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PG-EE-2013

SUBJECT : Physics

B

10718

Sr. No. .....

Time : **1¼ Hours** Max. Marks : **100** Total Questions : **100**

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SEAL

1. Due to Frenkel defect, the density of ionic solids :
   (1) decreases
   (2) increases
   (3) does not change
   (4) changes

2. Critical angle for total internal reflection of light of a certain frequency at a denser-rarer boundary is 30°. At what angle should the same light be incident on the boundary from the side of denser medium that the reflected and refracted rays are mutually perpendicular ?
   (1) $\tan^{-1}(2)$
   (2) $\tan^{-1}\left(\frac{1}{3}\right)$
   (3) $\cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$
   (4) $\cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$

3. When the surface of the lake is calm, a fish, submerged in water will see the entire outside world within an inverted cone whose apex is situated at the eye of the fish and the cone subtends an angle of :
   (1) 10°
   (2) 60°
   (3) 98°
   (4) 30°

4. A meniscus lens has convex surface of curvature 20 cm and concave surface 30 cm. If the lens is made of glass ($\mu = 1.5$) the focal length will be :
   (1) − 4 cm
   (2) + 4 cm
   (3) − 120 cm
   (4) + 120 cm

5. A long sighted person can not see objects clearly at a distance less than 40 cm from his eye. The power of the lens needed to read an object at 25 cm is :
   (1) − 2.5 D
   (2) + 2.5 D
   (3) − 6.25 D
   (4) + 1.5 D

6. In Young's experiment performed with light of wavelength 550 nm, the angular width of a fringe formed on a distant screen is 0.1°. Separation between the two slits is nearly :
   (1) 0.31 mm
   (2) 0.51 mm
   (3) 0.71 mm
   (4) 0.81 mm

7. A thin film of water ($\mu = 4/3$) is 3100 $\mathring{A}$ thick. If it is illuminated by white light at normal incidence, the colour of film in reflected light will be :
   (1) Blue
   (2) Green
   (3) Yellow
   (4) Red

8. Light is incident normally on a diffraction grating through which the first order diffraction is seen at 32° . The second order diffraction will be seen at :
   (1) 48°
   (2) 64°
   (3) 80°
   (4) No second order diffraction in this case

9. For a beam of light incident on a glass plate at an angle of incidence 60°, the reflected ray is polarized. The angle of refraction for an angle of incidence 45° is :

(1) $\sin^{-1}\frac{\sqrt{3}}{2}$ (2) $\cos^{-1}\frac{\sqrt{3}}{2}$ (3) $\sin^{-1}\frac{1}{\sqrt{6}}$ (4) $\sin^{-1}\frac{1}{\sqrt{3}}$

10. The focal length of a plano convex lens is 0.3 m and its convex surface is silvered. For $\mu = 7/4$ for the lens, the radius of curvature of convex surface is :

(1) 0.45 m (2) 1.05 m (3) 3 m (4) 0.9 m

11. The average value of p_x^2 for the particle in a box of length L is :

(1) mE (2) $2\,mE$ (3) $3\,mE$ (4) $4\,mE$

12. The ground state energy of an electron in an one dimensional box of length 1 $\mathring{A}$ is approximately :

(1) $6.04\times10^{-12}\,J$ (2) $6.04\times10^{-14}\,J$ (3) $6.04\times10^{-16}\,J$ (4) $6.04\times10^{-18}\,J$

13. The ground state energy for a spherically symmetric well is :

(1) $E_{000}=0$ (2) $E_{111}=\frac{3\pi^2\hbar^2}{2m}$

(3) $E_{111}=\frac{3\pi\hbar^2}{2ma^2}$ (4) $E_{111}=\frac{3\pi^2\hbar^2}{2ma^2}$

14. In Zeeman effect, one applies :
(1) external electric field only
(2) external magnetic field only
(3) both electric and magnetic fields simultaneously
(4) both electric and magnetic fields sequentially

15. The Lande g-factor for the level $3D_3$ is :

(1) $\frac{2}{3}$ (2) $\frac{3}{2}$ (3) $\frac{3}{4}$ (4) $\frac{4}{3}$

16. The three nodes of a harmonic oscillator are located at :

(1) $0, \pm\frac{2}{3}$ (2) $0, \pm\sqrt{\frac{2}{3}}$ (3) $+1, 0, -1$ (4) $0, \pm\sqrt{\frac{3}{2}}$

