PHYSICS (CODE - 042)
SAMPLE PAPER 2
CLASS XII

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

General Instructions:
1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Sections A, B, C, D and E.
3. Section A contains twelve MCQs and four assertion-reason questions of 1 mark each. Section B contains five questions of 2 marks each. Section C contains seven questions of 3 marks each. Section D contains two case-based questions of 4 marks each. Section E contains three long answer questions of 5 marks each.
4. There is no overall choice. However, an internal choice has been provided in two questions in Section B, one question in Section C, and all three questions in Section E.
5. Use of calculators is not allowed.

You may use the following values of physical constants where necessary:
- $c = 3 \times 10^8$ m/s
- me = 9.1×10^{-31} kg
- mp = 1.7×10^{-27} kg
- $e = 1.6 \times 10^{-19}$ C
- $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
- $h = 6.63 \times 10^{-34}$ J s
- $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
- Avogadro's number = 6.023×10^{23} per gram mole

SECTION A

Question numbers 1 to 12 carry 1 mark each and are multiple choice questions.

1. Two point charges +4q and +q are placed at a distance r apart. At what distance from the +4q charge, on the line joining them, is the electric field zero?

(A) r/2

(B) 2r/3

(C) r/3

(D) 3r/4

2. A wire of resistance R is stretched uniformly until its length is doubled. Assuming the volume of the wire remains constant, its new resistance is:

(A) R/4

(B) R/2

(C) 2R

(D) 4R

3. The magnetic field at the centre of a circular current-carrying loop of radius r is B. If the same length of wire is now bent into a loop of radius r/2 carrying the same current, the new magnetic field at the centre is:

(A) B/4

(B) B/2

(C) 2B

(D) 4B

4. A bar magnet is cut into two equal halves along its length (parallel to the axis). Each half will have:

(A) Half the original pole strength and half the original magnetic moment

(B) The same pole strength but half the magnetic moment

(C) Half the pole strength but the same magnetic moment

(D) The same pole strength and the same magnetic moment

5. A conducting rod slides on two parallel rails in a region of uniform magnetic field perpendicular to the plane of the rails. For an induced current to flow, which of the following is necessary?

(A) The rod must be stationary

(B) The magnetic field must be increasing with time

(C) The area of the circuit enclosed must be changing

(D) The resistance of the rod must be zero

6. In a series LCR circuit at resonance, the impedance of the circuit is:

(A) Maximum and equal to R

(B) Minimum and equal to R

(C) Zero

(D) Maximum and equal to XL + XC

7. Electromagnetic waves used for satellite communication and mobile phones belong to which part of the spectrum?

(A) Infrared

(B) Microwaves

(C) Ultraviolet

(D) X-rays

8. A convex lens produces a real, inverted, and magnified image of an object. The object must be placed:

(A) Beyond 2F

(B) At 2F

(C) Between F and 2F

(D) Between the lens and F

9. In a single slit diffraction experiment, the width of the central maximum is found to be x. If the slit width is halved (keeping other quantities the same), the new width of the central maximum will be:

(A) x/4

(B) x/2

(C) 2x

(D) 4x

10. According to de Broglie's hypothesis, the wavelength associated with a moving particle of momentum p is given by:

(A) $\lambda = hp$

(B) $\lambda = h/p$

(C) $\lambda = p/h$

(D) $\lambda = pc/h$

11. The half-life of a radioactive substance is 20 days. The fraction of the original sample remaining undecayed after 60 days is:

(A) 1/2

(B) 1/4

(C) 1/8

(D) 1/16

12. In an n-type semiconductor, the majority and minority charge carriers are respectively:

(A) Holes and electrons

(B) Electrons and holes

(C) Electrons and electrons

(D) Holes and holes

Question numbers 13 to 16 have two statements, Assertion (A) and Reason (R). Choose the correct option:
(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) Both A and R are false.

13. Assertion (A): A capacitor allows AC to pass through it but blocks DC. Reason (R): The capacitive reactance of a capacitor is inversely proportional to the frequency of the applied voltage, becoming infinite at zero frequency (DC).

