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Your JEE Guide

MP Board Class XII · Physics

Sample Question Paper 3 · Session 2026-27

Time allowed: 3 hours **Maximum marks: 70**

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This is an original practice paper written to the MPBSE 2027 sample question paper pattern; it is not issued by MPBSE.

General instructions:

1. All questions are compulsory.
2. Questions 1 to 5 are objective questions (28 in all): choose the correct option, fill in the blanks, true/false, match the columns and answer in one word or sentence. Each sub-question carries 1 mark.
3. Questions 6 to 12 are very short answer questions of 2 marks each. Answer each in about 30 words.
4. Questions 13 to 16 are short answer questions of 3 marks each. Answer each in about 75 words.
5. Questions 17 to 20 are long answer questions of 4 marks each. Answer each in about 120 words.
6. Internal options are given in questions 13 to 20.
7. Draw neat and labelled diagrams wherever necessary.
8. The general meanings of the symbols in the question paper are according to the textbook.

1.	**(i)** *Choose the correct option and write it:* The work done in moving a charge between two points on an equipotential surface is: (a) infinite (b) zero (c) positive (d) negative	1
	(ii) A wire is stretched to twice its length, its volume staying the same. Its resistance becomes: (a) four times (b) half (c) twice (d) unchanged	1
	(iii) A charged particle enters a uniform magnetic field at an angle other than 0° or 90° to it. Its path is: (a) a circle (b) a straight line (c) a parabola (d) a helix	1
	(iv) The reactance of an inductor of inductance L at angular frequency ω is: (a) $\omega^2 L$ (b) $\frac{L}{\omega}$ (c) ωL (d) $\frac{1}{\omega L}$	1

	(v) Microwave ovens heat food because the frequency of microwaves matches the resonant frequency of: (a) glass (b) water molecules (c) salt crystals (d) plastic	1
	(vi) The ratio of the radii of nuclei with mass numbers 27 and 64 is: (a) 1 : 1 (b) 9 : 16 (c) 27 : 64 (d) 3 : 4	1
2.	**(i)** *Fill in the blanks:* The SI unit of electric potential is the _____.	1
	(ii) The resistivity of a semiconductor _____ as its temperature rises.	1
	(iii) A current-carrying solenoid behaves like a _____.	1
	(iv) The production of an emf in a coil by a change of current in the same coil is called _____.	1
	(v) The idea of displacement current was introduced by _____.	1
	(vi) The radius of the first Bohr orbit of the hydrogen atom is about _____.	1
3.	Match each scientist in column A with the work in column B:	6

Column A	Column B
(i) Coulomb	(a) law of force between two point charges
(ii) Ørsted	(b) wave theory of light
(iii) Faraday	(c) magnetic effect of electric current
(iv) Maxwell	(d) displacement current
(v) Huygens	(e) diffraction of electrons
(vi) Davisson and Germer	(f) electromagnetic induction

4.	**(i)** *Write True or False:* The capacitance of a capacitor depends on the charge on it.	1
	(ii) The resistance of an ideal ammeter is zero.	1
	(iii) The average power consumed by a pure capacitor in an a.c. circuit is zero.	1
	(iv) A photon of red light has more energy than a photon of violet light.	1
	(v) Nuclear forces are independent of charge.	1
5.	**(i)** *Answer in one word or one sentence:* What is the dielectric constant of a metal?	1
	(ii) Name the instrument used to measure potential difference.	1

