ in the wire is increasing steadily.

8. State de-Broglie hypothesis.

9. A ray of light, incident on an equilateral glass prism ($\mu = \sqrt{3}$) moves parallel to the base line of the prism inside it. Find the angle of incidence for this ray.
10. Distinguish between ‘Analog and Digital signals’.

OR

Mention the function of any two of the following used in communication system:

(i) Transducer
(ii) Repeater
(iii) Transmitter
(iv) Bandpass Filter

11. A cell of emf $E$ and internal resistance $r$ is connected to two external resistances $R_1$ and $R_2$ and a perfect ammeter. The current in the circuit is measured in four different situations:

(i) without any external resistance in the circuit
(ii) with resistance $R_1$ only
(iii) with $R_1$ and $R_2$ in series combination
(iv) with $R_1$ and $R_2$ in parallel combination

The currents measured in the four cases are 0.42 A, 1.05 A, 1.4 A and 4.2 A, but not necessarily in that order. Identify the currents corresponding to the four cases mentioned above.
12. The susceptibility of a magnetic material is \(-2.6 \times 10^{-5}\). Identify the type of magnetic material and state its two properties.

13. Two identical circular wires P and Q each of radius R and carrying current \(I\) are kept in perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and direction of the net magnetic field at the common centre of the two coils.

14. When an ideal capacitor is charged by a dc battery, no current flows. However, when an ac source is used, the current flows continuously. How does one explain this, based on the concept of displacement current?

15. Draw a plot showing the variation of (i) electric field \((E)\) and (ii) electric potential \((V)\) with distance \(r\) due to a point charge Q.

16. Define self-inductance of a coil. Show that magnetic energy required to build up the current \(I\) in a coil of self inductance \(L\) is given by \(\frac{1}{2} LI^2\).
17. The current in the forward bias is known to be more (~mA) than the current in the reverse bias (~μA). What is the reason, then, to operate the photodiode in reverse bias?

18. A metallic rod of ‘L’ length rotates with angular frequency of ‘ω’ with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Deduce the expression for the emf between the centre and the metallic ring.

19. 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 capacitor at resonance.
20. A rectangular loop of wire of size $4 \text{ cm} \times 10 \text{ cm}$ carries a steady current of $2 \text{ A}$. A straight long wire carrying $5 \text{ A}$ current is kept near the loop as shown. If the loop and the wire are coplanar, find

(i) the torque acting on the loop and
(ii) the magnitude and direction of the force on the loop due to the current carrying wire.

21. (a) Using Bohr’s second postulate of quantization of orbital angular momentum show that the circumference of the electron in the $n^{th}$ orbital state in hydrogen atom is $n$ times the de Broglie wavelength associated with it.

(b) The electron in hydrogen 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?
In the figure a long uniform potentiometer wire AB is having a constant potential gradient along its length. The null points for the two primary cells of emfs $\varepsilon_1$ and $\varepsilon_2$ connected in the manner shown are obtained at a distance of 120 cm and 300 cm from the end A. Find (i) $\varepsilon_1/\varepsilon_2$ and (ii) position of null point for the cell $\varepsilon_1$.

How is the sensitivity of a potentiometer increased?

OR

A long wire AB is having a constant potential gradient along its length. Two cells with emfs $\varepsilon_1$ and $\varepsilon_2$ are connected in the manner shown, and null points are obtained at distances of 120 cm and 300 cm from the end A. Find (i) $\varepsilon_1/\varepsilon_2$ and (ii) position of null point for the cell $\varepsilon_1$.

विभवमापी की एक लंबा तार AB दिखाया गया है, जिसमें उसकी लम्बाई के अनुसार एक नियत (अपरिवर्ती) विभव प्रवाहणता (पाल) (ई.एम.एफ.) $\varepsilon_1$ तथा $\varepsilon_2$ है, आरेख में दिखाये गये अनुसार संबंधित है। इनके लिये शून्य विक्षेप स्थितियों (अविक्षेप बिन्दु) A सिरे से 120 cm तथा 300 cm दूरी पर प्राप्त होती हैं। तो ज्ञात कीजिये

(i) $\varepsilon_1/\varepsilon_2$

(ii) सेल $\varepsilon_1$ के लिये शून्य विक्षेप स्थिति (अविक्षेप बिन्दु) की दूरी।

विभवमापी की संबंधनशीलता को कैसे बढ़ाया जाता है?

अथवा

किर्चोफ के नियमों का उपयोग करते हुए परिणाम में अतिशय प्रतिरोध R का मान ज्ञात कीजिये, ताकि 4 Ω प्रतिरोध से कोई विद्युतधारा प्रवाहित न हो। A और D के बीच विभवांतर का मान भी ज्ञात कीजिये।
Using Kirchhoff’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.

23. (i) वर्तमान संख्या (A) के 30 व 170 के बीच मानों, के लिये, प्रत्येक न्यूक्लियर संख्या संबंधन ऊर्जा (BE/A) के मान के रिचर्ड रहने की व्याख्या न्यूक्लियर बलों के किस लक्षणिक गुण के द्वारा की जा सकती है?
(ii) दशाग्रह कि नामिकों के एक विश्वसनीय परिसर में नामिक का घनत्व स्ट्रिक्ट्र (नियत) रहता है और यह इन्द्रियां संख्या (A) पर निर्भर (आश्रित) नहीं होता।
(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.