14. Assertion (A): The resistivity of a good conductor increases with an increase in temperature. Reason (R): The relaxation time of electrons in a conductor decreases as temperature increases, due to more frequent collisions.

15. Assertion (A): The image formed by a simple microscope is virtual, erect, and magnified. Reason (R): A simple microscope uses a convex lens with the object placed between the lens and its focus.

16. Assertion (A): In nuclear fission, the sum of the masses of the product nuclei is slightly less than the mass of the original nucleus. Reason (R): The mass defect appears as the binding energy released during the fission process, in accordance with Einstein's mass-energy equivalence relation.

SECTION B

Question numbers 17 to 21 carry 2 marks each.

17. State Gauss's law in electrostatics. Use it to find the electric field due to an infinitely long, thin, uniformly charged straight wire with linear charge density λ, at a perpendicular distance r from the wire. [2]

18. Two cells of emf 2 V and 4 V and internal resistances 1 Ω and 2 Ω respectively are connected in parallel so as to send current in the same direction through an external resistor. Find the equivalent emf and internal resistance of this combination. [2]

OR

Define the terms 'drift velocity' and 'relaxation time' for electrons in a conductor, and write the relation connecting drift velocity to the electric field applied across the conductor.

19. A rectangular loop of area 0.2 m^2 is placed in a uniform magnetic field of 0.5 T, with its plane perpendicular to the field. The field is reduced to zero in 0.1 s at a steady rate. Find the magnitude of the emf induced in the loop during this time. [2]

OR

State Faraday's laws of electromagnetic induction and Lenz's law. Explain briefly why Lenz's law is regarded as a consequence of the law of conservation of energy.

20. Distinguish between a paramagnetic and a diamagnetic substance on the basis of their behaviour in a non-uniform magnetic field and the effect of temperature on their susceptibility. [2]

21. Draw a labelled ray diagram showing the formation of an image by a simple astronomical telescope in normal adjustment (final image at infinity), and write the expression for its magnifying power. [2]

SECTION C

Question numbers 22 to 28 carry 3 marks each.

22. With the help of a neat circuit diagram, explain the working of a p-n junction diode as a half wave rectifier. Draw the input and output waveforms. [3]

23. State the principle of a Wheatstone bridge. Derive the balance condition for the bridge in terms of the four resistances forming its arms. [3]

OR

A metre bridge is used to determine the resistance of an unknown wire. If the balancing length from the left end is 40 cm when a known resistance of 6 Ω is placed in the right gap, find the value of the unknown resistance.

24. A radioactive nucleus 92U238 decays by emitting an alpha particle to form a nucleus of thorium. (i) Write the nuclear decay equation. (ii) If the half-life of this decay is 4.5×10^9 years, calculate the decay constant. [3]

25. An astronomical telescope has an objective of focal length 100 cm and an eyepiece of focal length 5 cm. Calculate (i) the magnifying power of the telescope for image formation at infinity, and (ii) the separation between the objective and the eyepiece in this case. [3]

26. State Huygens' principle. Using it, derive the laws of refraction of light at a plane interface between two media. [3]

27. In the Young's double slit experiment, two slits are separated by 0.5 mm and the screen is placed 1.0 m away. If the wavelength of light used is 5000 Å, calculate (i) the fringe width, and (ii) the distance of the 4th bright fringe from the central maximum. [3]

28. A conducting circular coil of 100 turns and radius 5 cm is placed perpendicular to a magnetic field that varies as B = 0.02t Tesla, where t is time in seconds. Calculate the emf induced in the coil at t = 3 s. [3]

SECTION D

Question numbers 29 and 30 are case-based questions carrying 4 marks each.

29. Read the passage given below and answer the questions that follow: [4]

A capacitor is a device used to store electric charge and energy. The capacitance of a parallel plate capacitor depends on the area of the plates, the separation between them, and the nature of the medium between them. When a dielectric material is introduced between the plates of a charged, isolated capacitor, it becomes polarised, producing an induced electric field opposite to the original field, which reduces the net field between the plates and hence increases the capacitance. Capacitors can be combined in series or parallel to obtain a desired effective capacitance; in series combination, the reciprocal of the effective capacitance is the sum of the reciprocals of individual capacitances, while in parallel combination, the effective capacitance is simply the sum of individual capacitances.

