Paper - II

Physical Science

Booklet Code

A

Test Booklet No.

SUBJECT CODE : 0 5

Roll No. : | | | | | | | | | | | |

(Figures as per admission card)

Roll No. (in words) : _____

_____

OMR Sheet No. : | | | | | | | |

Name and Signature of Invigilator/s

Signature : _____

Name : _____

Time : 2 Hours | Maximum Marks : 200

Number of Pages in this Booklet : 32 | **Number of Questions in this Booklet : 100**

Instructions for the Candidates

1. Write your roll number in the space provided on the top of this page.
2. This paper consists of hundred (100) multiple-choice type of questions.
3. At the commencement of examination, the test booklet will be given to you. In the first 5 minutes, you are requested **To Open the Booklet and Compulsorily Examine it as Below:**
   (i) To have access to the Test Booklet, tear off the paper seal on the edge of the cover page. Do not accept a booklet without sticker seal or open booklet.
   (ii) Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to pages/questions missing or duplicate or not in serial order or any other discrepancy should be got replaced immediately by a correct booklet from the invigilator within the period of 5 minutes. Afterwards, neither the Test Booklet will be replaced nor any extra time will be given.
   (iii) After the verification is over, the Test Booklet Number should be entered in the OMR Sheet and the OMR Sheet Number should be entered on this Test Booklet.
4. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
   Example : Ⓐ Ⓑ ● Ⓓ
   where (C) is the correct response.
5. Your responses to the questions are to be indicated in the **OMR Sheet kept inside this Booklet**. If you mark at any place other than in the circles, the OMR Sheet will not be evaluated.
6. Read the instructions given in OMR Sheet carefully. Fill the Booklet Code of Paper-II in OMR Sheet **Compulsorily**.
7. Rough Work is to be done in the end of this booklet.
8. If you write your name or put any mark on any part of the OMR Answer Sheet, except for the space provided for the relevant entries, which may disclose your identity, you will render yourself liable to disqualification.
9. You have to return the OMR answer Sheet to the invigilators at the end of the examination compulsorily and must NOT carry it with you outside the Examination Hall.
10. You can take away test booklet and carbon copy of OMR Answer Sheet after the examination.
11. **Use only Blue/Black Ball point pen.**
12. **Use of any calculator, electronic gadgets or log table, etc. is prohibited.**
13. **There is no negative mark for incorrect answer.**

1. At a surface current, which one of the magnetostatic boundary condition is NOT CORRECT?
   (i) Normal component of the magnetic field is not continuous.
   (ii) Normal component of the magnetic vector potential is continuous.
   (iii) Tangential component of the magnetic vector potential is continuous.
   (iv) Tangential component of the magnetic vector potential is not continuous.
   Choose the correct answer from the code given below :
   (A) (i), (iii)
   (B) (ii), (iv)
   (C) (iii), (iv)
   (D) (i), (iv)

2. The product PQ of any two real, symmetric matrices P and Q is :
   (A) Hermitian for all P and Q
   (B) Never Symmetric or Hermitian
   (C) Symmetric, if PQ = QP
   (D) Anti-Symmetric for all P and Q

3. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:
   Assertion (a): The velocity of all electromagnetic waves in vacuum is different.
   Reason (r): Because all waves are of different frequency.
   (A) Both (a) and (r) are true and (r) is correct explanation of (a).
   (B) Both (a) and (r) are true but (r) is not correct explanation of (a).
   (C) (a) is true, but (a) is false.
   (D) (a) is false, but (r) is true.

4. Match List-I and List-II and select the correct answer from the codes given below:

List-I

P. Phonons
Q. Plasmon
R. Polarons
S. Polariton

List-II

1. Quasi particle result from the strong coupling of EM wave
2. Elastic arrangement of atoms and molecules
3. Quasi particle used to understand the interaction between electron and atoms in solid material
4. Quantum of Plasma excitation which means collective electron oscillation

Code:

(A)	P-2	Q-4	R-3	S-1
(B)	P -2	Q-3	R-1	S-4
(C)	P -3	Q-2	R-1	S-4
(D)	P -2	Q-3	R-4	S-1

5. Given below are two statements:

Statement I: $E_\lambda : T^4 = \text{Constant}$

Statement II: $E_\lambda : T = \text{Constant}$

In light of the above statements, choose the most appropriate answer from the codes given below:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

6. A rain drop falling vertically under gravity gathers moisture from the atmosphere at a rate given by $dm/dt = kt^2$, where m is the instantaneous mass, t is time and k is a constant. The equation of motion of the rain drop is

$mdv/dt + vdm/dt = mg$

If the drop starts falling at t = 0, with zero initial velocity and initial mass m_0 (m_0=2gm, k= 12gm/s^3 and g=1000 cm/s^2), the velocity v of the drop after one second is :

(A) 250 cm/s

(B) 500 cm/s

(C) 750 cm/s

(D) 1000 cm/s

7. Given below are two statements:

Statement I: Newton's laws of motion and Maxwell's equations are both invariant under Galilean transformations.

Statement II: Newton's laws of motion are invariant under Galilean transformations and Maxwell's equations are invariant under Lorentz transformations.

In light of the above statements, choose the most appropriate answer from the codes given below:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

8. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The resistivity of a semiconductor decreases with temperature.

Reason (r) : The atoms of a semiconductor vibrate with larger amplitude at higher temperature thereby increasing its resistivity.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

9. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : Density of all the nuclei is same.

