K1 Level

1. Each quanta is associated with definite amount of energy given by--------------

a $E= h\vartheta$b   b. $E= h\mu$c   c. $E= h\theta$d   **d. None of these**

2. Hisenberg's uncertainty principle is expressed mathematically as----------------

a. $\mathbf{\Delta x \times \Delta px \geq \frac{h}{4\pi}}$ b. $\Delta x \times \Delta px = \frac{h}{4\pi}$

c. $\Delta x \times \Delta px \geq \frac{h}{2\pi}$ d. $\Delta x \times \Delta px \geq \frac{v}{4\pi}$

3. Which is not the Properties of Hermitionoperator:

a. Eigen values are real

b. Eigen functions corresponding to different eigen values are orthogonal

c. Eigen functions corresponding to different eigen values are normalised

d. Eigen functions corresponding to different eigen values are standardized

4. Unit used for measuring wavelength is

a. angstrom   b. centimetre   c. meter   d.millimetre

5. Planck proposed that energy travels in

a. **discontinuous manner**   b. continuous manner   c. slow manner   c. general manner

6. Distance between two adjacent crests or troughs is called

a. wave number   b. frequency   **c. wave length**   d. radiation

7. In case of radiation amount of energy is proportional to

a. **frequency of radiation**   b. density of radiation

c. waves d. light

8. Quantum numbers are

a. arithmetical values **b. numerical values** c. geometric values d. logical values

9. Energy is absorbed by body in form of

a. **photons** b. quantas c. waves d. energy

10. A black body is a

(a) perfect absorber (b) perfect emitter

(c) perfect absorber and emitter (d) none of the above

11. The radiation given out by a black body is dependent on the

(a) wavelength of the incident radiation **(b) temperature of the cavity**

(c) nature of the interior material (d) nature of the surface

12. According to Heisenberg's uncertainty principle,

(a) $\Delta x.\ \Delta p \geq h/8\pi$ **(b)** $\mathbf{\Delta x.\ \Delta p \geq h/4\pi}$ (c) $\Delta x.\ \Delta p \leq h$ (d) $\Delta x/\Delta p = h$

13. The probability of finding a particle per unit volume is known as

(a) particle density **(b) probability density** (c) normalization

(d) orthogonalization

14. Which one of the following is not a correct statement about an acceptable wave function?

(a) ψ is single valued (b) ψ and its first derivative are continuous

(c) ψ approaches infinity (d) ψ is finite

15. Two wavefunctionsψi and ψj are said to be normalized if

(a) $\int \psi i * \psi j d\tau = 1 ; i = j$ (b) $\int \psi i * \psi j d\tau = 0 ; i \neq j$ (c) $\int \psi i * \psi j d\tau = 0 ; i = j$

(d) $\int \psi i * \psi j d\tau = \psi 2$

16. Two wavefunctionsψi and ψj are said to be mutually orthogonal if

(a) $\int \psi i * \psi j d\tau = 1 ; i = j$ **(b) $\int \psi i * \psi j d\tau = 0 ; i \neq j$** (c) $\int \psi i * \psi j d\tau = 0 ; i = j$

(d) $\int \psi i * \psi j d\tau = \psi 2$

17. What is the energy of the photon having wavelength 1.5 Ao.

(a) 13.25x10-16J (b) 13.25 KJ (c) 13.25x10-12J (d) 13.25x10-18J

18. Work function w is given by

(a) λ/p **(b) hvo** (c) h/mc (d) nhν

19. Lyman series of hydrogen spectra lies in

(a) uv region (b) IR region (c) Microwave (d) far IR

20. The equation relating λ and potential difference is

(a) h/2meV (b) Vme/h **(c) h/(2meV)1/2** (d) (2meV)1/2/h

21. The energy of the photon corresponding to the wavelength 140 nm is

14.2x10-18J (b) 14.2 x10-18 KJ **(c) 1.42x10-18J** (d) 1.42x10-18KJ

11.The square of Ψ is a measure of

(a) probability (b) particle density (c) intensity **(d) all the above**

12. The wave function Ψ describes

(a) state of the system (b) intensity (c) energy density (d) probability

13. Paschen series of hydrogen spectra lies in

(a) uv region **(b) Near IR region** (c) Microwave (d) far IR

14. The eigen value of the function Ψ=8eaxof the operator d/dx is

(a) 16 (b) 8 (c) 3 **(d) 4**

15. If A and B commute [A,B] =

(a) 5 (b) 2 (c) 1 **(d) 0**

16.Eigen functions of a hermitian operator corresponding to different eigen values are