I. Why does the capacitance of a parallel plate capacitor increase when a dielectric slab is introduced between its plates, keeping the charge constant? [1]

II. Three capacitors of capacitance 2 μF, 3 μF, and 6 μF are connected in series. Calculate the effective capacitance of the combination.

OR

The same three capacitors (2 μF, 3 μF, 6 μF) are connected in parallel instead. Calculate the effective capacitance in this case. [1]

III. Explain why the effective capacitance of a series combination is always less than the smallest individual capacitance in the combination. [2]

30. Read the passage given below and answer the questions that follow: [4]

De Broglie proposed that matter, like radiation, exhibits a dual wave-particle nature. According to his hypothesis, a particle of momentum p has an associated wavelength λ = h/p, where h is Planck's constant. This wave nature of matter becomes significant only for very small particles such as electrons, and is negligible for macroscopic objects due to their large momentum (and correspondingly minuscule wavelength). The wave nature of electrons was experimentally confirmed by the Davisson-Germer experiment, which observed diffraction of electrons by a crystal, analogous to the diffraction of X-rays.

I. Why is the de Broglie wavelength of a cricket ball moving at a normal speed not observable in practice, even though the formula λ = h/p applies to it as well? [1]

II. An electron is accelerated through a potential difference of 100 V. Calculate its de Broglie wavelength.

OR

How does the de Broglie wavelength of an electron change if the accelerating potential difference is increased? [1]
III. What experimental observation in the Davisson-Germer experiment confirmed the wave nature of electrons? [1]

SECTION E

Question numbers 31 to 33 are long answer questions carrying 5 marks each.

31. Attempt either (A) or (B). [5]

(A)
I. Derive the expression for the electric potential at a point due to a point charge Q at a distance r from it. [2]
II. Three point charges of +1 μC, +2 μC, and –3 μC are placed at the vertices of an equilateral triangle of side 10 cm. Calculate the total electrostatic potential energy of the system. [3]

OR

(B)
I. Derive an expression for the capacitance of a parallel plate capacitor without a dielectric medium between the plates. [2]
II. Two capacitors of capacitance 4 μF and 6 μF are first connected in series and then in parallel across the same 12 V battery. Calculate the ratio of the energy stored in the parallel combination to that in the series combination. [3]

32. Attempt either (A) or (B). [5]

(A)
I. Derive an expression for the magnetic field at a point on the axis of a circular current-carrying loop, at a distance x from its centre. [3]
II. Two identical circular coils, each of radius 10 cm and carrying the same current, are placed with their centres coinciding and their planes perpendicular to each other. If the magnetic field at the common centre due to each coil is B, find the resultant magnetic field at the centre. [2]

OR

(B)
I. State and explain Biot-Savart law. Use it to derive the expression for the magnetic field at the centre of a circular coil of N turns and radius R carrying current I. [3]
II. A long straight wire carries a current of 10 A. Find the magnitude of the magnetic field at a perpendicular distance of 5 cm from the wire. [2]

33. Attempt either (A) or (B). [5]

(A)
I. With the help of a labelled diagram, describe the working of an AC generator based on electromagnetic induction. [3]
II. A coil of 200 turns and area 0.05 m^2 rotates at 50 revolutions per second in a magnetic field of 0.1 T, with its axis of rotation perpendicular to the field. Calculate the peak emf generated. [2]

OR

(B)
I. Explain, with the help of a phasor diagram, the variation of current and voltage in a series LCR circuit connected to an AC source, and derive the expression for the impedance of the circuit. [3]
II. A series LCR circuit has R = 30 Ω, XL = 70 Ω, and XC = 30 Ω, connected to a 220 V AC source. Calculate the impedance of the circuit and the current flowing through it. [2]

