Roll No. रोल नं.

नोट		NOTE	
(I)	कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **19** हैं ।	(I)	Please check that this question paper contains **19** printed pages.
(II)	प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए कोड नम्बर को छात्र उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।	(II)	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.
(III)	कृपया जाँच कर लें कि इस प्रश्न-पत्र में **37** प्रश्न हैं ।	(III)	Please check that this question paper contains **37** questions.
(IV)	कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें ।	(IV)	Please write down the Serial Number of the question in the answer-book before attempting it.
(V)	इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक छात्र केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।	(V)	15 minute 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-book during this period.

भौतिक विज्ञान (सैद्धान्तिक)
PHYSICS (Theory)

निर्धारित समय : 3 घण्टे

Time allowed : 3 hours

अधिकतम अंक : 70

Maximum Marks : 70

General Instructions :

Read the following instructions very carefully and strictly follow them :
(i) *This question paper comprises **four** Sections – **A, B, C** and **D**.*
(ii) *There are **37** questions in the question paper. **All** questions are compulsory.*
(iii) ***Section A** – Questions no. **1** to **20** are very short answer type questions, carrying **1** mark each.*
(iv) ***Section B** – Questions no. **21** to **27** are short answer type questions, carrying **2** marks each.*
(v) ***Section C** – Questions no. **28** to **34** are long answer type questions, carrying **3** marks each.*
(vi) ***Section D** – Questions no. **35** to **37** are also long answer type questions, carrying **5** marks each.*
(vii) *There is no overall choice in the question paper. However, an internal choice has been provided in **2** questions of 1 mark, **2** questions of 2 marks, **1** question of three marks and all the **3** questions of five marks. You have to attempt only one of the choices in such questions.*
(viii) *In addition to this, separate instructions are given with each section and question, wherever necessary.*
(ix) *Use of calculators and log tables is **not** permitted.*
(x) *You may use the following values of physical constants wherever necessary :*

$$c = 3 \times 10^8 \text{ m/s}$$

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

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

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

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

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

Boltzmann constant = 1.38×10^{-23} JK^{-1}

Note : *Select the most appropriate option from those given below each question :*

1. A cell of internal resistance r connected across an external resistance R can supply maximum current when *1*

    (A)   R = r

    (B)   R > r

    (C)   R = $\dfrac{r}{2}$

    (D)   R = 0

2. In a current carrying conductor, the ratio of the electric field and the current density at a point is called *1*

    (A)   Resistivity

    (B)   Conductivity

    (C)   Resistance

    (D)   Mobility

3. An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will *1*

    (A)   move in a straight line.

    (B)   move in a circle.

    (C)   remain stationary.

    (D)   move in a helical path.

4. Above Curie temperature, a *1*

    (A)   ferromagnetic material becomes diamagnetic.

    (B)   ferromagnetic material becomes paramagnetic.

    (C)   paramagnetic material becomes ferromagnetic.

    (D)   paramagnetic material becomes diamagnetic.

5. Displacement current exists only when *1*

    (A)   electric field is changing.

    (B)   magnetic field is changing.

    (C)   electric field is not changing.

    (D)   magnetic field is not changing.

6. Electromagnetic waves used as a diagnostic tool in medicine are   *1*
    (A)   X-rays.
    (B)   ultraviolet rays.
    (C)   infrared radiation.
    (D)   ultrasonic waves.

7. At equilibrium, in a p-n junction diode the net current is   *1*
    (A)   due to diffusion of majority charge carriers.
    (B)   due to drift of minority charge carriers.
    (C)   zero as diffusion and drift currents are equal and opposite.
    (D)   zero as no charge carriers cross the junction.

8. In an n-type semiconductor, the donor energy level lies   *1*
    (A)   at the centre of the energy gap.
    (B)   just below the conduction band.
    (C)   just above the valance band.
    (D)   in the conduction band.

9. When two nuclei ($A \leq 10$) fuse together to form a heavier nucleus, the   *1*
    (A)   binding energy per nucleon increases.
    (B)   binding energy per nucleon decreases.
    (C)   binding energy per nucleon does not change.
    (D)   total binding energy decreases.

10. In β^- decay, a   *1*
    (A)   neutron converts into a proton emitting antineutrino.
    (B)   neutron converts into a proton emitting neutrino.
    (C)   proton converts into a neutron emitting antineutrino.
    (D)   proton converts into a neutron emitting neutrino.