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	(iii) Write the relation between the focal length and the radius of curvature of a spherical mirror.	1
	(iv) What is the energy of the electron in the ground state of the hydrogen atom?	1
	(v) What is the addition of a suitable impurity to a pure semiconductor called?	1
6.	What is an equipotential surface? Why is the electric field always at right angles to it?	2
7.	A wire of resistance 10 Ω is drawn out to three times its length without any change in volume. Find its new resistance.	2
8.	An electron moves at 2×10^6 m s^{-1} at right angles to a magnetic field of 0.01 T. Find the radius of its circular path. ($m = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C)	2
9.	Define self-inductance. Write its SI unit.	2
10.	Name the electromagnetic waves used (i) in the remote controls of TV sets, (ii) to detect fractures in bones.	2
11.	The refractive index of water is 4/3. Find the speed of light in water. ($c = 3 \times 10^8$ m s^{-1})	2
12.	Find the energy, in electron volts, of a photon of wavelength 500 nm. (hc = 1240 eV nm)	2
13.	Derive the expression for the potential energy of an electric dipole placed in a uniform electric field. When is it least? **OR** Derive the expression for the electric potential at a point on the axial line of an electric dipole.	3
14.	n identical cells, each of emf ε and internal resistance r, are connected (a) in series, (b) in parallel. Write the equivalent emf and internal resistance in each case. When is each arrangement useful? **OR** How does the resistivity of (a) a metal, (b) a semiconductor change with temperature? Explain why, and sketch the graphs.	3
15.	State Lenz's law. Show, using a bar magnet and a coil, that it follows from the conservation of energy. **OR** Derive the expression for the mutual inductance of two long coaxial solenoids of the same length l.	3

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16.	What is total internal reflection? State the two conditions for it, and give two of its applications. **OR** A small bulb is placed at the bottom of a tank of water 80 cm deep. Find the radius of the circle on the water surface through which light from the bulb can emerge. (n = 4/3)	3
17.	Using Gauss's law, derive the expression for the electric field due to an infinite plane sheet of charge with uniform surface charge density σ. **OR** Using Gauss's law, find the electric field due to a uniformly charged thin spherical shell of radius R at a point (a) outside, (b) inside it.	4
18.	A particle of charge q and mass m moves with speed v at right angles to a uniform magnetic field B. Derive the radius of its path and its frequency of revolution. What happens if the velocity has a component along B? **OR** Derive the expression for the magnetic field at a point on the axis of a circular loop of radius R carrying a current I.	4
19.	For a series LCR circuit connected to an a.c. source, draw the phasor diagram and derive the expressions for the impedance and the phase angle. **OR** Derive the expression for the average power in an a.c. circuit. What is wattless current?	4
20.	Using Bohr's model, derive the expression for the total energy of the electron in the nth orbit of the hydrogen atom. Why is it negative? **OR** What are mass defect and binding energy? Draw the curve of binding energy per nucleon against mass number and explain how it accounts for the release of energy in fission and fusion.	4

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Answers and Marking Scheme

Marks for each step are shown in brackets. Any correct alternative method gets full credit.

Question 1

(i) **(b)** zero. *Working:* W = q(V_B – V_A) and V_B = V_A.

(ii) **(a)** four times. *Working:* l doubles and A halves, so R = ρl/A becomes 4 times.

(iii) **(d)** a helix. *Working:* The parallel component of velocity is unchanged while the perpendicular component makes it go round in a circle.

(iv) **(c)** ωL. *Working:* X_L = ωL.

(v) **(b)** water molecules. *Working:* Water molecules absorb the energy and the food warms up.

(vi) **(d)** 3 : 4. *Working:* R ∝ A^(1/3): 27^(1/3) : 64^(1/3) = 3 : 4.

Question 2

(i) volt.

(ii) decreases.

(iii) bar magnet.

(iv) self-induction.

(v) Maxwell.

(vi) 0.53 Å (5.3×10^{-11} m).

3. (i) – (a) law of force between two point charges; (ii) – (c) magnetic effect of electric current; (iii) – (f) electromagnetic induction; (iv) – (d) displacement current; (v) – (b) wave theory of light; (vi) – (e) diffraction of electrons

Question 4

(i) False: it depends on the size, shape and separation of the plates and the medium.

(ii) True.

(iii) True.

(iv) False: violet light has the higher frequency and so more energy per photon.