PHYSICS (CODE - 042)
MARKING SCHEME - SAMPLE PAPER 2
CLASS XII

SECTION A

1. (B) 2r/3. Since the charges are of the same sign, the null point lies between them, closer to the smaller charge. Let x be the distance from +4q. Setting fields equal: $k(4q)/x^2 = k(q)/(r-x)^2 \Rightarrow [(r-x)/x]^2 = 1/4 \Rightarrow (r-x)/x = 1/2 \Rightarrow 2r-2x = x \Rightarrow 2r = 3x \Rightarrow x = 2r/3$. [1]

2. (D) 4R. Since volume V = AL is constant and length is doubled (L′ = 2L), the new area A′ = V/L′ = A/2. New resistance $R' = \rho L'/A' = \rho(2L)/(A/2) = 4\rho L/A = 4R$. [1]

3. (D) 4B. Same length of wire means $2\pi r = N' \times 2\pi(r/2)$, so the number of turns doubles (N′ = 2) for the smaller loop. Field at centre for N turns: $B = \mu_0 NI/(2r)$; for the new loop, $B' = \mu_0(2)I/(2 \times r/2) = 2\mu_0 I/r = 4 \times [\mu_0 I/(2r)] = 4B$. [1]

4. (B) The same pole strength but half the magnetic moment – cutting a bar magnet parallel to its length (along its length) keeps the length of each piece the same but halves the cross-sectional area (and hence pole strength, since each half now carries half the original 'flux capacity'); since magnetic moment m = (pole strength) × (length), and length is unchanged while pole strength is halved, m is halved for each piece. [1]

5. (C) The area of the circuit enclosed must be changing – induced emf requires a changing magnetic flux ($\Phi = BA\cos\theta$); with a uniform, constant field, only a changing enclosed area (as the rod slides) can change the flux and induce an emf. [1]

6. (B) Minimum and equal to R – at resonance, XL = XC, so they cancel in $Z = \sqrt{R^2+(XL-XC)^2}$, leaving Z = R, the minimum possible impedance. [1]

7. (B) Microwaves – used for satellite communication and mobile telephony due to their short wavelength, straight-line propagation, and ability to be focused into narrow beams. [1]

8. (C) Between F and 2F – an object placed here forms a real, inverted, magnified image beyond 2F on the other side of a convex lens. [1]

9. (C) 2x – the angular width of the central maximum is inversely proportional to the slit width; halving the slit width doubles the width of the central maximum. [1]

10. (B) $\lambda = h/p$ – the de Broglie wavelength equals Planck's constant divided by momentum. [1]

11. (C) 1/8 – number of half-lives = 60/20 = 3, so fraction remaining = $(1/2)^3 = 1/8$. [1]

12. (B) Electrons and holes – in an n-type semiconductor, electrons are the majority carriers and holes are the minority carriers. [1]

13. (A) Both A and R are true, and R is the correct explanation – since $X_c = 1/(\omega C)$ becomes infinite as $\omega \to 0$ (DC), a capacitor blocks DC while offering a finite, frequency-dependent reactance to AC, allowing it to pass. [1]

14. (A) Both A and R are true, and R is the correct explanation – resistivity $\rho = m/(ne^2\tau)$; rising temperature increases lattice vibrations, causing more frequent electron collisions, which reduces the relaxation time τ and hence increases ρ for a metallic conductor. [1]

15. (A) Both A and R are true, and R is the correct explanation – placing the object within the focal length of a convex lens produces a virtual, erect, magnified image, exactly how a simple microscope (magnifying glass) is used. [1]

16. (A) Both A and R are true, and R is the correct explanation – the small mass defect in fission converts to energy via $E = \Delta mc^2$, appearing as the large energy released. [1]

SECTION B

17. [2]

Gauss's law states that the total electric flux through any closed surface equals $1/\varepsilon_0$ times the total charge enclosed: $\oint E \cdot dA = Q_{enclosed}/\varepsilon_0$. For an infinitely long charged wire, take a coaxial cylindrical Gaussian surface of radius r and length L. By symmetry, E is radial and uniform in magnitude over the curved surface (zero flux through the flat ends): $E \times (2\pi rL) = (\lambda L)/\varepsilon_0$ $E = \lambda/(2\pi\varepsilon_0 r)$, directed radially outward for $\lambda > 0$.