17. A medium in which the group velocity 'V_g' is independent of 'k' is known as :
(1) Denser Medium (2) Rarer Medium
(3) Dispersive Medium (4) Dispersionless Medium

18. An electron with energy E incident upon a potential barrier V, such that $V > E$ and thickness l, then the transmission coefficient :
(1) is zero
(2) is proportional to l^2
(3) increases exponentially with thickness
(4) decreases exponentially with thickness

19. The probability of locating a particle inside the classical limits for an oscillator in its normal state is approximately :
(1) 16% (2) 32% (3) 64% (4) 84%

20. Longitudinal waves cannot :
(1) have a unique wavelength (2) transmit energy
(3) have a unique wave velocity (4) be polarised

21. In motion under central force, which of the following is ***true*** ?
(1) Linear momentum is conserved (2) Torque of such a force is zero
(3) Angular momentum is conserved (4) Both (2) and (3)

22. If constraint forces do work and total mechanical energy is not conserved then constraints are named as :
(1) Bilateral Constraint (2) Unilateral Constraint
(3) Dissipative Constraint (4) None of these

23. If in an electrical circuit comprising of an inductor L and a capacitor C, the capacitor is charged to q coulombs, then, the required Lagrange's eqn. of motion is :
(1) $\ddot{q}+\frac{q}{LC}=0$ (2) $\ddot{q}+qLC=0$ (3) $\ddot{q}-\frac{q}{LC}=0$ (4) $\ddot{q}-LCq=0$

24. Which of the following is ***true*** for work done by a perfect gas during quasi-static adiabatic expansion ?
(1) $W=C_p(T_1-T_2)$ (2) $W=C_v(T_1-T_2)$
(3) $W=V(T_1-T_2)$ (4) W= zero

25. The specific heat of saturated steam is always :
(1) Positive (2) Zero (3) Negative (4) Infinite

26. In case of a perfect gas, the value of Joule-Thomson coefficient is :
(1) 0 (2) 1 (3) $\frac{3}{2}$ (4) $\frac{1}{3}$

27. The coefficient of diffusion in a gas is :
(1) directly proportional to pressure and inversely to (temperature)^2
(2) inversely proportional to pressure and directly to (temperature)^2
(3) directly proportional to pressure and inversely to (temperature)$^{\frac{3}{2}}$
(4) inversely proportional to pressure and directly to (temperature)$^{\frac{3}{2}}$

28. According to Maxwell-Boltzmann's distribution of velocities for gas molecules, the probability of molecule to have zero velocity is :
(1) nil (2) maximum (3) $\frac{1}{2}$ (4) very small

29. Which of the following is ***correct*** expression for Clapeyron's latent heat relation ?
(1) $\frac{dP}{dt} = \frac{L}{T(V_2 - V_1)}$ (2) $\frac{dL}{dt} = \frac{P}{T(V_1 - V_2)}$
(3) $\frac{dV}{dt} = \frac{L}{V(P_1 - P_2)}$ (4) $\frac{dP}{dt} = \frac{L(V_2 - V_1)}{T}$

30. The correct relation between internal energy and canonical partition function is :
(1) $u = -kT\log Z$ (2) $u = -\frac{\partial}{\partial T}(\log Z)$
(3) $u = -kT^2 \frac{\partial}{\partial T}(\log Z)$ (4) $u = -kT^{3/2} \frac{\partial}{\partial T}(\log Z)$

31. A magnet is cut into four equal parts by cutting it parallel to its length. What will be time period of each part, if the time period of original magnet in the same field is T_0 ?
(1) $T_0/\sqrt{2}$ (2) $T_0/2$ (3) $T_0/4$ (4) $4T_0$

32. If at a certain instant, the magnetic induction of the electromagnetic wave in vacuum is 6.7×10^{-12} T, then the magnitude of electric field intensity will be :
(1) $2 \times 10^{-3} N/C$ (2) $3 \times 10^{-3} N/C$
(3) $4 \times 10^{-3} N/C$ (4) $1 \times 10^{-3} N/C$