(a) zero (b) real **(c) orthogonal** (d) parallel

17. Which of the following is the energy operator?

(a) momentum (b) Laplacian **(c) Hamiltonian** (d) √

18. [y.d/dx] Ψ =

(a) 9 (b) 4 (c) 1 **(d) 0**

19.Balmer series in hydrogen spectra lies in

(a) uv region (b) Near IR region (c) Microwave (d) far IR

20. Which of the following is the odd function

(a) tanx (b) x **(c) sin x** (d) cos x

21. Ψ= tanx is

(a) acceptable **(b) not acceptable** (c) finite (d) continuous

22.Which of the following statement is wrong for Ψ= sin x

(a) acceptable **(b) discontinous** (c) finite (d) continuous

23. For a particle in one dimensional box, potential energy V =**_____**inside the box.

(a) 0 (b) 1 (c) ∞ (d) -1

24. For a particle in one dimensional box, potential energy V =**_____**outside the box.

(a) 0 (b) 1 **(c)** ∞ (d) -1

25. The general solution for the differential equation $d^2\psi/dx^2 + k^2\psi = 0$ is

(a) ψ = ASinkx - BCosKx **(b) ψ = ASinkx + BCosKx**

(c) ψ = ASinkx + BSinKx (d) ψ = ACoskx + BCosKx

26. The normalization constant for a particle in one-dimensional box is

(a) 2/a (b) a/2 **(c) $(2/a)^{1/2}$** (d) n□x/a

27. The normalized wave function for a particle in one-dimensional box is given by

(a) $(2/a)^{1/2}$ Sin^2n□x/a (b) $(a/2)^{1/2}$ Sin n□x/a (c) $(2/a)^{1/2}$ Cos n□x/a **(d) $(2/a)^{1/2}$ Sin n□x/a**

28. The zero point energy of a particle in one-dimensional box is given by

(a) $h^2/8ma^2$ (b) h^2/ma^2 (c) $3h^2/8ma^2$ (d) $h^2/4ma^2$

29. For a particle in one-dimensional box, the number of nodes (N) and quantum number are related as

(a) N = n **(b) N = n-1** (c) N = 2n (d) N = n+1

30. According to Hooke's law F_x =

(a) kx (b) 1/kx **(c) -kx** (d) k^x

31. The fundamental frequency of oscillation of an LHO is given by

(a) $\nu_0 = 2\pi\ (k/m)^{1/2}$ **(b)$\nu_0 = 1/2\pi\ (k/m)^{1/2}$** (c)$\nu_0 = 2\pi\ (m/k)^{1/2}$ (d)$\nu_0 = 1/2\pi\ (m/k)^{1/2}$

32. The zero-point vibrational energy of an LHO, E_0 =

(a) $h\nu_0$ (b) $h\nu_0^2$ (c) $2h\nu_0$ **(d)1/2 $h\nu_0$**

33. The separation between two adjacent vibrational energy levels is

(a) $(h\nu_0)^{1/2}$ (b) $h\nu_0^2$ **(c) $h\nu_0$** (d)1/2 $h\nu_0$

34. The energy of a rigid rotor according to classical mechanics is given by

(a) $E = \mu r^2$ (b) $E = h^2\ J(J+1)/8\pi^2 I$ **(c) $L^2/2\ \mu r^2$** (d) $2\ \mu r^2)/L^2$

35. The energy of a rigid rotor according to quantum mechanics is given by

(a) $E = \mu r^2$ **(b) $E = h^2\ J(J+1)/8\pi^2 I$** (c) $L^2/2\ \mu r^2$ (d) $2\ \mu r^2)/L^2$