18. [2]

For two cells in parallel, aiding each other: $1/r_{eq} = 1/r_1 + 1/r_2 = 1/1 + 1/2 = 1.5 \Rightarrow r_{eq} = 2/3 \approx 0.67\ \Omega$ $\varepsilon_{eq}/r_{eq} = \varepsilon_1/r_1 + \varepsilon_2/r_2 = 2/1 + 4/2 = 2 + 2 = 4$ $\varepsilon_{eq} = r_{eq} \times 4 = (2/3) \times 4 = 8/3 \approx 2.67$ V

OR

Drift velocity is the average velocity gained by free electrons in a conductor under an applied electric field (superimposed on their random thermal motion). Relaxation time is the average time between successive collisions of an electron with the lattice ions. Relation: $v_d = eE\tau/m$, where e is the electron charge, E the applied field, τ the relaxation time, and m the electron mass.

19. [2]

Initial flux $\Phi_i = BA = 0.5 \times 0.2 = 0.1$ Wb. Final flux $\Phi_f = 0$. Induced emf magnitude, $\varepsilon = |\Delta\Phi/\Delta t| = (0.1-0)/0.1 = 1$ V

OR

Faraday's first law: an emf is induced in a circuit whenever the magnetic flux linked with it changes. Faraday's second law: the induced emf equals the rate of change of flux linkage, $\varepsilon = -N(d\Phi/dt)$. Lenz's law: the induced emf/current always opposes the change in flux causing it. Lenz's law follows from energy conservation: if the induced current instead aided the change in flux, it would reinforce itself indefinitely, creating energy from nothing; opposing the change ensures external work is required to sustain any further change in flux.

20. [2]

A paramagnetic substance is weakly attracted towards regions of stronger field in a non-uniform magnetic field, and its susceptibility decreases with rising temperature (Curie's law, $\chi \propto 1/T$). A diamagnetic substance is weakly repelled towards regions of weaker field, and its susceptibility is small, negative, and essentially independent of temperature.

21. [2]

In normal adjustment, parallel rays from a distant object are focused by the objective at its focal point, which coincides with the focal point of the eyepiece; the eyepiece then renders these rays parallel again, forming the final virtual image at infinity. (Ray diagram: objective forms real image at the common focus of objective and eyepiece; eyepiece produces final parallel emergent rays.) Magnifying power (normal adjustment): $M = -f_o/f_e$, where f_o and f_e are the focal lengths of the objective and eyepiece.

SECTION C

22. [3]

In a half wave rectifier, the AC input is connected in series with a single p-n junction diode and a load resistor. During the positive half-cycle, the diode is forward biased and conducts, so current flows through the load and the output follows the input voltage shape. During the negative half-cycle, the diode is reverse biased and does not conduct, so the output voltage is zero. The result is a pulsating DC output consisting only of the positive half-cycles of the input, with each negative half-cycle removed. (Circuit: AC source, diode, and load resistor in series. Input: full sine wave. Output: only positive humps, flat zero during negative half-cycles.)

23. [3]

A Wheatstone bridge has four resistances P, Q, R, S arranged in a loop, with a galvanometer connected between the junction of P-Q and the junction of R-S, and a battery connected across the other diagonal. The bridge is 'balanced' when no current flows through the galvanometer. At balance, the same current I_1 flows through P and Q, and I_2 through R and S; since there is no potential difference across the galvanometer, the potential drop across P equals that across R, and across Q equals that across S: $I_1P = I_2R$ and $I_1Q = I_2S$ Dividing these: $P/Q = R/S$, which is the balance condition.