(v) True.

Question 5

(i) Infinite.

(ii) A voltmeter.

(iii) f = R/2.

(iv) −13.6 eV.

(v) Doping.

6. A surface on which every point is at the same potential (1). If E had a component along the surface, work would be done in moving a charge along it, which is not possible when the potential

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is the same everywhere on it (1).

7. Length becomes 3l and area A/3, so R′ = ρ(3l)/(A/3) = 9R (1) = 90 Ω (1).

8. $r = \frac{mv}{eB}$ (1) $= \frac{9.1\times10^{-31}\times2\times10^{6}}{1.6\times10^{-19}\times0.01} \approx 1.14 \times 10^{-3}$ m (1).

9. The magnetic flux linked with a coil per unit current through it, Φ = LI (or the emf induced per unit rate of change of current) (1). SI unit: henry (1).

10. (i) Infrared waves (1). (ii) X-rays (1).

11. v = c/n (1) = $3 \times 10^8 \times 3/4 = 2.25 \times 10^8$ m s^{-1} (1).

12. E = hc/λ (1) = 1240/500 = 2.48 eV (1).

13. The torque on the dipole is pE sin θ; the work done in turning it from θ_0 to θ is $\int_{\theta_0}^{\theta} pE\sin\theta\, d\theta$ (1). Taking $\theta_0 = 90°$ as zero, U = –pE cos θ = $-\vec{p}\cdot\vec{E}$ (1). It is least (–pE) when the dipole is parallel to the field, θ = 0 (1).

OR At distance r from the centre, the point is r – a from +q and r + a from –q (1). $V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r-a} - \frac{1}{r+a}\right)$ (1) $= \frac{p}{4\pi\varepsilon_0(r^2-a^2)}$, $\approx \frac{p}{4\pi\varepsilon_0 r^2}$ for r ≫ a (1).

14. (a) Series: emf nε, internal resistance nr (1). (b) Parallel: emf ε, internal resistance r/n (1). Series is useful when the external resistance is large; parallel when it is small (1).

OR (a) For metals it increases: the ions vibrate more, so collisions become more frequent and the relaxation time falls (1). (b) For semiconductors it decreases: more electrons and holes become free, which outweighs the effect of more collisions (1). Graphs: ρ rising roughly linearly for a metal and falling steeply for a semiconductor (1).

15. The induced current flows in such a direction that it opposes the change producing it (1). When the north pole of a magnet approaches a coil, the induced current makes the near face of the coil a north pole, so work must be done against the repulsion to push the magnet in (1). This work appears as electrical energy; if the induced current aided the motion, energy would be created from nothing (1).

OR Let the inner solenoid have radius r_1 and n_1 turns per unit length, and the outer n_2 turns per unit length. A current I_2 in the outer solenoid produces $B_2 = \mu_0 n_2 I_2$ inside it (1). The flux linked with the inner solenoid is $N_1\Phi_1 = (n_1 l)(\pi r_1^2)(\mu_0 n_2 I_2)$ (1). So $M = \mu_0 n_1 n_2 \pi r_1^2 l$ (1).

16. When light going from a denser to a rarer medium is wholly reflected back into the denser medium (1). Conditions: light must travel from the optically denser to the rarer medium, and the angle of incidence must exceed the critical angle (1). Uses: optical fibres; totally reflecting prisms in binoculars; sparkling of diamonds; mirage (any two) (1).

OR Light emerges where the angle of incidence is less than the critical angle: sin C = 3/4 (1). tan C = 3/√7 = 1.134 (1). r = 0.80 × 1.134 ≈ 0.91 m (1).

17. Take a cylindrical Gaussian surface of cross-section A piercing the sheet, with its ends on either side (1). Flux passes only through the two flat ends: 2EA (1). Charge enclosed is σA, so 2EA = σA/ε_0 (1). $E = \frac{\sigma}{2\varepsilon_0}$, independent of distance, normal to the sheet (1).