33. Calculate the stress for one litre of a perfect gas, at a pressure of 72 cm of Hg, when it is compressed isothermally to a volume of 900 cc :
(1) $9.88 \times 10^3 Nm^{-2}$ (2) $10.88 \times 10^3 Nm^{-2}$
(3) $1.088 \times 10^3 Nm^{-2}$ (4) $2 \times 10^3 Nm^{-2}$

34. At what temperature, pressure remaining constant, will the rms speed of a gas molecules increases by 10% of the rms speed at NTP ?
(1) 57.3 k (2) 57.3 °c (3) 557.3 k (4) 27.3° c

35. Three moles of oxygen are mixed with two moles of helium. The ratio of specific heats at constant pressure and constant volume for this mixture will be :
(1) 6.7 (2) 1.5 (3) 3.7 (4) 2.7

36. The first diffraction minimum due to single slit diffraction is θ for an incident radiation with $\lambda = 5000$ Å . If the width of the slit is 1×10^{-4} cm, then value of θ is :
(1) 30° (2) 45° (3) 60° (4) 15°

37. A ruby laser produces radiations of wavelength 662.6 nm in pulses of duration $10^{-9} s$. If the laser produces 0.39 J of energy per pulse, how many photons are produced in each pulse ?
(1) 1.3×10^{9} (2) 1.3×10^{18} (3) 1.3×10^{27} (4) 3.9×10^{18}

38. Consider a system of two identical particles. One of the particles is at rest and the other has an acceleration $\vec{a}$. The centre of mass has an acceleration :
(1) Zero (2) $\frac{\vec{a}}{2}$ (3) $\vec{a}$ (4) $2\vec{a}$

39. If I_1 & I_2 be the moment of inertia of two bodies of identical geometrical shape, the first made of Aluminium & the second of Iron, then :
(1) $I_1 > I_2$
(2) $I_1 = I_2$
(3) $I_1 < I_2$
(4) relation in I_1 & I_2 depends on actual shapes of the bodies

40. A thin circular ring of mass M and radius r is rotating about its axis with an angular speed w. Two particles of mass m each are now attached at diametrically opposite points. The angular speed of the ring becomes :
(1) $\frac{wM}{M+m}$ (2) $\frac{wM}{M+2m}$ (3) $\frac{w(M-2m)}{M+2m}$ (4) $\frac{w(M+2m)}{M}$

41. γ-rays are deflected by :
(1) an electric field but not by a magnetic field
(2) a magnetic field but not by an electric field
(3) both electric and magnetic fields
(4) neither an electric nor a magnetic field

42. The principle of controlled chain reaction is used in :

(1) Atomic Energy Reactor (2) Atom Bomb

(3) in the core of the Sun (4) Artificial Radioactivity

43. A dip needle in a plane perpendicular to magnetic meridian will be :

(1) Vertical (2) Horizontal

(3) at an angle of 45° to the horizontal (4) at an angle of dip to the horizontal

44. Liquid oxygen remains suspended between two pole faces of a magnet because it is :

(1) Diamagnetic (2) Paramagnetic

(3) Ferromagnetic (4) Antiferromagnetic

45. Speed of electromagnetic waves travelling in a medium with relative permeability 1.3 and relative permittivity 2.14 will be :

(1) $13.6 \times 10^6\,ms^{-1}$ (2) $1.8 \times 10^6\,ms^{-1}$ (3) $3.6 \times 10^7\,ms^{-1}$ (4) $1.8 \times 10^8\,ms^{-1}$

46. A lamp radiates power P_0 uniformally in all directions; the magnitude of electric field strength E_0 at a distance r from it is :

(1) $E_0 = \dfrac{P_0}{2\pi \in_0 cr^2}$ (2) $\left(\dfrac{P_0}{2\pi \in_0 cr^2}\right)^{1/2}$

(3) $\left(\dfrac{P_0}{4\pi \in_0 cr^2}\right)^{1/2}$ (4) $\left(\dfrac{P_0}{8\pi \in_0 cr^2}\right)^{1/2}$

47. A solenoid has 2000 turns wound over a length of 0.3 m. The area of cross section is $1.2 \times 10^{-3}\,m^2$. Around its central portion a coil of 300 turns is wound. If initial current 2 Amp in the solenoid is reversed in 0.25 sec, the emf induced will be :