36. The magnitude of angular momentum L =

(a) $[l(l+1)]^{1/2}\ h/2\pi$ (b) $l(l+1)h/2\pi$ (c) $l(l+1)^2h/2\pi$ (d) $[l(l+2)]^{1/2}\ h/2\pi$

37. The reduced mass of a rigid diatomic molecule is given by

(a) $\mu = m_1m_2/m_1-m_2$ **(b) $\mu = m_1+m_2/m_1m_2$** (c) $\mu = m_1m_2/m_1+m_2$

(d) $\mu = m_1-m_2/m_1m_2$

38. The relation between angular momentum (L) and moment of inertia (I) is

(a) ω/I (b) I/ω **(c) $L = I\omega$** (d) $L = (I\omega)^{1/2}$

39. The kinetic energy of rigid rotor is given by

(a) $T = L^2/2I$ (b) $T = 2L/I$ (c) $T = L/2I^2$ (d) $T = L/2I$

40. Relation between angular momentum and linear momentum

(a) $P = r.L$ (b) $L = r/p$ **(c) $L = r.p$** (d) $L = r^2.p$

41. In the absence of electric or magnetic field, L^2 is _____ fold degenerate.

(a) 2(l+1) **(b) 2l+1** (c) 2l (d) 2l-1

42. The maximum probability of finding the electron for the ground state hydrogen atom is found to be at

(a) 0.0529 nm (b) 0.00529 nm (c) 0.529 nm (d) 0.158 nm

43. The energy in 1D box is proportional to

(a) $1/L^2$ (b) L^2 (c) $2/L^2$ (d) n/L^2

44. For macroscopic bodies the energy levels are

(a) closely spaced (b) equally spaced (c) not equal (d) both a and b

45. The points inside the box where $\psi=0$ are called

(a) anti nodes **(b) nodes** (c) radial points (d) angular points

46. The boundary condition is

(a) **$x=0, \psi=0$; $x=a$, $\psi=0$** (b) $x=1$ $\psi=0$; $x=0$, $\psi=0$ (c) $x=a$, $\psi=0$; $x=a$, $\psi=1$
(d) $x=1$, $\psi=0$; $x=0$, $\psi=1$