Note :   *Fill in the blanks with appropriate answer :*

11. If the electric flux entering and leaving a closed surface in air are ϕ_1 and ϕ_2 respectively, the net electric charge enclosed within the surface is

    _____ .   *1*

12. In Young's double slit experiment, the path difference between two interfering waves at a point on the screen is $\dfrac{5\,\lambda}{2}$, λ being wavelength of the light used. The _____ dark fringe will lie at this point.   *1*

<div align="center">OR</div>

If one of the slits in Young's double slit experiment is fully closed, the new pattern has _____ central maximum in angular size.   *1*

13. For a higher resolving power of a compound microscope, the wavelength of light used should be _____ . *1*

14. Unpolarised light passes from a rarer into a denser medium. If the reflected and the refracted rays are mutually perpendicular, the reflected light is linearly polarised _____ to the plane of incidence. *1*

15. Out of red, blue and yellow lights, the scattering of _____ light is maximum. *1*

Note : *Answer the following :*

16. What is the impedance of a capacitor of capacitance C in an ac circuit using source of frequency n Hz ? *1*

OR

What is the value of impedance of a resonant series LCR circuit ? *1*

17. A conducting rod of length l is kept parallel to a uniform magnetic field $\overrightarrow{B}$. It is moved along the magnetic field with a velocity $\overrightarrow{v}$. What is the value of emf induced in the conductor ? *1*

18. Draw the graph showing variation of the value of the induced emf as a function of rate of change of current flowing through an ideal inductor. *1*

19. What is the wavelength of a photon of energy $3 \cdot 3 \times 10^{-19}$ J ? *1*

20. Define the term 'threshold frequency' in photoelectric emission. *1*

SECTION B

21. Define the term 'mobility' of charge carriers in a current carrying conductor. Obtain the relation for mobility in terms of relaxation time. *2*

OR

Define the term 'drift velocity' of electrons in a current carrying conductor. Obtain the relationship between the current density and the drift velocity of electrons. *2*

22. An ammeter of resistance $0 \cdot 8$ Ω can measure a current up to $1 \cdot 0$ A. Find the value of shunt resistance required to convert this ammeter to measure a current up to $5 \cdot 0$ A. *2*

23. (a) Explain the term 'sharpness of resonance' in ac circuit.

(b) In a series LCR circuit, $V_L = V_C \neq V_R$. What is the value of power factor for this circuit ? *2*

OR

An ac source of emf $V = V_0 \sin \omega t$ is connected to a capacitor of capacitance C. Deduce the expression for the current (I) flowing in it. Plot the graph of (i) V vs. ωt, and (ii) I vs. ωt. *2*

24. Which of the following electromagnetic waves has (a) minimum wavelength, and (b) minimum frequency ? Write one use of each of these two waves.

Infrared waves, Microwaves, γ-rays and X-rays *2*

25. An object is kept 20 cm in front of a concave mirror of radius of curvature 60 cm. Find the nature and position of the image formed. *2*

26. In Geiger-Marsden scattering experiment, the trajectory of α-particles in Coulomb's field of a heavy nucleus is shown in the figure.
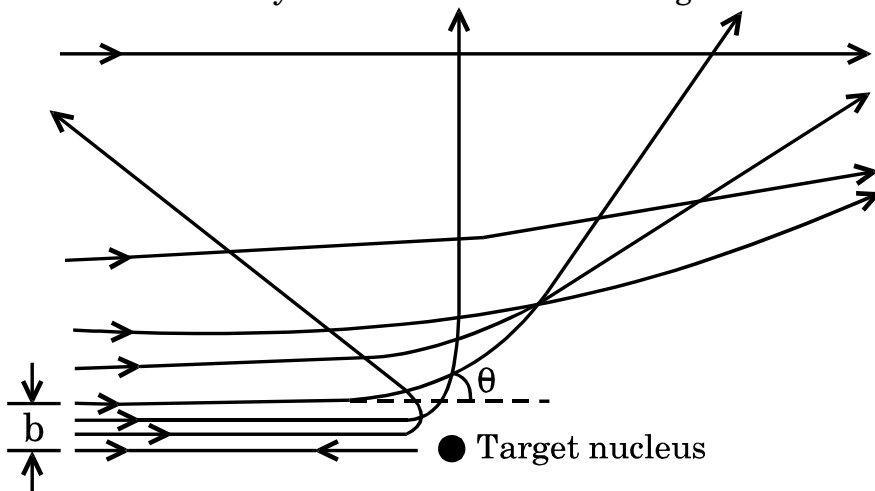
(a) What do 'b' and 'θ' represent in the figure ?