(1) $6 \times 10^{-4}\,V$ (2) 48 mV (3) $6 \times 10^{-2}\,V$ (4) 48 kV

48. The tunnel diode has thickness of depletion layer approximately :

(1) 8.2×10^{-8} m (2) 1.0×10^{-9} m (3) 0.1×10^{-7} m (4) 8.1×10^{-5} m

49. The feedback network of a phase shift oscillator usually consists of :

(1) LC Circuit (2) RC Circuit (3) RL Circuit (4) a transistor

50. In an astable multivibrator, which of the following is ***true*** ?

(1) $\beta = 1$ (2) $\beta > 1$ (3) $\beta < 1$ (4) $\beta A = 1$

51. If a convex lens of focal lengh 20 cm and refractive index 1.5 is immersed in liquid with refractive index 1.33, the change in focal length will be :
(1) 62.2 cm (2) 5.82 cm (3) 58.2 cm (4) 6.22 cm

52. 20% of a radioactive substance decays in 10 days. The amount of original material left after 30 days will be :
(1) 51.2% (2) 62.6% (3) 15% (4) 21.27%

53. The amount of energy released per nucleon of the rectant in the thermonuclear reaction $3_1H^2 \rightarrow {}_2He^4 + {}_1H^1 + {}_0n^1 + 21.6$ MeV is :
(1) 21.6 MeV (2) 7.2 MeV (3) 3.6 MeV (4) 1.8 MeV

54. The ratio of de Broglie wavelengths of a proton and an α-particle will be 1 : 2 if their :
(1) kinetic energies are in ratio 1 : 8 (2) kinetic energies are in ratio 8 : 1
(3) velocities are in ratio 1 : 8 (4) velocities are in ratio 8 : 1

55. Bremsstrahlung is produced when :
(1) electrons move with uniform speed
(2) neutrons travel past the nucleus
(3) protons are accelerated by the nucleus
(4) electrons travel through electric field of a nucleus

56. Transuranium elements are :
(1) those having atomic number less than 92
(2) those having atomic number more than 92
(3) those having atomic number greater than 100
(4) radioactive isotopes of uranium

57. Interaction of a position with an electron results in :
(1) formation of a neutron at rest
(2) annihilation of both and total mass appearing as energy
(3) formation of an X-ray photon
(4) a neutral particle with high energy

58. The probability of a radioactive atom to survive 5 times longer than its half life period is :
(1) 2/5 (2) 2×5 (3) 2^{-5} (4) 2^5

59. Graphite and heavy water act as moderator in a nuclear reactor and their function is :
(1) to slow down neutrons to thermal energies
(2) to absorb neutrons & stop the chain reaction
(3) to cool the reactor
(4) to control the energy released in the reactor

60. Out of the following, the one which can pass through a steel slab of 20 cm thickness is :

(1) α rays (2) β rays (3) γ rays (4) UV rays

61. Intrinsic carrier concentration in a semiconductor at 0 K is :

(1) $10^{19} m^{-3}$ (2) zero (3) $3.0 \times 10^{15} m^{-3}$ (4) $4.2 \times 10^{8} m^{-3}$

62. The stray wiring capacitance in an amplifier has an effect on :

(1) lower cut off frequency (2) mid band frequencies
(3) upper cut off frequency (4) output resistance

63. The base omitter voltage of an ideal silicon transistor is :

(1) 0 V (2) 0.7 V (3) 0.3 V (4) 1.0 V

64. A capacitor of 2.4 μF is used in a transmitter to transmit λ wavelength. If the inductor of $10^{-8} H$ is used for resonant circuit, then the value of λ is :

(1) 292 m (2) 400 m (3) 334 m (4) 446 m

65. An ac signal V = 140 sin 50 t is applied to a resistor 10Ω to produce ΔH heat in time Δt. The dc current required to produce same heat in same time is :

(1) 14 A (2) 20 A (3) 10 A (4) None of these

66. For a dry cell of emf 1.5 V connected across the primary of a step-up transformer of turn ratio 3,5, the voltage developed across the secondary will be :