47. When $\psi(x)= \psi(-x)$ the function is

(a) **symmetric** (b) antisymmetric (c) sine (d) finite

48. When $\psi(x)= -\psi(-x)$ the function is

(a)symmetric **(b) antisymmetric** (c) cosine (d) finite

49. Hermite polynomial is associated with

(a) hydrogen atom (b) sphere **(c) harmonic oscillator** (d) rigid rotor

50. According to the classical treatment the lowest energy is

(a) 1 (b) ½ hν **(c) Zero** (d) finite

51. The relation between energy and momentum is given by

(a) $1/L^2$ (b) $L^2/2$ (c) $2/L^2$ **(d) $L^2/2I$**

52. In hydrogen like atom the potential energy is given by

(a) $1/r^2$ (b) r/e^2 **(c) $-Ze^2/r$** (d) $-e^2/r$

K2 Level

1. Find the degree of degeneracy of a 3-D box with $E = 14h^2/ 8ma^2$.
2. A one-electron wave function is called a/an----
3. Write the orthonormaility condition.
4. Write the expression for Hamiltonian operator.
5. Give the energy of H-atom.
6. Write Schrodinger wave equation.
7. Note down the properties of acceptable wave functions.
8. Write down any Eigen value equation.
9. What is Expectation value?
10. Give an expression for deBroglie wave relation.
11. Explain degeneracy in 3-D box.
12. Give the significance of tunneling effect.
13. Explain uncertainity principle of harmonic oscillator.
14. What is classical mechanical treatment of harmonic oscillator and derive
15. Equation for frequency of harmonic oscillator and energy.
16. Discuss about Energy of rigid rotor
17. Derive associated Legendre polynomials equation.
18. Give classical mechanical treatment of rigid rotor.
19. Relate n with l using associated Laguerre equation.
20. Derive an expression for particle in 1-D box.
21. Give quantum mechanical treatment of harmonic oscillator & Define zero point energy.
22. Explain rigid rotor of a diatomic molecule.
23. Derive an expression for a particle in a three dimensional box.
24. Explain the harmonic oscillator of a diatomic molecule
25. Derive the radial and angular part of the wavefunction of hydrogen atom.
26. Normalise the wavefunction and find the orthogonality of a particle in 1D box.
27. Prove that the wave functions for a particle in one-dimensional box are orthonormal.
28. A steel ball weighing 10 g is rolling on a smooth floor of a 10 cm wide box with a speed of 3.3 cm s^{-1}. Calculate the value of quantum number corresponding to the translation energy of the ball.
29. Derive an expression for energy of a particle in one-dimensional box.
30. Discuss the conclusions of quantum mechanical treatment of a linear harmonic oscillator.
31. Set up Schrodinger equation for H-atom in terms of spherical coordinates.
32. Explain the origin and physical significance of the quantum numbers J and m.
33. What is separation of variables? Illustrate it with respect to particle in three-dimensional box.
34. What is Variation theory and prove it.
35. Explain Pauli's exclusion principle.
36. What is Slater determinant and explain.
37. Discuss about perturbation theory.
38. How will you include electron spin into the wavefunction?
39. How will you arrive at the approximate wave function for many electron atoms.
40. What is Born-Oppenheimer approximation and derive expression for bonding and antibonding orbitals.

41. Determine approximate wave functions by Perturbation methods and its application to Helium atom.
42. Account for stability and unstability of chemical bond for H2+ion .
43. How was the spinning property of an electron experimentally demonstrated by Stern-Gerlach?
44. Explain ‘Falkenhagen effect’.
45. Write the application s of Debye Huckel limiting law.
46. Calculate the ionic strength of 0.3 m Na_2SO_4.
47. Write a note on activity coefficient.
48. Derive Debye Huckel Onsager equation.
49. Discuss the theories of double layer.
50. Define and explain activity and activity coefficient.
51. Write a note on Debye huckel limiting law.
52. Calculate the mean activity coefficient of 0.001M $ZnSO_4$.
53. Discuss Debye Falkenhagen and Wien effect.
54. Describe Helmhotz –Perrin model of electrical double layer.
55. Calculate the mean activity coefficient of 0.01 M $ZnSO_4$ at 25^oC.
56. Write a note on Debye Falkenhagen and Wien effect and their applications.
57. Explain the term mean activity coefficient .
58. Calculate the ionic strength of 0.2 mKClaqueus solution and 0.02 mNaIaquous at 25^oC..
59. Calculate the mean activity coefficient of 0.01M $BaCl_2$ at 25^oC in water.
60. Calculate the mean ionic activity $a\pm$and the activity a_2 in 0.1 m solution of $CuSO_4$ if mean molal activity coefficient $\nu\pm$ is 0.74.
61. How Debye Huckel Onsager equation tested experimentally?

K3 Level

1. Explain Expectation value.
2. What is an Eigen function and Eigen value. Explain it with examples.
3. Give an expression for deBroglie wave relation.
4. If $f(x) = x^2 + 3e^x$; $\hat{A} = d/dx$; $\hat{C} = +3$. Find $\hat{A}f(x) + \hat{C}\, f(x)$; $\hat{A}\, f(x) - \hat{C}\, f(x)$; $\hat{A}\, \hat{C}\, f(x)$.
5. What is commutator operator &Findwhether√ and log are linear operators .
6. Derive Time dependant Schrodinger wave equation.
7. Explain the terms (i) Black body (ii) heat capacity of solids
8. How will you say a wave function acceptable?
9. What isBorns interpretation of wave function?
10. Explain Heisenberg uncertainity Principle.
11. Explain the correspondence between physical quantities in classical mechanics and operators in quantum mechanics.
12. Explain the angular momentum operator and its quantisation.
13. An electron is accelerated by applying a potential difference of 1000V. What is the de broglie wavelength associated with it.
14. What is the product of uncertainity in position and velocity for an electron of mass 9.11×10^{-31} kg according to uncertainityprinciple.
15. What is the wave length of a proton ($m = 1.7 \times 10^{-27}$ kg) moving with a velocity equal to 1/100 of that of light?
16. A cricket ball whose mass is 200 g . If the uncertainity in position is of the order of 5 pm then find the corresponding uncertainity in its velocity.
17. The work function for sodium metal is 1.82 eV.Calculate the threshold frequency for sodium.
18. Verify that the laplacian operator is linear.
19. Find the eigen function and the eigen value of linear momentum operator.
20. Evaluate the commutators [x, d/dx]
21. Summarize the results of photoelectric effect.
22. What are the postulates of Planck's quantum theory?