Reason (r) : Radius of nucleus is directly proportional to the square root of mass number.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

10. Match List-I and List-II and select the correct answer from the codes given below:

List-I (System)		**List-II (Moment of Inertia)**
P.	Hollow Sphere	1. $2MR^2/5$
Q.	Disc about its Diameter	2. $MR^2/2$
R.	Solid Sphere	3. $3MR^2/2$
S.	Solid Cylinder	4. $2MR^2/3$
		5. $MR^2/4$

Code:

(A)	P -1	Q-5	R-2	S-4
(B)	P -5	Q-4	R-3	S-2
(C)	P -4	Q-5	R-3	S-1
(D)	P -4	Q-5	R-1	S-2

11. Match List-I and List-II and select the correct answer from the codes given below:

List-I (Particle)		**List-II (3rd Component of Isospin)**
P.	K^+	1. +1
Q.	Π^+	2. -1
R.	K*0	3. +1/2
S.	Σ^-	4. -1/2

Code:

(A)	P -3	Q-1	R-4	S-2
(B)	P-4	Q-1	R-3	S-2
(C)	P-1	Q-3	R-2	S-4
(D)	P-1	Q-2	R-3	S-4

12. The formula for normal strain in a longitudinal bar is given by, $\in = F/AE$ where F is normal force applied, A is cross-sectional area of the bar and E is Young's modulus. If $F = 100 \pm 0.5N$, $A = 0.5 \pm 0.002m^2$ and $E = 220 \times 10^9 \pm 1 \times 10^9$ Pa, the maximum error in the measurement of strain is

(A) 1×10^{-12}

(B) 1.2×10^{-11}

(C) 198×10^{-9}

(D) 2.95×10^{-10}

13. What are the eigenvalues of the operator $H = \sigma \cdot a$, where σ are the three Pauli matrices and a is a vector?

(A) $a_x + a_y$ and a_z

(B) $a_x + a_z \pm ia_y$

(C) $\pm$ Mod a vector

(D) $\pm a_x + a_y + a_z$

14. Let ψ_{nlm} denote the eigenfunctions of a Hamiltonian for a spherically symmetric potential V_r. The wavefunction $\psi_{nlm} = [\psi_{320} + \psi_{32-1} + \psi_{321}]$ is an eigenfunction only of:

(A) H L^2, and L_z

(B) H and L_z

(C) H and L^2

(D) L^2 and L

15. Consider a transformation from one set of generalized coordinate and momentum (q,p) to another set (Q, P) denoted by,

$Q = pq^s$, $P = q^r$

where s and r are constants. The transformation is canonical if :

(A) s = 0 and r =1

(B) s = 2 and r = -1

(C) s = 0 and r = -1

(D) s = 2 and r =1

16. For a bipolar junction transistor, which of the following statements are true?

(i) Doping concentration of emitter region is more than that in collector and base region.

(ii) Only electrons participate in current conduction.

(iii) The current gain β depends on temperature.

(iv) Collector current is less than the emitter current.

Choose the correct answer from the code given below:

(A) (i), (ii), (iv)

(B) (i), (iii), (iv)

(C) (ii), (iii), (iv)

(D) (i), (ii), (iii), (iv)

17. For a Atomic Packing Fraction, which of the following statements are true?

(i) Simple cubic have the atomic packing fraction of 55%.

(ii) The atomic packing fraction of body-centred cubic is 68%.

(iii) The atomic packing fraction of face-centred cubic is 74%.

(iv) The atomic packing fraction of NaCl crystal is 78%.

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (i), (iv)

(C) (i), (ii)

(D) (ii), (iii)

18. Which of the following statement is/ are true ?

(i) Zeeman experiment is used for the space quantization of L.

(ii) Davisson and Germer experiment is used for the wave nature of the particle.

(iii) Stern-Gerlach experiment is used for the quantization of energy of the electron.

(iv) Franck-Hertz experiment is used for the existence of the electron spin.

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (ii)

(D) (ii), (iii)

19. Which of the following statements is/ are true ?

(i) The Lande g-factor for the level $^3d_3$ is 3/2 .

(ii) The Lande g-factor for the level $^3d_3$ is 1/2 .

(iii) The Lande g-factor for the level $^3p_0$ is 1 .

(iv) The Lande g-factor for the level $^3p_0$ is 2 .

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (ii)

(D) (ii), (iii)

20. Given below are two statements:

Statement I: Homonuclear molecule shows the dipole moment and there is emission of infrared radiation.

Statement II: Homonuclear molecules show the rotational spectra which is an effect arising due to polarizability of the molecules.

In light of the above statements, choose the most appropriate answer from the codes given below:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

21. A plane in a cubic lattice makes intercepts of a, a/2 and 2a/3 with the three crystallographic axes, respectively. The Miller indices for this plane are:

(A) (243)

(B) (342)

(C) (634)

(D) (123)

22. Consider an anti-symmetric tensor P_{ij} with indices i and j running from 1 to 5. The number of independent components of the tensor is :

(A) 3

(B) 10

(C) 9

(D) 6

23. Consider $w = f(z) = u(x, y) + iv(x, y)$ to be an analytic function in a domain D . Which one of the following options is correct?

(i) u (x, y) satisfies Laplace equation in D

(ii) v (x, y) satisfies Laplace equation in D

(iii) $\int f(z)\, dz$ is dependent on the choice of the contour between z_1 and z_2 in D

(iv) f (z) can be Taylor expended in D

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (ii), (iv)

(D) (ii), (iii)

24. Consider a particle of electric charge e and mass m moving under the influence of a constant horizontal electric field E and constant vertical gravitational field described by acceleration due to gravity g. If the particle starts from rest, what will be its trajectory?