OR

Metre bridge balance condition: R1/R2 = l/(100–l), where l is the balancing length from the end connected to R1. Given known resistance 6 Ω in the right gap, balancing length from left = 40 cm (so from right = 60 cm): Runknown/6 = 40/60 Runknown = 6 × (40/60) = 4 Ω

24. [3]

(i) ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$ (alpha particle) (ii) λ = 0.693/t½ = 0.693/(4.5×10^{9}) ≈ 1.54 × 10^{-10} per year

25. [3]

(i) Magnifying power (normal adjustment) = fo/fe = 100/5 = 20 (ii) Tube length (separation) = fo + fe = 100 + 5 = 105 cm

26. [3]

Huygens' principle: every point on a wavefront acts as a source of secondary wavelets that spread out with the speed of light in that medium; the envelope (tangent surface) of these wavelets at a later instant gives the new wavefront. Derivation: consider a plane wavefront AB incident at angle i on a plane interface between media of speeds v1 and v2. While the disturbance from B travels to C on the surface in time τ, the wavelet from A travels a distance v2τ into the second medium (to point D). sin i = BC/AC, sin r = AD/AC, with BC = v1τ and AD = v2τ sin i/sin r = v1/v2 = n21 (a constant, giving Snell's law - the second law of refraction). The incident ray, refracted ray, and normal all lying in the same plane gives the first law of refraction.

27. [3]

(i) β = λD/d = (5000×10^{-10} × 1.0)/(0.5×10^{-3}) = (5×10^{-7})/(5×10^{-4}) = 1×10^{-3} m = 1 mm (ii) Distance of 4th bright fringe = 4β = 4 × 1 mm = 4 mm

28. [3]

ε = –N(dΦ/dt) = –NA(dB/dt) dB/dt = d(0.02t)/dt = 0.02 T/s (constant) A = πr^2 = π$(0.05)^2$ ≈ 7.85 × 10^{-3} m^2 ε = 100 × 7.85×10^{-3} × 0.02 ≈ 0.0157 V. Since dB/dt is constant, this value is the same at every instant, including t = 3 s.

SECTION D

29. [4]

I. The dielectric becomes polarised in the applied field, producing an induced field that opposes and reduces the net field between the plates; for the same charge Q, the reduced field means a lower potential difference V = Ed, and since C = Q/V, a lower V (with Q fixed) gives a higher capacitance. [1]

II. Series: 1/Ceq = 1/2 + 1/3 + 1/6 = 3/6 + 2/6 + 1/6 = 1 ⇒ Ceq = 1 μF

OR: Parallel: Ceq = 2 + 3 + 6 = 11 μF [1]

III. In series, each capacitor carries the same charge Q, and the applied voltage is shared among them (V = V1+V2+V3, with each Vi = Q/Ci). Since Ceq = Q/V and V exceeds any single Vi, Ceq must be smaller than every individual capacitance in the combination, including the smallest one. [2]

30. [4]

I. Since the cricket ball has a very large mass moving at ordinary speed, its momentum p is very large, making its de Broglie wavelength (λ = h/p) extremely small - far too small to detect or observe by any practical means, unlike for microscopic particles like electrons. [1]

II. λ = h/√(2meV) = (6.63×10^{-34})/√(2 × 9.1×10^{-31} × 1.6×10^{-19} × 100) = (6.63×10^{-34})/√(2.912×10^{-27}) = (6.63×10^{-34})/(5.396×10^{-14}) ≈ 1.23 × 10^{-10} m (≈ 1.23 Å)

OR: As the accelerating potential increases, the electron's momentum increases, so its de Broglie wavelength (λ ∝ 1/√V) decreases. [1]

III. Electrons scattered from a nickel crystal showed intensity maxima and minima at specific angles, forming a diffraction pattern analogous to X-ray diffraction, confirming the wave nature of electrons with a wavelength matching de Broglie's prediction. [1]

SECTION E

31 (A). [5]

I. The potential at a point at distance r from charge Q is the work done per unit positive charge in bringing a test charge from infinity to that point: $V(r) = -\int(\infty \text{ to } r)\, E\, dx = -\int(\infty \text{ to } r)\, [kQ/x^2]\, dx = kQ/r = Q/(4\pi\varepsilon_0 r)$ [2]