OR (a) Take a concentric spherical surface of radius r > R: E × 4πr² = q/ε_0 (1), so $E = \frac{q}{4\pi\varepsilon_0 r^2}$, as if all the charge were at the centre (1). (b) For r < R the surface encloses no charge (1), so E = 0

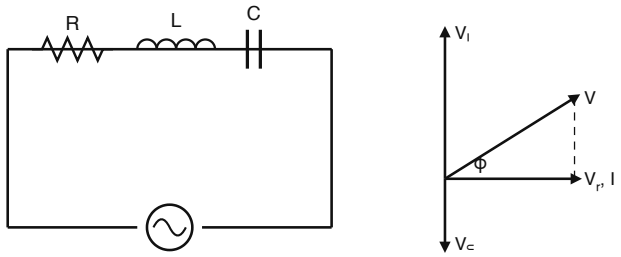
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inside (1).

18. The magnetic force qvB provides the centripetal force: qvB = mv²/r (1), so r = mv/(qB) (1). The time period T = 2πr/v = 2πm/(qB), so the frequency ν = qB/(2πm), independent of speed (1). With a component along B, the particle also moves along the field, so the path becomes a helix (1).

OR Each element dl produces dB = $\frac{\mu_0}{4\pi}\frac{I\,dl}{x^2+R^2}$ at the point, at right angles to the line joining them (1). By symmetry the perpendicular components cancel and the axial components add: dB cos α with cos α = R/√(x² + R²) (1). Integrating dl round the loop (2πR) (1) gives $B = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$ (1).

19. Phasor diagram (1):

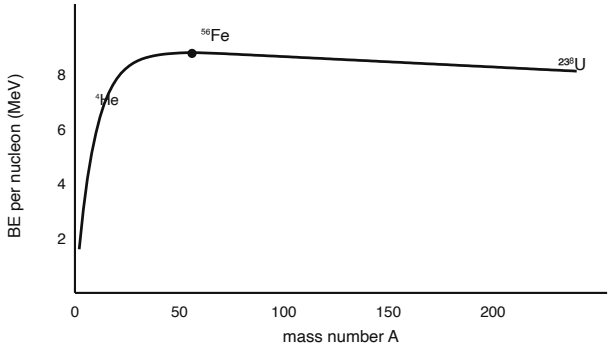


V_R is in phase with I, V_L leads I by 90° and V_C lags by 90° (1). $V^2 = V_R^2 + (V_L - V_C)^2$, so $Z = \sqrt{R^2 + (X_L - X_C)^2}$ (1). $\tan\phi = \frac{X_L - X_C}{R}$ (1).

OR With v = v_m sin ωt and i = i_m sin(ωt + ϕ), p = vi (1). Averaging over a cycle, P = ½$v_m i_m$ cos ϕ = $V_{rms} I_{rms}$ cos ϕ (1½). When ϕ = 90°, as in a pure inductor or capacitor, P = 0 although a current flows: this is called wattless current (1½).

20. From $\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$, the kinetic energy is $K = \frac{e^2}{8\pi\varepsilon_0 r}$ and the potential energy $U = -\frac{e^2}{4\pi\varepsilon_0 r}$ (1). So $E = K + U = -\frac{e^2}{8\pi\varepsilon_0 r}$ (1). With $r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$, $E_n = -\frac{me^4}{8\varepsilon_0^2 n^2 h^2} = -\frac{13.6}{n^2}$ eV (1). It is negative because the electron is bound to the nucleus: energy must be supplied to free it (1).

OR Mass defect is the difference between the total mass of the nucleons and the mass of the nucleus; binding energy is its energy equivalent, Δm c² (1). Curve (1):



Heavy nuclei split into middle-mass nuclei of higher binding energy per nucleon, releasing energy in fission (1). Light nuclei join to form a nucleus of higher binding energy per nucleon, releasing energy in fusion (1).

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