(A) Parabolic

(B) Elliptic

(C) Straight line

(D) Circular

25. The electric and magnetic field caused by an accelerated charged particle are found to scale as $E \propto r^{-n}$ and $B \propto r^{-m}$ at large distances. What are the value of n and m ?

(A) n=1, m=2

(B) n=1, m=1

(C) n=2, m=2

(D) n=2, m=1

26. Consider a system of two particles A and B . Each particle can occupy one of three possible quantum states 1 , 2 and 3 . The ratio of the probability that the two particles are in the same state to the probability that the two particles are in different states is calculated for bosons and classical (Maxwell-Boltzmann) particles. They are respectively :

(A) 1, 0

(B) 1/2, 1

(C) 1, 1/2

(D) 0, 1/2

27. Which of the following statement/ statements is/are correct ?

(i) The degeneracy of the second excited state of the 3-dimensional cubical box is 3.

(ii) The degeneracy of the second excited state of the 3-dimensional cubical box is 6.

(iii) The degenerate energy for the 2nd excited state of the 3-dimensional cubical box is $11E_0$.

(iv) The degenerate energy for the 2nd excited state of the 3-dimensional cubical box is $9E_0$.

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (iv)

(D) (ii), (iii)

28. Which of the following commutations relation/relations is/are correct?

(i) $[H,L] = 0$

(ii) $[L^2, V(r)] = 0$

(iii) $[x, L^2] = 0$

(iv) $[L^2, L] = 0$

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv), (iii)

(C) (i), (ii), (iv)

(D) (ii), (iii)

29. Which of the following statement/ statements is/are true ?

(i) If the function is given by $f(x) = a_1 f_1(x) + a_2 f_2(x)$….. then the Fourier transform of its function is given as $g(t) = a_1 g_1(t) + a_2 g_2(x)$….. .

(ii) If g(t) is the Fourier transform of f(x), then the Fourier transform of f(ax) is ag(at) .

(iii) If g(t) is the Fourier transform of f(x), then the Fourier transform of complex conjugate of f(t) is given by $g^*(-t)$, where * indicate the complex conjugate of the complex function.

(iv) None of the above written options are correct.

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (iv)

(D) (ii), (iii)

30. Which of the following statement/ statements is/are true ?

(i) The order if a subgroup of the finite group must be an integral multiple of the order of the group.

(ii) The element of the group which are conjugate to one another form a class of the group.

(iii) In a group of matrices, all the matrices which belongs to the same class have the same trace.

(iv) All are correct.

Choose the correct answer from the code given below:

(A) (i), (iii)

(B) (ii), (iv)

(C) (i), (iv)

(D) (ii), (iii)

31. Which one of the following quantities is invariant under Lorentz transformation?

(A) Charge density

(B) Charge

(C) Current

(D) Electric field

32. Which of the following is the correct expression for the Laplacian operator in cylindrical coordinates (ρ, φ, z)?

(A) $\nabla^2 = \frac{\left(\frac{1}{\rho}\right)\partial}{\partial\rho}\left(\rho\frac{\partial}{\partial\rho}\right) + \frac{\left(\frac{1}{\rho^2}\right)\partial^2}{\partial\varphi^2} + \frac{\partial^2}{\partial z^2}$

(B) $\nabla^2 = \frac{\partial^2}{\partial\rho^2} + \frac{\left(\frac{1}{\rho}\right)\partial}{\partial\rho} + \frac{\left(\frac{1}{\rho^2}\right)\partial^2}{\partial\varphi^2} + \frac{\partial^2}{\partial z^2}$

(C) $\nabla^2 = \frac{\partial^2}{\partial\rho^2} + \frac{\left(\frac{1}{\rho}\right)\partial}{\partial\rho} + \frac{\left(\frac{1}{\rho^2}\right)\partial^2}{\partial\varphi^2} - \frac{\partial^2}{\partial z}$

(D) $\nabla^2 = \frac{\left(\frac{1}{\rho}\right)\partial}{\partial\rho}\left(\rho\frac{\partial}{\partial\rho}\right) - \frac{\left(\frac{1}{\rho^2}\right)\partial^2}{\partial\varphi^2} + \frac{\partial^2}{\partial z^2}$

33. The fractional quantum Hall effect occurs in two-dimensional electron systems at low temperatures and:

(A) High magnetic fields

(B) Low magnetic fields

(C) Zero magnetic field

(D) High electric fields

34. Which of the following materials exhibits the highest critical temperature (T_c) for superconductivity?

(A) Lead (Pb)

(B) Mercury (Hg)

(C) Yttrium Barium Copper Oxide (YBCO)

(D) Aluminium (Al)

35. A particle of unit mass moves in a potential $V(x) = ax^2 + b/x^2$, where a and b are positive constants. The angular frequency of small oscillations about the minimum of the potential is :

(A) 8b

(B) 8a

(C) 8a / b

(D) 8b / a

36. Consider a rectangular waveguide with transverse dimensions 2m×1m driven with an angular frequency ω =109 rad/s. Which transverse electric (TE) modes will propagate in this waveguide?