24. किसी सिग्नल को मोड्यूलेट करने की आवश्यकता के आधार पर, किसी डुरार्कोप्य वाहन तरंग पर, किसी मोड्यूलेट सिग्नल के आधारपरणे तरंग, चौथाई मोड्यूलेट तरंग को दर्शाने के लिये, एक अर्थात बनाये।
Write any two factors which justify the need for modulating a signal.
Draw a diagram showing an amplitude modulated wave by superposing a modulating signal over a sinusoidal carrier wave.

25. आईएनडीएच का प्रकाश-विभूत समीकरण लिखिये। संसार की दिग्गज की इस समीकरण को विद्युत-चुम्बकीय विकिरणों के फोटोन-चित्र के उपयोग द्वारा कैसे प्राप्त किया जा सकता है?
Write Einstein’s photoelectric equation. State clearly how this equation is obtained using the photon picture of electromagnetic radiation.
Write the three salient features observed in photoelectric effect which can be explained using this equation.

26. (अ) संसार व्यवस्थापन पैटर्न प्राप्त करने के लिये कला संबंध स्थलों का होना कोई आवश्यक है?
(ब) यांग के एक दिशाई प्रयोग में, λ, तरंग दैर्घ्य के एक तरंग प्रकाश का उपयोग किया गया है। जिससे पर्याप्त के एक बिन्दु पर, जहाँ पदातान λ, प्रकाश की तीव्रता K एकक (ंयूनिट) है। तो, उस बिन्दु पर प्रकाश की तीव्रता होंगी जिन्हें पदातान λ के लिये पदातान λ/3 है।
(a) Why are coherent sources necessary to produce a sustained interference pattern?
(b) In Young’s double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is λ/3.
27. Use Huygens’s principle to explain the formation of diffraction pattern due to a single slit illuminated by a monochromatic source of light. When the width of the slit is made double the original width, how would this affect the size and intensity of the central diffraction band?

28. Explain the principle of a device that can build up high voltages of the order of a few million volts. Draw a schematic diagram and explain the working of this device. Is there any restriction on the upper limit of the high voltages set up in this machine?

OR

(a) Define electric flux. Write its S.I. units.
(b) Using Gauss’s law, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance from it.
(c) How is the field directed if (i) the sheet is positively charged, (ii) negatively charged?

29. Suggest a suitable method of protection for your installation against lightning. For this purpose calculate the shielding factor of a cylindrical tower of height 12 m and radius 0.5 m. Sheilding factor is defined as the ratio of the electric field intensity outside the shield to the electric field intensity inside the shield.

OR

(a) A region of 50 km² is covered by a network of 10,000 km of overhead lines. The line presented to the public is 400 V. If the lines are operated at a potential difference of 20 kV, calculate the efficiency of the network. Assume that the lines are in parallel and that the line resistance and capacitance are negligible.
(b) A transmission line is designed to deliver 1000 MW of electrical power at a voltage of 200 kV. Calculate the required cross-sectional area of the conductor if the resistance of the line is 0.005 Ω/km and the maximum allowable conductor temperature is 65°C.

Discuss the implications of pollution and noise. How can the government and citizens contribute to reducing pollution and noise?
Define magnifying power of a telescope. Write its expression.
A small telescope has an objective lens of focal length 150 cm and an eye piece of focal length 5 cm. If this telescope is used to view a 100 m high tower 3 km away, find the height of the final image when it is formed 25 cm away from the eye piece.

OR

How is the working of a telescope different from that of a microscope?
The focal lengths of the objective and eyepiece of a microscope are 1.25 cm and 5 cm respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

30. CE विन्यास में किसी ट्रांजिस्टर प्रवर्धक के लिये एक सरल परिपथ आरेख बनाइये। इसकी कार्य विधि को स्पष्ट कीजिये। यह दर्शाइये कि इस प्रवर्धक की बोल्ट्रा लॉब्ह A_V = \frac{\beta_{ac} R_L}{r_i}, जहाँ \beta_{ac} = धारा लॉब्ह,
R_L = लोड प्रतिरोध तथा r_i = निवेश प्रतिरोध है।
बोल्ट्रा लॉब्ह के लिये न्याय, धारा लॉब्ह के अण्तर्गत चिन्ह का क्या महत्त्व है?

अथवा

(अ) एक ऐसे पूर्ण तरंग टुकड़कारी के लिये परिपथ आरेख बनाइये जिसमें p-n संधि डायोड का उपयोग किया गया हो। इसकी कार्य विधि को स्पष्ट कीजिये तथा निवेश और निर्गत तरंग रूपों को दर्शाइये।

(ब) निम्नलिखित निवेशों A और B के लिये निर्गत तरंग रूप (Y) को दर्शाइये:
(i) OR गेट तथा (ii) NAND गेट

Draw a simple circuit of a CE transistor amplifier. Explain its working. Show that the voltage gain, \( A_V \), of the amplifier is given by \( A_V = \frac{\beta_{ac} R_L}{r_i} \), where \( \beta_{ac} \) is the current gain, \( R_L \) is the load resistance and \( r_i \) is the input resistance of the transistor. What is the significance of the negative sign in the expression for the voltage gain?

OR

(a) Draw the circuit diagram of a full wave rectifier using p-n junction diode. Explain its working and show the output, input waveforms.

(b) Show the output waveforms (Y) for the following inputs A and B of (i) OR gate (ii) NAND gate

\[
\begin{array}{c}
A \\
B \\
\end{array}
\]

\[
\begin{array}{cccccccc}
t_1 & t_2 & t_3 & t_4 & t_5 & t_6 & t_7 & t_8 \\
A & & & & & & & \\
B & & & & & & & \\
\end{array}
\]