II. $U = k[q1q2/r + q2q3/r + q1q3/r]$ (equal side r = 0.1 m) $= (k/r)[(1)(2) + (2)(-3) + (1)(-3)] \times 10^{-12} = (k/r)(2-6-3) \times 10^{-12} = (k/r)(-7) \times 10^{-12} = (9\times10^9/0.1)(-7\times10^{-12}) = (9\times10^{10})(-7\times10^{-12}) \approx -0.63$ J [3]

OR (B)
I. For a parallel plate capacitor of plate area A and separation d, with surface charge density $\sigma = Q/A$, the field between the plates is $E = \sigma/\varepsilon_0$. Potential difference $V = Ed = Qd/(A\varepsilon_0)$. Capacitance $C = Q/V = A\varepsilon_0/d$ [2]

II. Series: $1/Cs = 1/4 + 1/6 = 3/12 + 2/12 = 5/12 \Rightarrow Cs = 12/5 = 2.4$ μF $Us = (1/2)CsV^2 = 0.5 \times 2.4\times10^{-6} \times 144 = 172.8 \times 10^{-6}$ J Parallel: Cp = 10 μF, $Up = (1/2)CpV^2 = 0.5 \times 10\times10^{-6} \times 144 = 720 \times 10^{-6}$ J Ratio Up:Us = 720:172.8 ≈ 4.17 : 1 [3]

32 (A). [5]

I. For a circular loop of radius R carrying current I, at a point P on the axis at distance x from the centre, each current element contributes a field dB perpendicular to the line joining it to P (by Biot-Savart law); by symmetry, only the axial components survive, while perpendicular components cancel. Integrating over the loop: $B = \mu_0 I R^2/[2(R^2+x^2)^{(3/2)}]$, directed along the axis. [3]

II. Since the two identical coils carry the same current and their planes are perpendicular, the two field vectors (each of magnitude B) are mutually perpendicular. Resultant: $Bnet = \sqrt{(B^2+B^2)} = B\sqrt{2}$ [2]

OR (B)
I. Biot-Savart law: $dB = (\mu_0/4\pi)(I\, dl \times \hat{r})/r^2$, giving the field due to a current element I dl at a point located by position vector r from the element. For a coil of N turns and radius R, every element at the centre is at the same perpendicular distance R, contributing fields in the same direction: $B = N \times (\mu_0 I\, dl)/(4\pi R^2)$, integrated over the full loop ($\sum dl = 2\pi R$): $B = \mu_0 NI/(2R)$ [3]

II. $B = \mu_0 I/(2\pi r) = (4\pi\times10^{-7} \times 10)/(2\pi \times 0.05) = (4\times10^{-6} \times 10)/0.1 = 4 \times 10^{-5}$ T [2]

33 (A). [5]

I. An AC generator consists of a rectangular armature coil rotated at constant angular velocity ω in a uniform magnetic field, using slip rings and brushes for external connection. Rotation causes the flux through the coil to vary sinusoidally, inducing an alternating emf $\varepsilon = NBA\omega \sin\omega t$ (N = turns, A = area), which drives an alternating current in the external circuit. [3]

II. $\varepsilon_0 = NBA\omega$, $\omega = 2\pi f = 2\pi(50) = 100\pi$ rad/s $\varepsilon_0 = 200 \times 0.1 \times 0.05 \times 100\pi \approx 314.16$ V

OR (B)
I. In a series LCR circuit, the same current I flows through R, L, and C. VR is in phase with I, VL leads I by 90°, and VC lags I by 90°. On a phasor diagram, VL and VC point in opposite directions (both perpendicular to VR); the net reactive voltage is (VL−VC), and the applied voltage is the vector sum: $V = \sqrt{[VR^2+(VL-VC)^2]} = I\sqrt{[R^2+(XL-XC)^2]}$ $Z = V/I = \sqrt{[R^2+(XL-XC)^2]}$ [3]

II. $Z = \sqrt{[30^2+(70-30)^2]} = \sqrt{[900+1600]} = \sqrt{2500} = 50\ \Omega$ $I = V/Z = 220/50 = 4.4$ A [2]