(A) TE_{10}, TE_{01} and TE_{20}

(B) TE_{01}, TE_{11} and TE_{20}

(C) TE_{01}, TE_{10} and TE_{11}

(D) TE_{01}, TE_{10} and TE_{22}

37. The electrostatic potential V(x, y) in free space in a region where the charge density ρ is zero is given by V(x,y) = 4e2x +f(x) – $3y^2$. Given that the x-component of the electric field E_x, and V are zero at the origin, f(x) is :

(A) $3x^2 - 4e^{2x} + 8x$

(B) $3x^2 - 4e^{2x} + 16x$

(C) $4e^{2x} - 8$

(D) $3x^2 - 4e^{2x}$

38. A particle in one-dimension moves under the influence of a potential $V(x) = ax^6$, where a is a real constant For large n the quantized energy level E_n depends on n as:

(A) $E_n \sim n^3$

(B) $E_n \sim n^{4/3}$

(C) $E_n \sim n^{6/5}$

(D) $E_n \sim n^{3/2}$

39. Given the usual canonical commutation relations, the commutator [A, B] of A = i(xpy – ypx) and B = (ypz + zpy) is :

(A) $\hbar(xp_z - zp_x)$

(B) $-\hbar(xp_z - zp_x)$

(C) $\hbar(xp_z + p_xz)$

(D) $-\hbar(xp_z - p_xz)$

40. An RC network produces a phase-shift of 30º. How many such RC networks should be cascaded together and connected to a Common Emitter amplifier so that the final circuit behaves as an oscillator?

(A) 6

(B) 12

(C) 9

(D) 3

41. A spectral line due to a transition from an electronic state p to an s state splits into three Zeeman lines in the presence of a strong magnetic field. At intermediate field strengths the number of spectral lines is :

(A) 10

(B) 3

(C) 6

(D) 9

42. A nucleus decays by the emission of a gamma ray from an excited state of spin-parity 2+ to the ground state with spin-parity 0+, what is the type of the corresponding radiation?

(A) Magnetic dipole

(B) Electric quadrupole

(C) Electric dipole

(D) Magnetic quadrupole

43. The muon has mass 105 MeV/c^2 and mean life time 2.2 μs in its rest frame. The mean distance traversed by a muon of energy 315 MeV before decaying is approximately :

(A) 3×10^5 km

(B) 2.2 cm

(C) 6.6 μm

(D) 1.86 km

44. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The Schrödinger equation describes the time evolution of quantum systems.

Reason (r) : The Hamiltonian operator represents the total energy of the quantum system.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

45. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : When a car takes a turn on a banked road, the friction force plays no role in keeping the car in circular motion.

Reason (r) : The normal force provides the necessary centripetal force for the car's circular motion.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

46. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : In a superconductor, the magnetic field cannot penetrate the bulk of the material below the critical temperature.

Reason (r) : The Meissner effect expels magnetic fields from the interior of a superconductor due to the formation of Cooper pairs.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

47. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The half-life of a radioactive nucleus depends on external factors such as temperature and pressure.

Reason (r) : The half-life of a radioactive nucleus is an intrinsic property that solely depends on the specific nucleus undergoing decay.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but(r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

48. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The phenomenon of neutrino oscillations implies that neutrinos have non-zero masses.

Reason (r) : Neutrino oscillations occur because neutrinos are fermions and follow the Pauli exclusion principle.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

49. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The Rutherford scattering experiment provided evidence for the existence of a nucleus in an atom.

Reason (r) : The alpha particles used in the experiment were deflected by the negatively charged electrons present in the atom.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

50. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : The cut-off frequency of a high-pass filter decreases when the value of the capacitor decreases.

Reason (r) : A smaller capacitor allows more low-frequency signals to pass through the filter.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

51. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a) : Bose-Einstein condensation occurs only for bosons with integral spin.

Reason (r) : Bosons with half-integral spin cannot occupy the same quantum state due to the Pauli exclusion principle.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

52. Match List-I and List-II and select the correct answer from the codes given below:

List-I

(Spectroscopic regions)

P. Infrared region

Q. Ultraviolet visible region

R. X-ray region

S. γ-ray region

List-II

(Type of Transitions)

1. Electronic transitions involving valence electrons

2. Nuclear transitions

3. Vibrational transitions of molecules

4. Transitions involving inner shell electrons

Code:

	P	Q	R	S
(A)	1	3	2	4
(B)	2	4	1	3
(C)	3	1	4	2
(D)	4	1	2	3

53. Match List-I and List-II and select the correct answer from the codes given below:

List-I

P. Franck-Hertz experiment

Q. Hartree-Fock method

R. Stern-Gerlach experiment

S. Franck-Condon principle

List-II

1. Electronic excitation of molecules
2. Wave function of atoms
3. Spin angular momentum of atoms
4. Energy levels in atoms

Code:

	P	Q	R	S
(A)	4	2	3	1
(B)	1	4	3	2
(C)	3	2	4	1
(D)	4	1	3	2

54. Match List-I and List-II and select the correct answer from the codes given below:

List-I

(Characteristic)

P. Atomic configuration $1s^2, 2s^2 2p^6, 3s^2, 3p^6$

Q. Strongly electropositive

R. Strongly electronegative

S. Covalent Bonding

List-II

(Element)

1. Na
2. Si
3. Ar
4. Cl

Code:

	P	Q	R	S
(A)	1	2	3	4
(B)	3	2	4	1
(C)	3	1	4	2
(D)	3	4	1	2

55. Match List-I and List-II and select the correct answer from the codes given below:

List-I

P. Rest mass

Q. Charge

R. Four-momentum

S. Electromagnetic field

List-II

1. Time like vector
2. Lorentz invariant
3. Tensor of rank 2
4. Conserved and Lorentz invariant

Code:

