ਪੰਜਾਬ ਟੈਕਨੀਕਲ ਯੂਨੀਵਰਸਿਟੀ ਜਲੰਧਰ

PUNJAB TECHNICAL UNIVERSITY JALANDHAR

Max. Marks: 90 **Time: 90 Mins.**

Entrance Test for Enrollment in Ph.D. Programme

Important Instructions

- *Fill all the information in various columns, in capital letters, with blue/black ball point pen.*
- *Use of calculators is not allowed.*
- *All questions are compulsory. No negative marking for wrong answers.*
- *Each question has only one right answer.*
- *Questions attempted with two or more options/answers will not be evaluated.*

Stream *(Engg./Arch./Pharm./Mgmt./App.Sci./Life Sci.)* **Applied Sciences**

Discipline / Branch **Physics**

Name .....

Father's Name .....

Roll No. ..... Date. .....

Signature of Candidate .....

Signature of Invigilator .....

Q.1. If a force $\vec{F}$ is derivable from a potential function V(r), where r is the distance from the origin of the coordinate system, it follows that

(a) $\vec{\nabla} \times \vec{F} = 0$ (b) $\vec{\nabla}.\vec{F} = 0$

(c) $\vec{\nabla} V = 0$ (d) $\nabla^2 V = 0$

Q.2. The eigen values of the matrix

$$\begin{bmatrix} 2 & 3 & 0 \\ 3 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$ are

(a) 5, 2, -2 (b) -5, -1, 1

(c) 5, 1, -1 (d) -5, 1, 1

Q.3. The value of contour integral, $\left|\int_C \vec{r} \times d\,\vec{\theta}\right|$, for a circle of radius r with centre at the origin is

(a) $2\pi r$ (b) $\frac{r^2}{2}$

(c) πr^2 (d) r

Q.4. The curl of a vector field $\vec{F}$ is $2\hat{z}$. Identify the appropriate vector field $\vec{F}$ from the choices given below.

(a) $\vec{F} = 2z\hat{x} + 3z\hat{y} + 5y\hat{z}$

(b) $\vec{F} = 3z\hat{y} + 5y\hat{z}$

(c) $\vec{F} = 3x\hat{y} + 5y\hat{z}$

(d) $\vec{F} = 2\hat{x} + 5y\hat{z}$

Q.5. The average value of the function f(x) = $4x^3$ in the interval 1 to 3 is

(a) 15 (b) 20

(c) 40 (d) 80

Q.6. The determinant of a 3×3 real symmetric is 36. If two of its eigen values are 2 and 3 then the third eigen value is

(a) 4 (b) 6

(c) 8 (d) 9

Q.7. For function $\varphi = x^2y + xy$, the value of $|\vec{\nabla}\varphi|$ at x=y=1 is

(a) 5 (b) $\sqrt{5}$

(c) 13 (d) $\sqrt{13}$

Q.8. The two vectors $\vec{i} = i$, $\vec{j} = \frac{(i+j)}{\sqrt{2}}$ are

(a) related by rotation

(b)related by a reflection through the xy-plane

(c) related by an inversion

(d) not linearly independent

Q.9. If two matrices A and B can be diagonalized simultaneously, which of the following is true ?

(a) $A^2B = B^2A$ (b) $A^2B^2 = B^2A$

(c) A B = B A (d) $AB^2\,AB = BABA^2$

Q.10. A particle of unit mass moves along the X-axis under the influence of a potential, $V(x) = x(x-2)^2$. The particle is found to be in stable equilibrium at the point x=2. The time period of oscillation of the particle is

(a) $\frac{\pi}{2}$ (b) π

(c) $\frac{3\pi}{2}$ (d) 2π

Q.11. The Lagrangian of a free particle in spherical polar coordinates is given by

$$L = \frac{1}{2}m\left[\dot{r} + r\dot{\theta}^2 + r^2\dot{\phi}^2 Sin^2\theta\right]$$

The quantity that conserved is

(a) $\frac{\partial L}{\partial \dot{r}}$ (b) $\frac{\partial L}{\partial \dot{\theta}}$

(c) $\frac{\partial L}{\partial \dot{\phi}}$ (d) $\frac{\partial L}{\partial \dot{\phi}} + \dot{r}\dot{\theta}$

Q.12. A particle is moving in an inverse square field. If the total energy of the particle is positive, then trajectory of particle is