(b) What will be the value of 'b' for (i) $\theta = 0°$, and (ii) $\theta = 180°$? *2*

27. Draw V-I characteristics of a p-n junction diode. Explain, why the current under reverse bias is almost independent of the applied voltage up to the critical voltage. *2*

28. Two small identical electric dipoles AB and CD, each of dipole moment $\vec{p}$ are kept at an angle of 120° to each other in an external electric field $\vec{E}$ pointing along the x-axis as shown in the figure. Find the

(a) dipole moment of the arrangement, and

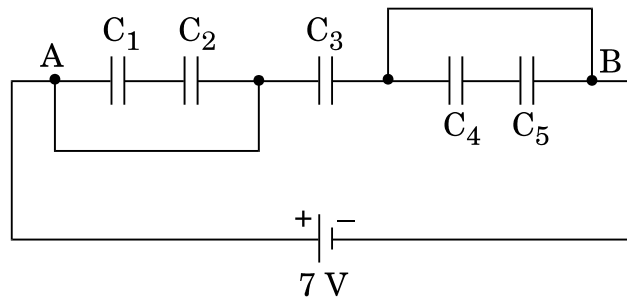(b) magnitude and direction of the net torque acting on it. *3*
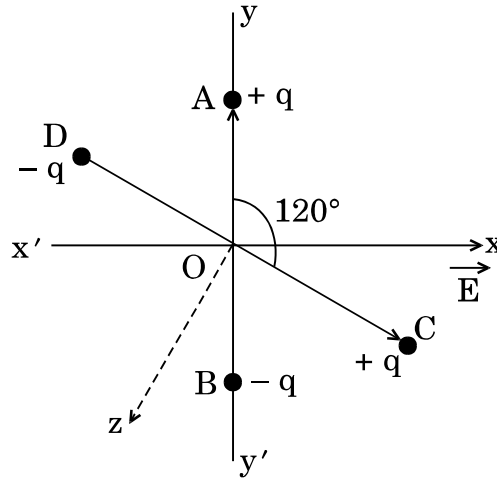
OR

In the figure given below, find the

(a) equivalent capacitance of the network between points A and B.
Given : $C_1 = C_5 = 8\ \mu F$, $C_2 = C_3 = C_4 = 4\ \mu F$.

(b) maximum charge supplied by the battery, and
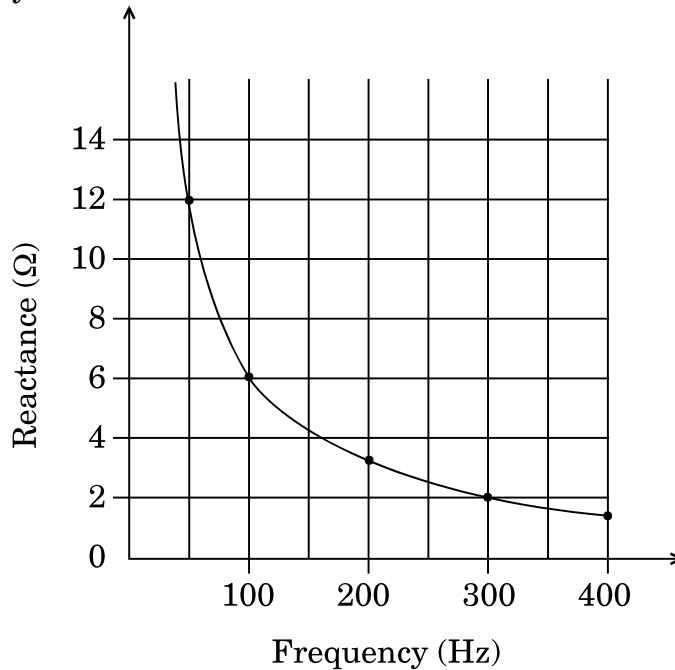
(c) total energy stored in the network. *3*

29. (a) Derive the condition of balance for Wheatstone bridge.