(1) 30 V (2) 5 V (3) zero (4) 2.5 V

67. ABCD is parallelogram and $\vec{a}, \vec{b}, \vec{c}$ and $\vec{d}$ are position vectors of the vertices A, B, C and D; choose the ***correct*** option :

(1) $\vec{c} + \vec{b} = \vec{d} - \vec{a}$ (2) $\vec{c} - \vec{b} = \vec{d} - \vec{a}$
(3) $\vec{b} - \vec{c} = \vec{d} - \vec{a}$ (4) None of these

68. A force $\vec{F} = a\hat{i} + b\hat{j} + c\hat{k}$ acts upon a body of mass m. If the body starts from rest with origin as initial position, the new coordinates after time t will be :

(1) $\frac{at^2}{2m}, \frac{bt^2}{2m}, \frac{ct^2}{2m}$ (2) $\frac{at^2}{2m}, \frac{2bt^2}{m}, \frac{ct^2}{2m}$ (3) $\frac{at^2}{m}, \frac{bt^2}{m}, \frac{ct^2}{2m}$ (4) $\frac{at^2}{m}, \frac{bt^2}{m}, \frac{ct^2}{m}$

69. A point charge is projected along axis of a circular ring of charge Q and radius $10\sqrt{2}$ cm. The distance of the point charge from the centre of ring, where acceleration of charged particle is maximum, will be :

(1) 10 cm (2) 20 cm (3) 16 cm (4) infinity

70. If a point charge q is placed at one corner of a cube, the flux linked with the cube is :

(1) $\frac{q}{\epsilon_0}$ (2) $\frac{q}{2\epsilon_0}$ (3) $\frac{q}{3\epsilon_0}$ (4) $\frac{q}{8\epsilon_0}$

71. A cubical block of mass M and edge a slides down a rough inclined plane of inclination θ with a uniform velocity. The torque of the normal force on the block about its centre has a magnitude :

(1) Zero (2) Mga (3) $Mga \sin\theta$ (4) $\frac{1}{2}Mga \sin\theta$

72. Consider the following two equations :

(A) $L = Iw$ (B) $\frac{dL}{dt} = \Gamma$

In non-inertial frames :

(1) both (A) and (B) are true (2) (A) is true but (B) is false

(3) (B) is true but (A) is false (4) both (A) and (B) are false

73. The radius of gyration of a uniform disc about a line perpendicular to the disc equals its radius (r). The distance of the line from the centre is :

(1) $\left(\frac{r}{\sqrt{2}}\right)$ (2) $\frac{r}{2}$ (3) $\frac{r}{2\sqrt{2}}$ (4) $\frac{r}{4}$

74. The centre of a wheel rolling on a plane surface moves with a speed v_0. A particle on the rim of the wheel at the same level as centre will be moving at speed :

(1) Zero (2) v_0 (3) $\sqrt{2}v_0$ (4) $2v_0$

75. As the wavelength is increased from violet to red, the luminosity :

(1) continuously increases (2) continuously decreases

(3) increases then decreases (4) decreases then increases

76. A pair is constrained to move along the inner surface of a hemisphere, then the number of degrees of freedom of the particle is :

(1) One (2) Two (3) Three (4) Four

77. The dimensions of generalized force are similar as that of :

(1) Work (2) Force

(3) Length (4) Angular displacement

78. The canonical momenta, for a charged particle in an electromagnetic field is :

(1) $mv - \frac{qA}{c}$ (2) $mv + \frac{qA}{c}$ (3) $mv - \frac{q^2 A}{mc^2}$ (4) $_2mv^2 - \frac{mc^2}{qA}$

79. If a coordinate is cyclic, then its Hamiltonian reduces the number of variables in one form to :

(1) 2 (2) 4 (3) 6 (4) 8

80. All functions whose Poisson's bracket with Hamiltonian vanish must be :

(1) constant of motion (2) involving time explicitly
(3) both (1) and (2) (4) None of these

81. The Bravis Lattice, formed by all points with set of integers (n_1, n_2, n_3) when n_1, n_2, n_3 are either all odd or all even is :

(1) simple cubic (2) fcc
(3) bcc (4) hexagonal

82. In the Debye theory, a solid is regarded as :

(1) an isotropic discrete (2) an anisotropic discrete
(3) an isotropic continuum (4) an anisotropic continuum