23. Explain black body radiation on the basis of classical mechanics.

How does quantum mechanics successfully explain black body radiation?

24. Solve Schrodinger wave equation for rigid rotator by quantum mechanics.
25. Give an expression for associated Laguerre polynomials and find its solution.
26. Derive normalized wave equation for 1D box and quantise energy.
27. Illustrate the uncertainity principle and correspondence principle with reference to the particle in 1D box.
28. Explain the classical and quantum mechanical treatment of a simple harmonic oscillator.
29. Solve Schrodinger wave equation for Hydrogen atom.
30. Derive an expression for a particle in a three dimensional box and explain degeneracy.
31. Discuss the various energy levels involved in the H atom spectrum.
32. How will you separate the variables in solving the solution for Hydrogen atom.
33. Find the lowest kinetic energy of an electron in a 3D box of dimensions

K4 Level

1. Derive an expression for Bohr’s hydrogen atom model.

2. Examine which of the following functions are acceptable.

(i) x2 (ii) ex (iii) e-x (iv) sin x (v) e-x2 (vi) tan x

3. An electron moves in the first orbit with a speed of 2x 10 6 ms–1 .If its momentum is measured with an accuracy of 1% .What is the uncertainity of position.Comment.

4. Explain Photo electric effect with an experiment.

5. Explain black body radiation on the basis of classical mechanics and

quantum mechanics.

6. Explain the theorems under Hermitian operator.

7. What is Orthonormal set and expansion theorem.

8. Prove that Ĥ□ = E□.

9. How does quantum mechanics explain photoelectric effect and heat capacity of solids adequately?

10. Write the postulates of quantum mechanics. Explain it with clear statements and example.

11. Write notes on operators.

12. Give a note on angular momentum operator and its significance in classical mechanics and quantum mechanics. Explain its quantisation.

13. Show that the following functions are orthogonal.

(i)(1/2 π)1/2 (ii) (1/ π)1/2cos x. (iii) (1/ π)1/2 sin x.

14. Derive Time independent Scrodinger wave equation.

Derive the solutions of Schrodinger equation for helium atom.

15. Explain Pauli antisymmetry principle exemplifying helium atom.

16. Apply perturbation method and variation method to calculate energy of helium atom. Compare the results.

17. Explain the treatment of H2+ molecule by MO method.

18. Write notes on approximation methods.

19. What is Born-Oppenheimer approximation? Explain LCAO –MO method for H2+ molecule.

20. State Pauli's antisymmetry principle. What are symmetric and antisymmetric wave functions?

21. Apply variation method to calculate energy of helium atom.

22. Apply perturbation method to calculate energy of helium atom.

23. What are approximation methods? What is the need of approximation method in quantum mechanics?

24. How will you obtain secular equations and secular determinants for H_2^+ molecule?

25. What are the four possible product combinations of the orbital and spin wave functions?

26. Derive debyehuckel limiting law. How is it modified at higher concentrations?

27. Write a note on electro Osmosis and electrophoresis.

28. Explain the theory and application of electrophoresis

29. Derive Debye Huckel limiting law and discuss two of its applications

30. Derive the Debye Huckel Onsager equation for the conductance of strong electrolytes. Give its advantages and disadvantages.

31. What is stern model of double layer? Explain in detail.

32. Write atleast three applications of Debye-Huckel limiting law.

33. Derive Zeta potential for electro Osmosis.

34. Discuss the Helmholtz –Perrin and GouyChapmann model of the electrical double layer.

35. Derive the equation for ionic atmosphere.

36. Derive Debye-Huckel Onsager equation.What are the importance of that equation.?

37. Write a note on electrokinetic phenomena.