	P	Q	R	S
(A)	2	4	3	1
(B)	4	2	1	3
(C)	2	4	1	3
(D)	4	2	3	1

56. Match List-I and List-II and select the correct answer from the codes given below:

List-I

(Physical Phenomenon)

P. Doppler broadening

Q. Natural broadening

R. Rotational Spectrum

S. Total internal reflection

List-II

(Physical Parameter)

1. Moment of Inertia
2. Refractive index
3. Lifetime of the energy level
4. Pressure

Code:

	P	Q	R	S
(A)	4	3	1	2
(B)	3	2	1	4
(C)	2	3	4	1
(D)	1	4	2	3

57. Match List-I and List-II and select the correct answer from the codes given below:

List-I

(Crystal Structure)

P. Diamond Structure

Q. Body-Centred Cubic (BCC) Structure

R. Hexagonal Close-Packed (HCP) Structure

S Face-Centred Cubic Structure

List-II

(Material)

1. Iron (Fe)
2. Graphite (C)
3. Aluminium (Al)
4. Copper (Cu)

Code:

	P	Q	R	S
(A)	4	3	1	2
(B)	3	2	1	4
(C)	2	1	3	4
(D)	1	4	2	3

58. Given below are two statements:

Statement I: The quantum Zeno effect occurs when an unstable particle continuously observed does not decay.

Statement II: Quantum tunnelling is a classical phenomenon that allows particles to pass through impenetrable barriers.

In light of the above statements, choose the most appropriate answer:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

59. Given below are two statements:

Statement I: The Fourier transform of a real and even function is always real and even.

Statement II: The Laplace transform of a causal function is always analytic in the right-half plane.

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

60. Given below are two statements:

Statement I: A block of mass m is placed on a frictionless incline with an angle of elevation θ. A force F is applied parallel to the incline, pulling the block uphill.

Statement II: The normal force acting on the block is equal to its weight, and the acceleration of the block is zero.

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

61. Given below are two statements:

Statement I: In a two-dimensional electron gas, at zero magnetic field, the energy levels form Landau levels, and the density of states is given by a series of delta functions.

Statement II: The Hall conductance in a two-dimensional electron gas is quantized and given by the formula: $\sigma xy = (n*e\hat{}2)/h$, where n is an integer, e is the elementary charge, and h is the Planck constant.

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

62. Given below are two statements:

Statement I: The Franck-Condon principle states that electronic transitions in molecules occur without any change in nuclear positions.

Statement II: The Franck-Condon principle is applicable only to molecules in their ground electronic state.

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

63. Given below are two statements:

Statement I: The Stefan-Boltzmann law describes how the intensity of thermal radiation from a blackbody depends on its temperature.

Statement II: Wien's displacement law states that the wavelength corresponding to the maximum intensity of blackbody radiation is inversely proportional to the temperature.

In light of the above statements, choose the most appropriate answer:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

64. Given below are two statements:

Statement I: "A NOR gate can be converted into an OR gate by complementing all its inputs."

Statement II: "A NAND gate can be converted into an AND gate by complementing all its inputs."

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

65. Given below are two statements:

Statement I: The concept of color charge is used to explain the strong force that binds quarks together to form protons and neutrons.

Statement II: Quarks carry fractional electric charges, while gluons, the mediators of the strong force, have integral electric charges.

In light of the above statements, choose the most appropriate answer :

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

(D) Statement I is incorrect but Statement II is correct.

Read the following paragraph for the Questions 66-71 :

Suppose that the electric field amplitude of an electromagnetic wave is E_0 =120N/C and that its frequency is V=50.0MHz. The expression for the electric field is given by $E=E_0 \sin(kx-\omega t)j$. The equation for the electric field state that the motion of the electric field is in (j) direction and the direction of the propagation of the wave is x. Due to the changing value of the electric field the changing magnetic field is producing . Now based on the information provided in the above paragraph, Give the answers of the questions given below:

66. The direction of the propagation of magnetic field is :

(A) k (B) -k

(C) j (D) -j

67. The Magnitude of the magnetic field B_0 is given as :

(A) 4×10^{-6} (B) 2×10^{-7}

(C) 4×10^{-7} (D) 2×10^{-6}

68. What is the value of angular frequency ω in rad/s ?

(A) 3.14×10^{8}

(B) 3.14×10^{6}

(C) 4.21×10^{8}

(D) 4.21×10^{6}

69. Calculate the value of k in rad/m :

(A) 2.10 (B) 2.05

(C) 1.05 (D) 1.10

70. Calculate the value of wavelength in m :

(A) 6 (B) 7

(C) 9 (D) 8

71. Diamagnetism is the property of materials

(i) Universal

(ii) Satisfy Lenz's law

(iii) Whose susceptibility is independent of temperature

(iv) Sometime universal and sometime non-universal

Choose the correct set of answer :

(A) (i), (ii), (iv)

(B) (i), (ii), (iii)

(C) (ii), (iii)

(D) (i), (iv)

72. For Deuteron following properties are true

(i) Stability of the nucleus

(ii) Deuteron spends most of the time in the spherically symmetry state

(iii) Deuteron potential is non-central

(iv) Deuteron binding energy is very small (2.225±0.002MeV)

(v) Magnetic moment of the deuteron is $0.85735\mu_N$

Choose the correct answer from below options :

(A) (ii), (iii)

(B) (i), (iii), (iv)

(C) (i), (ii), (iv)

(D) (i), (ii), (iii), (iv), (v)