(a) circular (b) elliptical

(c) hyperbolic (d) parabolic

Q.13. For a particle in central field,

(a) the kinetic energy is a constant of motion

(b) the potential energy is velocity dependent

(c) the motion is confined in a plane

(d) the total energy is not conserved

Q.14. The homogeneity of time leads to the law of conservation of

(a) linear momentum (b) energy

(c) angular momentum (d) parity

Q. 15. A planet moves around the sun in an elliptical orbit with semi-major axis a and time period T. The T will be proportional to

(a) a^2 (b) $a^{1/2}$

(c) $a^{3/2}$ (d) a^3

Q. 16. Two bodies of masses m and 2m are connected by spring constant k, the frequency of normal mode is

(a) $\sqrt{\frac{3k}{2m}}$ (b) $\sqrt{\frac{k}{m}}$

(c) $\sqrt{\frac{2k}{3m}}$ (d) $\sqrt{\frac{k}{3m}}$

Q.17. Let (p,q) and (P,Q) be two pairs of canonical variables. The transformation $Q = q^{\alpha} \text{Cos}\beta p$ and $P = q^{\alpha} \text{Sin}\beta p$ is canonical for

(a) $\alpha = 2, \beta = ½$ (b) $\alpha = 2, \beta = 2$

(c) $\alpha = 1, \beta = 1$ (d) $\alpha = 1/2, \beta = 2$

Q. 18. Assuming the mean life time of a muon (in its rest frame) to be 2×10^{-6} sec, its life time in the laboratory frame, when it is moving with a velocity 0.95c is

(a) 6.4×10^{-6} sec (b) 0.62×10^{-6} sec

(c) 2.16×10^{-6} sec (d) 0.19×10^{-6} sec

Q. 19. A plane electromagnetic wave travelling in free space is incident normally on a glass plate of refractive index 3/2. If there is no absorption by the glass, its reflectivity is

(a) 4% (b) 16%

(c) 20% (d) 50%

Q.20. An insulating sphere of radius a carries a charge density $\rho(r)=\rho_o(a^2-r^2)\text{Cos}\Theta$; r<a. The leading order term for the electric field at a distance d, far away from the charge distribution, is proportional to

(a) d^{-1} (b) d^{-2}

(c) d^{-3} (d) d^{-4}

Q. 21. An electric field $\vec{E}$ exists in a given region R. Choose the wrong statement

(a) Circulation of $\vec{E}$ is zero

(b) $\vec{E}$ can always be expressed as the gradient of a scalar field

(c) The potential difference between any two arbitrary points in the region R is zero

(d) The work done in a closed path lying entirely in R is zero

Q. 22. Unpolarized light falls from air to a planer air-glass interface (refractive index of glass ia 1.5) and the reflected light is observed to be plane polarized. The polarization vector and the angle of incidence Θ_i are

(a) perpendicular to the plane of incidence and $\Theta_i = 42°$

(b) parallel to the plane of incidence and $\Theta_i = 56°$

(c) perpendicular to the plane of incidence and $\Theta_i = 56°$

(d) parallel to the plane of incidence and $\Theta_i = 42°$

Q. 23. A charged capacitor (C) is connected in series with an inductor (L). When the displacement current reduces to zero, the energy of the LC circuit is

(a) stored entirely in its magnetic field

(b) stored entirely in its electric field

(c) distributed equally among its electric and magnetic fields

(d) radiated out of the circuit

Q. 24. In an electromagnetic field, which one of the following remains invariant under Lorentz transformation

(a) $\vec{E}\times\vec{B}$ (b) $E^2 - c^2B^2$

(c) B^2 (d) E^2

Q.25. A charge +q is kept at a distance of 2R from the centre of a grounded conducting sphere of radius R. The image charge and its distance from the centre respectively, are

(a) $-\frac{q}{2}$ and $\frac{R}{2}$ (b) $-\frac{q}{2}$ and $\frac{R}{4}$

(c) $-q$ and $\frac{R}{2}$ (d) $+\frac{q}{2}$ and $\frac{R}{2}$

Q.26. An electric field applied along the length of a long cylinder produces a polarization P. The depolarization field produced in this configuration is