83. A phonon is the quantum of :

(1) Electromagnetic wave (2) Elastic wave
(3) Polarisation wave (4) Magnetisation wave

84. For a fcc crystal, the first Brillouin zone is :

(1) Truncated Octahedron (2) Regular Rhombic dodecahedron
(3) Rectangular parallelopiped (4) Cube

85. Larmor frequency is given as :

(1) $\frac{eB}{m}$ (2) $\frac{eB}{2m}$ (3) $\frac{em}{B}$ (4) $\frac{em}{2B}$

86. The density of carriers in an intrinsic semiconductors is proportional to :

(1) $\exp(-Eg/kT)$ (2) $\exp(-2Eg/kT)$
(3) $\exp(-Eg/kT^2)$ (4) $\exp(-Eg/2kT)$

87. Which of the following is ***incorrect*** ?

(1) GaAs LED emits red light

(2) GaP LED emits either red or green light

(3) LED emits no light when reverse biased

(4) LED arrays can display alphanumerics

88. The negative part of the output signal in a transistor circuit is clipped, if Q-point moves :

(1) towards the saturation point (2) towards the cut-off point

(3) towards the centre of load line (4) None of the above

89. The emitter resistor R_E bypassed by a capacitor :

(1) reduces the voltage gain (2) stabilises the Q point

(3) increases the voltage gain (4) causes thermal runaway

90. The number of atoms in 100 g of a fcc crystal with density 10 gcm^{-3} and cell edge 200 pm is equal to :

(1) 3×10^{25} (2) 5×10^{24} (3) 1×10^{25} (4) 2×10^{25}

91. Which of the following is ***not*** a Maxwell's thermodynamical equation ?

(1) $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$ (2) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

(3) $\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial S}{\partial T}\right)_V$ (4) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

92. The correct relation between C_p and C_v for a Vander Waals gas is :

(1) $C_p - C_V = R$ (2) $C_p = \frac{C_V}{R}$

(3) $C_p - C_V = R\left(1+\frac{2a}{VRT}\right)$ (4) $C_p - C_V = \frac{TE}{V}\alpha^2V^2$

93. Bragg's angle for the first and fourth order reflections are θ_1 and θ_4. Then $\sin\theta_1 / \sin\theta_4$ is :

(1) 1 (2) 4 (3) $\frac{1}{2}$ (4) $\frac{1}{4}$

94. The expectation value of position of a particle described by wave function $\psi = \sqrt{2}x$ between $0 < x < 1$ is given by :

(1) 1 (2) $\frac{1}{2}$ (3) $\frac{3}{2}$ (4) $\frac{3}{4}$

95. The energy of a γ ray photon corresponding to 1 $\mathring{A}$ is approximately :

(1) 1.24 keV (2) 12.4 keV (3) 124 keV (4) 1.24 MeV

96. For an ideal gas, if the volume remaining constant then which one among following is ***correct*** ?

(1) $C_V = 0$ (2) $C_V = \left(\frac{dH}{dT}\right)_V$ (3) $C_V = \left(\frac{du}{dT}\right)_V$ (4) $C_V = \left(\frac{dQ}{dT}\right)_P$

97. Which of the following relations for logic circuit is ***incorrect*** ?

(1) $\overline{A+B} = \overline{A}\,\overline{B}$ (2) $\overline{AB} = \overline{A} + \overline{B}$ (3) $A + A = A$ (4) $\overline{A+B} = \overline{AB}$

98. The wavefunction considered to be confined within a box of length L is $\psi(x) = \sqrt{\frac{2}{L}} \sin\frac{\pi x}{L}$ in the region $0 < x < L$. The probability of locating the particle in the region $0 < x < \frac{L}{2}$ is :

(1) 0 (2) $\frac{1}{2}$ (3) 1 (4) $\frac{1}{4}$

99. The probability density of a state is always :

(1) Real (2) Imaginary (3) $\frac{1}{2}$ (4) Complex

100. If $H = \frac{p^2}{2m} + V(x)$, then $[x,H]$ results :

(1) $\frac{i\hbar p}{m}$ (2) $\frac{i\hbar}{m}$ (3) $-\frac{\hbar p}{im}$ (4) $\frac{\ln p}{m}$