73. Which of the following reaction (s) is /are allowed by the conservation laws

(i) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(ii) $\pi^- + p \rightarrow \Lambda^0 + K^0$

Choose the correct answer from below options :

(A) Both (i) and (ii)

(B) Only (i)

(C) Only (ii)

(D) Neither (i) nor (ii)

74. One-dimensional Dirac Delta Function

(i) Is infinitely high function

(ii) Is a infinitesimally narrow spiked function with area 1

(iii) Density of a point charge is Dirac delta function

(iv) $(x)\,dx = 0$

(v) $LG(x:x') = \delta(x - x')$

Choose the correct answer from below options :

(A) (i), (ii), (iii), (v)

(B) (i), (iii), (iv)

(C) (i), (ii), (iii)

(D) (ii), (iii), (v)

75. Electric Quadrupole moment :

(i) Zero for spherical symmetric nuclei

(ii) Due to electric field gradient

(iii) Due to magnetic field gradient

(iv) Due to both electric and magnetic field gradient

Choose the correct answer from below options :

(A) (i), (ii)

(B) (i), (iv)

(C) (ii), (iii)

(D) (iii), (iv)

76. In the electromagnetic field

(i) Space-time electromagnetic tensor have 16 components

(ii) Space electromagnetic tensor have 9 components

(iii) Space-time electromagnetic tensor have 9 components

(iv) Space electromagnetic tensor have 16 components

Choose the correct answer from below options :

(A) (i), (ii)

(B) (i), (iv)

(C) (ii), (iii)

(D) (iii), (iv)

77. A ruby laser using a flash lamp is a

(i) A pulse laser

(ii) A three level laser

(iii) Optical pumping is used

Choose the correct answer from below options:

(A) (i), (ii), (iii)

(B) (ii), (iii)

(C) (i), (ii)

(D) (i), (iii)

78. OP-Amp as an integrator

(i) It is high pass filter

(ii) It is low pass filter

(iii) In integrator capacitor is used as feedback component

(iv) In Integrator resistance is used as feedback component

Choose the correct answer from below options:

(A) (i), (ii), (iii)

(B) (ii), (iii)

(C) (i), (ii), (iv)

(D) (i), (iii)

79. Match List-I and List-II and select the correct answer from the codes given below:

List-I

P. Potential

Q. Electric field

R. Magnetic field

S. Electromagnetism (electrodynamics)

List-II

1. Vector
2. Scalar
3. Axial vector
4 Both Scalar and Vector Potential

Code:

(A)	P-2	Q-1	R-3	S-4
(B)	P -2	Q-3	R-1	S-4
(C)	P -3	Q-2	R-1	S-4
(D)	P -2	Q-3	R-4	S-1

80. Match List-I and List-II and select the correct answer from the codes given below:

List-I	**List-II**
P. Propagation	1. $(2/\omega\mu\sigma)^{1/2}$
Q. Skin depth	2. $(\omega\mu_0/2\sigma)^{1/2}$
R. Sheet resistance	3. $(j\omega\mu_0)^{1/2}$
	4. $(\omega\mu_0\sigma/2)^{1/2}$

Code:

(A)	P-3	Q-1	R-2
(B)	P -2	Q-3	R-1
(C)	P -3	Q-2	R-1
(D)	P -2	Q-3	R-4

81. Match List-I and List-II and select the correct answer from the codes given below:

List-I	**List-II**
P. Electric medium	1. μ
Q. Magnetic medium	2. ε
R. Optical medium	3. Coefficient of elasticity
S. Mechanical medium	4. Refractive index

Code:

(A)	P-2	Q-1	R-4	S-3
(B)	P -2	Q-3	R-1	S-2
(C)	P -3	Q-2	R-1	S-4
(D)	P -2	Q-3	R-4	S-1

82. Match List-I and List-II and select the correct answer from the codes given below:

List-I

P. Ferromagnetic material

Q. Ferroelectric material

R. Antiferromagnetic material

S. Paramagnetic material

List-II

1. Fellow Curie-Weiss law
2. Neel Temperature
3. Domain Oriented
4. Randomization of spins

Code:

(A)	P-2	Q-1	R-4	S-3
(B)	P -2	Q-3	R-1	S-4
(C)	P -1	Q-3	R-2	S-4
(D)	P -2	Q-3	R-4	S-1

83. An accelerator which can accelerate proton

(i) Betatron

(ii) Linear accelerator

(iii) Cyclotron

(iv) G.M. Counter

Choose the correct answer from below options :

(A) (i), (ii), (iii)

(B) (i), (iii)

(C) (ii), (iii)

(D) (i), (iv)

84. Electronic specific heat of a solid at temperature T is $C = \gamma T$, where γ is a constant related to the thermal effective mass (m_{eff}) of the electrons. Then which of the following statements are correct?

(i) $\gamma \propto m_{eff}$

(ii) m_{eff} is greater than free electron mass for all solids.

(iii) Temperature dependence of C depends on the dimensionality of the solid.

(iv) The linear temperature dependence of C is observed at $T << \text{Debye temperature}$.

Choose correct answer from following options :

(A) (i), (iv)

(B) (i), (ii)

(C) (ii), (iii)

(D) (iii), (iv)

85. In a Hall effect experiment on an intrinsic semiconductor, which of the following statements are not correct?

(i) Hall voltage is always zero.

(ii) Hall voltage is negative if the effective mass of holes is larger than those of electrons.

(iii) Hall coefficient can be used to estimate the carrier concentration in the semiconductor.