(a) $4\pi P/3$ (b) $-4\pi P/3$

(c) $2\pi P$ (d) zero

Q.27. Consider an electric field $\vec{E}$ existing in the interface between a conductor and free space. Then the electric field $\vec{E}$ is

(a) external to the conductor and normal to the conductor's surface

(b) internal to the conductor and normal to the conductor's surface

(c) external to the conductor and tangential to the conductor's surface

(d) both external and internal to the conductor and normal to the conductor's surface

Q.28. A particle of mass m is confined in a two dimensional square well potential of dimension 'a'. The potential V(x,y) is given by

$V(x,y) = 0$ for $-a < x < a$ & $-a < y < a$

$= \infty$ elsewhere

The energy of the first excited state for this particle is given by

(a) $\frac{h^2}{4ma^2}$ (b) $\frac{h^2}{2ma^2}$

(c) $\frac{5h^2}{8ma^2}$ (d) $\frac{h^2}{ma^2}$

Q. 29.The wave function of a particle moving in free space is given by, $\psi = e^{iks} + e^{-iks}$. The energy of the particle is

(a) $\frac{5h^2k^2}{8\pi^2m}$ (b) $\frac{3h^2k^2}{16\pi^2m}$

(c) $\frac{h^2k^2}{8\pi^2m}$ (d) $\frac{h^2k^2}{4\pi^2m}$

Q.30. The quantum mechanical operator for the momentum of a particle moving in one dimension is given by

(a) $i\hbar\frac{d}{dx}$ (b) $-i\hbar\frac{d}{dx}$

(c) $i\hbar\frac{\partial}{\partial t}$ (d) $-\frac{\hbar^2}{2m}\frac{d}{dx}$

Q.31.Which one of the following relation is true for Pauli matrices σ_x, σ_y and σ_z

(a) $\sigma_x\sigma_y = \sigma_y\sigma_x$ (b) $\sigma_x\sigma_y = \sigma_z$

(c) $\sigma_x\sigma_y = i\,\sigma_z$ (d) $\sigma_x\sigma_y = -\sigma_y\sigma_x$

Q.32. The parities of the wave function (i) cos(*kx*), and (ii) tanh(*kx*) are

(a) (i) odd, (ii) odd

(b) (i) even, (ii) even

(c) (i) odd (ii) even

(d) (i) even, (ii) odd

Q.33. The commutator [x, p^2], where x and p are position and momentum operators respectively, is

(a) $2i\hbar p$ (b) $-i\hbar p$

(c) $2i\hbar p_x$ (d) $-2i\hbar p_x$

Q.34. a spinless particle moves in a central potential V(r).

(a) The kinetic energy and the potential energy of the particle cannot simultaneously have sharp values

(b) The total energy and the potential energy of the particle can simultaneously have sharp values

(c) The total energy and the square of the orbital angular momentum about the origin cannot simultaneously have sharp values

(d) The total energy of the particle can have only discrete eigen values.

Q. 35. The de-Broglie wavelength of particle of mass m with average momentum p at a temperature T in three dimensions is given by

(a) $\lambda = \frac{h}{\sqrt{2mk_BT}}$ (b) $\lambda = \frac{h}{\sqrt{3mk_BT}}$

(c) $\lambda = \frac{h}{\sqrt{2k_BT}}$ (d) $\lambda = \frac{h}{\sqrt{2m}}$

Q. 36. A particle of mass is confined in the ground state of a one dimensional potential box, extending from x = - 2L to x = +2L. The wave function of the particles in this state is $\psi(x) = \psi_o \cos\frac{\pi x}{4L}$. The normalization factor ψ_o of this wave function is

(a) $\sqrt{\frac{2}{L}}$ (b) $\sqrt{\frac{1}{4L}}$

(c) $\sqrt{\frac{1}{2L}}$ (d) $\sqrt{\frac{1}{L}}$

Q. 37. For ideal Fermi gas in three dimensions, the electron velocity V_F at the Fermi surface is related to electron concentration 'n' as

(a) $V_F \propto n^{1/2}$

(b) $V_F \propto n$

(c) $V_F \propto n^{2/3}$

(d) $V_F \propto n^{1/3}$

Q.38. Consider a system whose three energy levels are given by 0, ε and 2ε. The energy level ε is two-fold degenerate and the other two are non-degenerate. The partition function of the system with $\beta=1/k_BT$ is given by