(b) Draw the circuit diagram of a meter bridge to explain how it is based on Wheatstone bridge. *3*

30. The figure shows the graphical variation of the reactance of a capacitor with frequency of ac source.

(a) Find the capacitance of the capacitor.

(b) An ideal inductor has the same reactance at 100 Hz frequency as the capacitor has at the same frequency. Find the value of inductance of the inductor.

(c) Draw the graph showing the variation of the reactance of this inductor with frequency. *3*

31. What is the difference in the construction of an astronomical telescope and a compound microscope ? The focal lengths of the objective and eyepiece of a compound microscope are 1·25 cm and 5·0 cm, respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 when the final image is formed at the near point. *3*

32. The maximum kinetic energy of the photoelectrons emitted is doubled when the wavelength of light incident on the photosensitive surface changes from λ_1 to λ_2. Deduce expressions for the threshold wavelength and work function for the metal surface in terms of λ_1 and λ_2. *3*

33. (a) Differentiate between half-life and average life of a radioactive substance.

(b) A radioactive substance decays for an interval of time equal to its mean life. Find the fraction of the amount of the substance which is left undecayed after this time interval. *3*

34. What is the function of a solar cell ? Briefly explain its working and draw its I-V characteristic curve. *3*

SECTION D

35. (a) Use Gauss's law to show that due to a uniformly charged spherical shell of radius R, the electric field at any point situated outside the shell at a distance r from its centre is equal to the electric field at the same point, when the entire charge on the shell were concentrated at its centre. Also plot the graph showing the variation of electric field with r, for $r \leq R$ and $r \geq R$.

   (b) Two point charges of + 1 µC and + 4 µC are kept 30 cm apart. How far from the + 1 µC charge on the line joining the two charges, will the net electric field be zero ? *5*

OR

   (a) Two point charges q_1 and q_2 are kept r distance apart in a uniform external electric field $\vec{E}$. Find the amount of work done in assembling this system of charges.

   (b) A cube of side 20 cm is kept in a region as shown in the figure. An electric field $\vec{E}$ exists in the region such that the potential at a point is given by V = 10x + 5, where V is in volt and x is in m.
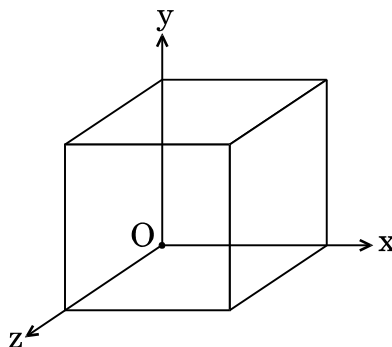
   Find the

   (i) electric field $\vec{E}$, and

   (ii) total electric flux through the cube. *5*

36. (a) A circular loop of radius R carries a current I. Obtain an expression for the magnetic field at a point on its axis at a distance x from its centre.

(b) A conducting rod of length 2 m is placed on a horizontal table in north-south direction. It carries a current of 5 A from south to north. Find the direction and magnitude of the magnetic force acting on the rod. Given that the Earth's magnetic field at the place is 0.6×10^{-4} T and angle of dip is $\dfrac{\pi}{6}$. 　　5

OR

(a) Obtain the expression for the deflecting torque acting on the current carrying rectangular coil of a galvanometer in a uniform magnetic field. Why is a radial magnetic field employed in the moving coil galvanometer ?

(b) Particles of mass 1.6×10^{-27} kg and charge 1.6×10^{-19} C are accelerated in a cyclotron of dee radius 40 cm. It employs a magnetic field 0·4 T. Find the kinetic energy (in MeV) of the particle beam imparted by the accelerator. 　　5

37. (a) Derive lens maker's formula for a biconvex lens.

(b) A point object is placed at a distance of 12 cm on the principal axis of a convex lens of focal length 10 cm. A convex mirror is placed coaxially on the other side of the lens at a distance of 10 cm. If the final image coincides with the object, sketch the ray diagram and find the focal length of the convex mirror. 　　5

OR

(a) What is a wavefront ? How does it propagate ? Using Huygens' principle, explain reflection of a plane wavefront from a surface and verify the laws of reflection.

(b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is obtained on a screen 1 m away. If the first minimum is formed at a distance of 2·5 mm from the centre of the screen, find the (i) width of the slit, and (ii) distance of first secondary maximum from the centre of the screen. 　　5