(iv) Hall voltage depends on the mobility of the carriers.

Choose correct answer from following options :

(A) (i), (ii), (iii)

(B) (i), (ii), (iv)

(C) (ii), (iii), (iv)

(D) (iii), (iv)

86. A plane polarized electromagnetic wave propagating in y-z plane is incident at the interface of two media at Brewster's angle. Taking z = 0 as the boundary between the two media, the electric field of the reflected wave is given by

$$\vec{E}_R = A_R \cos\left[k_o\left\{\frac{\sqrt{3}}{2}y - \frac{1}{2}z\right\} - \omega t\right]\hat{x}$$

then which among the following statements are correct?

(i) The angle of refraction is $\frac{\pi}{6}$.

(ii) Ratio of permittivity of the medium of refraction (ε_2) with respect to the medium on incidence (ε_1), $\frac{\varepsilon_2}{\varepsilon_1} = 3$.

(iii) The incident wave can have components of its electric field in y - z plane.

(iv) The angle of reflection is $\frac{\pi}{6}$.

Choose correct answer from following options :

(A) (i), (ii), (iii)

(B) (i), (ii), (iv)

(C) (ii), (iii), (iv)

(D) (iii), (iv)

87. A phosphorous doped silicon semiconductor (doping density: $10^{17}/cm^3$) is heated from 100° C to 200° C. Which one of the following statements is not CORRECT?

(i) Position of Fermi level moves towards conduction band.

(ii) Position of dopant level moves towards conduction band.

(iii) Position of Fermi level moves towards middle of energy gap.

(iv) Position of dopant level moves towards middle of energy gap.

Choose correct answer from following options :

(A) (i), (ii), (iii)

(B) (i), (ii), (iv)

(C) (ii), (iii), (iv)

(D) (iii), (iv)

88. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a): In the process of nuclear fission, the amount of nuclear energy generated by the fission of an atom of uranium is so tremendous that it produces 10 million times the energy produced by the combustion of an atom of carbon from coal.

Reason (r): The nucleus of a heavy atom such as uranium, when bombarded with low-energy neutrons, splits apart into lighter nuclei. The mass difference between the original nucleus and the product nuclei gets converted to tremendous energy.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

89. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a): Deuteron ground state is combination of ^3S and ^3D state.

Reason (r): Deuteron has small but +ve Quadrupole moment.

(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

90. Given below are two statements, one labelled as Assertion (a) and the other labelled as Reason (r). Read the statements and choose the correct answer from the code given below:

Assertion (a): The following reaction is forbidden

$\pi^- + p \rightarrow \Lambda^0 + \pi^0$

Reason (r): The baryon number of the reaction is not conserved.

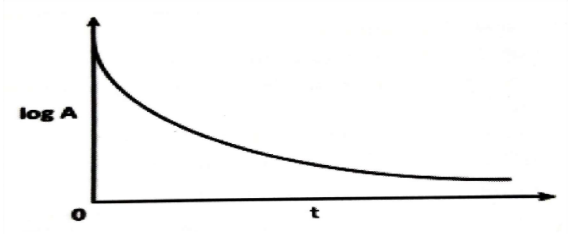
(A) Both (a) and (r) are true and (r) is correct explanation of (a).

(B) Both (a) and (r) are true but (r) is not correct explanation of (a).

(C) (a) is true, but (r) is false.

(D) (a) is false, but (r) is true.

91. The plot log A vs time t, where A is activity as shown in the figure, correspond to decay



(A) They have excess in neutrons

(B) They have excess of protons

(C) They are product of radioactive nuclides

(D) Their total kinetic energy is of the order of 200 MeV

92. The graph between inverse susceptibility and temperature of anti-ferromagnetic materials has

(A) Positive x intercept

(B) Positive y intercept

(C) Negative x intercept

(D) Negative y intercept

93. For the graphs given below, choose the correct statement

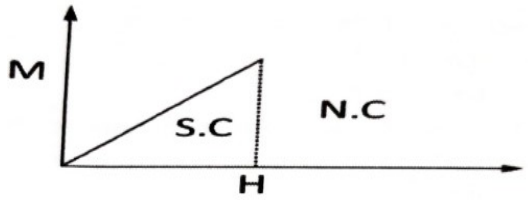


Fig. 1

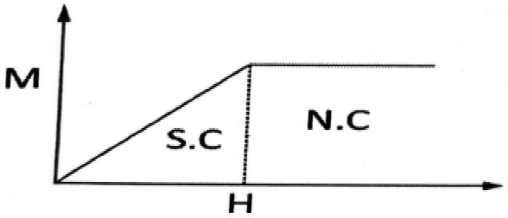


Fig. 2

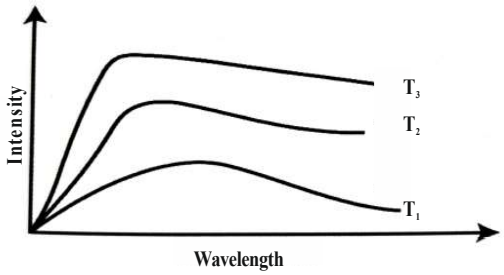
(A) Fig.1 is type 1 superconductor and Fig.2 is type 2 superconductor