(a) $1 + 2e^{-\beta\varepsilon}$

(b) $2e^{-\beta\varepsilon} + e^{-2\beta\varepsilon}$

(c) $(1 + e^{-\beta\varepsilon})^2$

(d) $1 + e^{-\beta\varepsilon} + e^{-2\beta\varepsilon}$

Q.39. In a first order phase transition, at the transition temperature, specific heat of the system

(a) diverges and its entropy remains the same

(b) diverges and its entropy has finite discontinuity

(c) remains unchanged and its entropy has finite discontinuity

(d) has finite discontinuity and its entropy diverges

Q.40. A system of N non-interacting classical point particles constrained to move on the two-dimensional surface of a sphere. The internal energy of the system is

(a) $\frac{3}{2}Nk_BT$ (b) $\frac{1}{2}Nk_BT$

(c) Nk_BT (d) $\frac{5}{2}Nk_BT$

Q. 41. The total number of accessible states of N non-interacting particles of spin ½ is

(a) 2^N (b) N^2

(c) $2^{N/2}$ (d) N

Q.42. The pressure for a non-interacting Fermi gas with internal energy U at temperature T is

(a) $p = \frac{3}{2}\frac{U}{V}$

(b) $p = \frac{2}{3}\frac{U}{V}$

(c) $p = \frac{3}{5}\frac{U}{V}$

(d) $p = \frac{1}{2}\frac{U}{V}$

Q. 43. The specific heat of an ideal Fermi gas in three-dimensions at very low temperature (T) varies as

(a) T

(b) $T^{3/2}$

(c) T^2

(d) T^3

Q. 44. For any process, the second law of thermodynamics requires that the change of entropy of the universe be

(a) positive only

(b) positive or zero

(c) zero only

(d) negative or zero

Q. 45. Which one of the following is a first order phase transition

(a) vaporization of a liquid at its boiling point

(b) ferromagnetic to paramagnetic

(c)normal liquid helium to superfluid helium

(d) superconducting to normal state

Q. 46. A Ge semiconductor is doped with acceptor impurity concentration of 10^{15} atom/cm^3. For the given hole mobility of 1800 $cm^2V^{-1}s^{-1}$, the resistivity of this material is

(a) 0.288 Ω-cm

(b) 0.694 Ω-cm

(c) 3.472 Ω-cm

(d) 6.944 Ω-cm

Q.47. If the peak output voltage of a full wave rectifier is 10V, then its DC voltage is

(a) 10.0 V

(b) 7.07 V

(c) 6.36 V

(d) 3.18 V

Q. 48. For an intrinsic semiconductor, m_e^* and m_h^* are respectively, the effective masses of electrons and holes near the corresponding band edges. At a finite temperature, the position of the Fermi level

(a) depends on m_e^* but not on m_h^*

(b) depends on m_h^* but not on m_e^*

(c) depends on both m_e^* and m_h^*

(d) depends neither on m_e^* nor on m_h^*

Q. 49. A power amplifier gives 150W output for an input of 1.5W. The gain in dB is

(a) 10 (b) 20

(c) 40 (d) 100

Q. 50. The high input impedance of Field Effect Transistor (FET) is due to

(a) the pinch-off voltage

(b) its very low gate current

(c) the source and drain being far apart

(d) the geometry of the FET

Q. 51.Which one of the following is true for a semiconductor p-n junction with no external bias

(a) The total charge in the junction is not conserved

(b) The p-side of the junction is positively charged

(c) The p-side of the junction is negatively charged

(d) No charge develops anywhere in the junction

Q.52 A piece od a semiconductor material is introduced into a circuit. If the temperature of the material is raised, the circuit current will

(a) increase

(b) remain the same

(c) decrease

(d) ceases to flow

Q. 53. An valance effect is observed in a diode when

(a) the forward voltage is less than the breakdown voltage

(b) the forward voltage exceeds the breakdown voltage

(c) the reverse voltage exceeds the breakdown voltage

(d) diode is heavily doped and forward biased

Q.54. A doped germanium crystal of length 2 cm, breadth 1cm and width 1 cm, carries a current of 1 mAalong its length parallel to +x-axis. A magnetic field of 0.5 T is applied along +z-axis. Hall voltage of 6 mV is measured with negative polarity at y=0 plane. The sign and concentration of the majority charge carrier are, respectively [Given, $e=1.6\times10^{-19}$]

(a) positive and 5.2×10^{19} m^{-3}

(b) negative and 5.2×10^{19} m^{-3}

(c) positive and 1.04×10^{20} m^{-3}

(d) negative and 1.04×10^{20} m^{-3}

Q.55. The NMR spectrum of ethanol (CH_3CH_2OH) comprises of three branches of spectral lines. The number of spectral lines in the bunch corresponding to CH_2 group is

(a) 1 (b) 2

(c) 3 (d) 4

Q. 56. To detect trace amounts of a gaseous species in a mixture of gases, the preferred probing tool is

(a) ionization spectroscopy with X-rays

(b) NMR spectroscopy

(c) ESR spectroscopy

(d) laser spectroscopy

Q. 57. Photomultiplies are based on the principle of

(a) pyro-electric effect

(b) photo voltaic effect

(c) photo conduction

(d) secondary emission

Q. 58. Bolometers are used for the measurement of

(a) optical inputs

(b) thermal radiation

(c) electrical signals

(d) potential differenc

Q. 59. Pyrometer is used to measure

(a) temperature

(b) pressure

(c) voltage

(d) magnetic field

Q. 60. The crystal structure of the solid can be identified from

(a) X-ray diffraction

(b) electron diffraction

(c) neutron diffraction

(d) Hall effect measurement

Q. 61. If the KE of a relativistic particle is equal to its rest mass energy then velocity of the particle is

(a) $\frac{\sqrt{3}}{2}c$ (b) c

(c) $\frac{1}{3}c$ (d) $\frac{2}{\sqrt{3}}c$

Q. 62. The average KE per electron $\bar{E}$ at 0K is linked to the Fermi energy E_F as

(a) $\bar{E} = \frac{1}{2}E_F$ (b) $\bar{E} = \frac{3}{2}E_F$

(c) $\bar{E} = \frac{3}{5}E_F$ (d) $\bar{E} = \frac{5}{3}E_F$

Q. 63. Two particles are moving in a straight path towards each other with uniform velocities 0.6c and 0.4c, where c is the velocity of light. The relative velocity of the particles is

(a) 0.2c (b) 1.0c

(c) 0.8c (d) 0.4c

Q. 64. Match the typical spectroscopic region specified in List I with the corresponding type of transition in List II and find the correct answer using the codes given below the list

List I	List II
P. Infrared region	1. Electronic transitions involving valence electrons
Q. Ultravoilet region	2. Nuclear transitions
R. X-ray region	3. Vibrational transitions of molecules
S. gama-ray region	4. Transitions involving inner shell electrons

Codes

	P	Q	R	S
(a)	1	3	2	4
(b)	2	4	1	3
(c)	3	1	4	2
(d)	4	1	2	3

Q. 65. Population inversion in a two-level laser material cannot be achieved by optical pumping because

(a) the rate of upward transitions is equal to the rate of downward transitions

(b) the upward transitions are forbidden but downward transitions are allowed

(c) the upward transitions are allowed but downward transitions are forbidden

(d) the spontaneous decay rate of the higher level is very low

Q. 66. An atom with one outer electron having orbital angular momentum l is placed in a week magnetic field. The number of energy levels into which the higher total angular momentum state split, is

(a) $2l+2$ (b) $2l+1$

(c) $2l$ (d) $2l-1$

Q. 67. The spectrum of radiation emitted by a black body at a temperature 1000K peaks in the

(a) visible range of frequencies

(b) infrared range of frequencies

(c) ultraviolet range of frequencies

(d) microwave range of frequencies

Q. 68. The target of an X-ray tube is subjected to an excitation voltage V. The wavelength of the emitted X-rays is proportional to

(a) $\frac{1}{\sqrt{V}}$ (b) $\sqrt{V}$

(c) $\frac{1}{V}$ (d) V

Q.69. The L_β line of X-rays emitted from an atom with principal quantum number n=1, 2, 3, 4, ……., arises from the transition

(a) n = 4 → n = 2 (b) n = 3 → n = 2

(c) n = 5 → n = 2 (d) n = 3 → n = 1

Q. 70. The Lande g factor for the level $^3d_3$ is

(a) $\frac{2}{3}$ (b) $\frac{3}{2}$

(c) $\frac{3}{4}$ (d) $\frac{4}{3}$

Q. 71. All vibrations producing a change in the electric dipole moment of a molecule yield

(a) Raman spectra

(b) Infrared spectra

(c) Ultra-violet spectra

(d) X-ray spectra

Q. 72. If the wavelength of the first line of the Balmer series in the hydrogen spectrum is λ, then the wavelength of the first line of the Lyman series is