(B) Fig.1 is type 2 superconductor and Fig.2 is type 1 superconductor

(C) Fig.1 is type 1 superconductor

(D) Fig.2 is type 2 superconductor

94. From the figure, what is the relation between T_1, T_2 and T_3?



(A) $T_1 > T_2 > T_3$

(B) $T_3 > T_1 > T_2$

(C) $T_3 > T_2 > T_1$

(D) $T_2 > T_1 > T_3$

95. Arrange the rank of Tensor in increasing order

(i) Electric field

(ii) Potential

(iii) $F_{\alpha\beta\gamma}$

(iv) $F_{\alpha\beta}$

Choose the correct answer from options given below:

(A) (ii), (i), (iv), (iii)

(B) (i), (ii), (iv), (iii)

(C) (i), (ii), (iii), (iv)

(D) (ii), (i), (iii), (iv)

96. Arrange the frequency of oscillation in increasing order :

(i) Cosmic

(ii) Microwave

(iii) Direct current

(iv) Alternating current

Choose the correct answer from options given below :

(A) (ii), (i), (iv), (iii)

(B) (i), (ii), (iv), (iii)

(C) (iii), (iv), (ii), (i)

(D) (ii), (i), (iii), (iv)

97. Arrange the magnetic moment in increasing order

(i) Al

(ii) Mg

(iii) Fe^{2+}

(iv) Fe^{3+}

Choose the correct answer from option sgiven below:

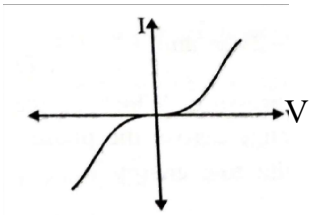
(A) (ii), (i), (iv), (iii)

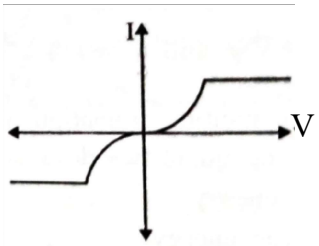
(B) (i), (ii), (iv), (iii)

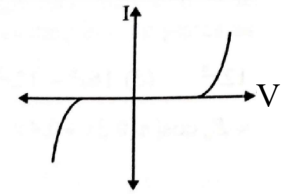
(C) (iii), (iv), (ii), (i)

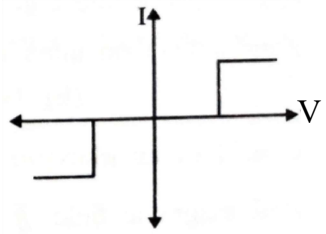
(D) (ii), (i), (iii), (iv)

98. Two identical Zener diodes are placed back-to-back in series and are connected to a variable DC power supply. The best representation of the I-V characteristics of the circuit is :

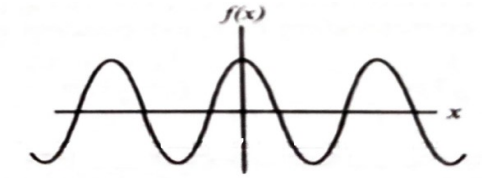
(A) 

(B) 

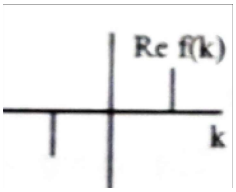
(C) 

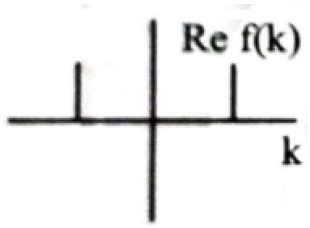
(D) 

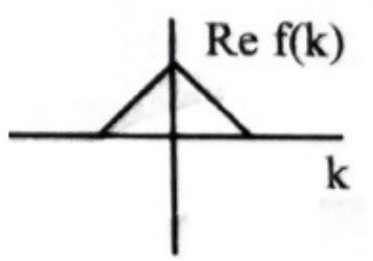
99. The graph of real periodic function f(x) for the range $[-\infty, \infty]$ is shown below

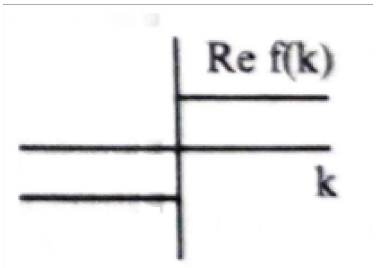


Which of the following graphs represents the real part of its Fourier transform?

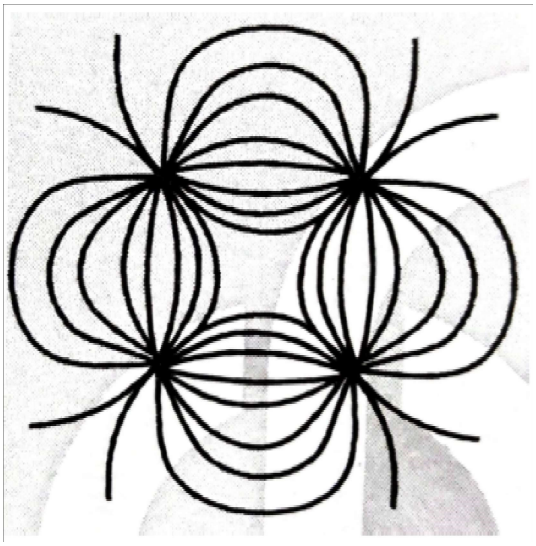
(A) 

(B) 

(C) 

(D) 

100. The electrostatic lines of force due to a system of four-point charges is sketched below



At a large distance r, the leading asymptotic behaviour of the electrostatic potential is proportional to :

(A) r

(B) r^{-1}

(C) r^{-2}

(D) r^{-3}

ROUGH WORK

ROUGH WORK

ROUGH WORK