(a) (27/5) λ (b) (5/27) λ

(c) (32/27) λ (d) (27/32) λ

Q. 73. The order of magnitude of the energy gap of a typical semiconductor is

(a) 1 MeV

(b) 1 keV

(c) 1 eV

(d) 1 meV

Q. 74. The valence electrons do not directly determine the following property of a metal

(a) electrical conductivity

(b) thermal conductivity

(c) shear modulus

(d) metallic lusture

Q. 75. Consider X-ray diffraction from a crystal with a face centred cubic (fcc) lattice. The lattice plane for which there is no diffraction peak is

(a) (2, 1, 2) (b) (1, 1, 1)

(c) (2, 0, 0) (d) (3, 1, 1)

Q. 76. A superconducting ring is cooled in presence of a magnetic field below its critical temperature (T_c). The total magnetic flux that passes through the ring is

(a) zero (b) $\frac{nh}{2e}$

(c) $\frac{nh}{4\pi e}$ (d) $\frac{ne^2}{hc}$

Q. 77. Metallic monovalent sodium crystallizes in body centered cubic structure. If the length of the unit cell is 4×10^{-8} cm, the concentration of conduction electrons in metallic sodium is

(a) 6.022×10^{23} cm^{-3}

(b) 3.125×10^{22} cm^{-3}

(c) 2.562×10^{21} cm^{-3}

(d) 1.25×10^{20} cm^{-3}

Q.78. The c/a ratio for an ideal hexagonal closed packed structure is

(a) $\frac{2}{\sqrt{3}}$ (b) $\sqrt{8}$

(c) $\sqrt{5}$ (d) $\sqrt{\frac{8}{3}}$

Q. 79. The number of independent elastic constants in an isotropic cubic solid is

(a) 1 (b) 2

(c) 3 (d) 4

Q. 80. The critical magnetic field for a solid in superconducting state

(a) does not depend upon temperature

(b) increases if the temperature increases

(c) increases if the temperature decreases

(d) does not depend on the transition temperature

Q. 81. The dielectric constant of a material at optical frequencies is mainly due to

(a) ionic polarizability

(b) electronic polarizability

(c) dipolar polarizability

(d) ionic and dipolar polarizabilities

Q. 82. The semi-empirical mass formula for the binding energy of nucleus contains a surface correction term. This term depends on the mass number A of the nucleus as

(a) $A^{-1/3}$ (b) $A^{1/3}$

(c) $A^{2/3}$ (d) A

Q. 83. In the nuclear shell model the spin parity of ^{15}N is given by

(a) $\frac{1^-}{2}$ (b) $\frac{1^+}{2}$

(c) $\frac{3^-}{2}$ (d) $\frac{3^+}{2}$

Q. 84. In the quark model which one of the following represents a proton

(a) udd (b) uud

(c) $u\bar{b}$ (d) $c\bar{c}$

Q. 85. Week nuclear forces act on

(a) both hedrons and leptons

(b) hedrons only

(c) all particles

(d) all charged particles

Q. 86. Which one of the following disintegration series of the heavy elements will give ^{209}Bi as a stable nucleus

(a) Thorium series

(b) Neptunium series

(c) Uranium series

(d) Actinium series

Q. 87. The order of magnitude of the binding energy per nucleon in a nucleus is

(a) 10^{-5} MeV (b) 10^{-3} MeV

(c) 0.1 MeV (d) 10 MeV

Q. 88. The volume of a nucleus in an atom is proportional to the

(a) mass number (b) proton number
(c) neutron number (d) electron number

Q. 89. Typical energies released in a nuclear fission and a nuclear fusion reactions are respectively

(a) 50 MeV and 1000 MeV

(b) 200 MeV and 1000 MeV

(c) 1000 MeV and 50 MeV

(d) 200 MeV and 10 MeV

Q. 90. Thermal neutron having speed v impinges on a ^{235}U nucleus. The reaction cross-section is proportional to

(a) v^{-1} (b) v

(c) $v^{1/2}$ (d) $v^{-1/2}$