BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

Buddha Institute ofTechnology

(AKTU CODE-525)

Department: Electronics and Communication Engineering Subject: Electronics Devices (BEC-301)

Faculty Name: Mr. Akhilesh Mishra

UNIT 1

QUEST 1: Derive and evaluate the expressions for Schrodinger wave equation? AKTU 21-22

ANS: The Schrödinger wave equation is a fundamental equation in quantum mechanics that describes how the wave function of a quantum system evolves over time. There are two main forms of the Schrödinger equation: the time-dependent Schrödinger equation and the time-independent Schrödinger equation. I'll provide you with both expressions and briefly explain them.

1. Time-Dependent Schrödinger Equation: The time-dependent Schrödinger equation describes how the wave function of a quantum system changes with time. It is given by:

$$i\hbar \partial t \partial \psi(r,t) = -2\mu\hbar 2 \nabla 2 \psi(r,t) + V(r,t)\psi(r,t)$$

Where:

- i is the imaginary unit.
- ħ (h-bar) is the reduced Planck constant, equal to $h/2\pi$, where hh is the Planck constant.
- $\psi(r,t)$ is the wave function of the quantum system, which depends on position (r) and time (t).
- $\partial t \partial \psi(r,t)$ is the partial derivative of the wave function with respect to time.
- $-2\mu\hbar 2\nabla 2\psi(r,t)$ represents the kinetic energy operator, where $-\hbar 22\nabla 22\mu - \hbar 2\nabla 2$ is the Laplacian operator applied to $()\psi(r,t)$, and μ is the reduced mass of the system.
- $V(r,t)$ is the potential energy function, which depends on both position and time.

1. Time-Independent Schrödinger Equation: The time-independent Schrödinger equation is a special case when the potential energy $V(r,t)$) does not depend explicitly on time. It is given by:

$$-2\mu\hbar 2\nabla 2\psi(r)+V(r)\psi(r)=E\psi(r)$$

Where,

- $\psi(r)$ is the wave function of the quantum system, which depends only on position (r) since it's time-independent.
- $-2\mu\hbar 2\nabla 2$ is the kinetic energy operator, as described earlier.
- $V(r)$ is the potential energy function, which depends only on position.
- E is the total energy of the quantum system.

To evaluate these equations for a specific quantum system, you would need to know the form of the potential energy function $V(r)$ and the physical characteristics of the system (e.g., mass μ, boundary conditions). Solving the Schrödinger equation allows you to determine the allowed energy levels and corresponding wave functions for the quantum system. The solutions provide information about the behavior of particles within that system according to quantum mechanics.

QUEST2: What do you understand by QUANTUM MECHANICS?

ANS: Quantum mechanics, often simply referred to as "quantum physics" or "quantum theory," is a fundamental branch of physics that describes the behavior of matter and energy on the smallest scales, typically at the level of atoms and subatomic particles.

QUEST 3: What do you understand by E-K Diagram?

ANS: The E-K diagram often referred to as the E-k dispersion diagram or energy-momentum diagram is a graphical representation used in physics to describe the relationship between the energy (E) and momentum (k) of particles or quasi particles in a material. It is particularly common in condensed matter physics, solid-state physics, and semiconductor physics.

QUEST4: What do you understand by Heisenberg uncertainty principle?

ANS: The Heisenberg Uncertainty Principle, formulated by the German physicist Werner Heisenberg in 1927, is a fundamental principle of quantum mechanics. It states that there is a fundamental limit to the precision with which certain pairs of complementary properties of a particle, such as its position and momentum, can be simultaneously known.

Mathematically, the uncertainty principle is often expressed in the following form:

$\Delta x * \Delta p \geq \hbar / 2$

Where:

- Δx represents the uncertainty in the particle's position.
- Δp represents the uncertainty in the particle's momentum.
- $\hbar$ (h-bar) is the reduced Planck constant, which is approximately equal to 1.0545718 x 10^-34 Joule-seconds.

The principle essentially tells us that the more precisely we know the position of a particle, the less precisely we can know its momentum, and vice versa. In other words, if we try to measure one of these properties with very high precision, the uncertainty in the other property will increase.

QUEST5: What are the effective mass of an electron?

ANS: So far, both the classical and quantum models of conduction have assumed that the current carrying electrons occupy pure planewave states. The dispersion relation of real materials, however, varies from the ideal parabola. We can approximate any dispersion relation by a plane wave if we allow the mass of the electron to vary. We call the modified mass the effective mass. Under this approximation, the electron is thought of as a classical particle and various complex phenomena are wrapped up in the *effective mass*. For example, given dispersion relation *E(k)*, a Taylor expansion about *k = 0* yields:

$$E(k)=E(0)+k\frac{dE}{dk}\Big|_{k=0}+\frac{1}{2}k^2\frac{d^2E}{dk^2}\Big|_{k=0}+\ldots$$

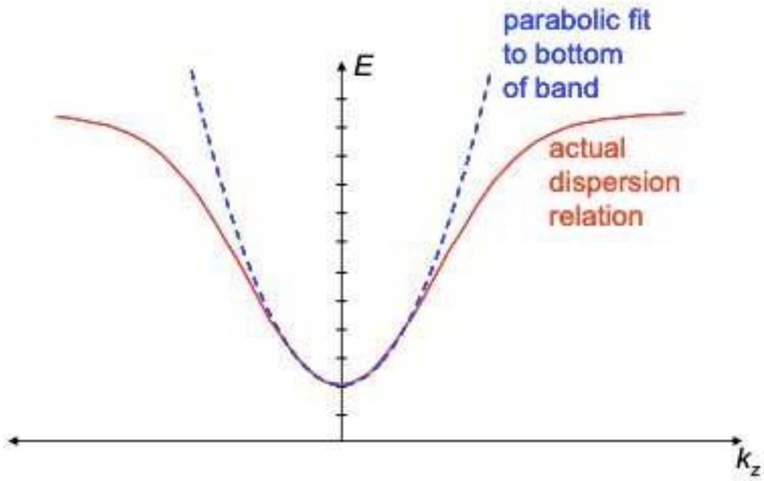
Approximating the dispersion relation by a plane wave gives

$$E(k)=E_0+\frac{\hbar^2k^2}{2m^*}$$

Equating the quadratic terms in Eqations. (4.13.1) and (4.13.2) we get an expression for the effective mass

$$m^*=\hbar^2\left(\frac{d^2E}{dk^2}\right)^{-1}$$

The effective mass concept is commonly used in classical models of electron transport, especially models of mobility



QUEST6: What is the condition for hyseinberg uncertainty principle?

ANS: The condition of hyseinberg uncertainty principle is

$$\Delta p \Delta x \geq h4\pi$$

$$\Delta t \Delta E \geq h4\pi$$

QUEST7: What are the applications of hyseinberg uncertainty principle?

ANS: The Heisenberg Uncertainty Principle is a fundamental concept in quantum mechanics that states that there is a limit to how precisely we can simultaneously know certain pairs of complementary properties of a particle, such as its position and momentum. This principle has wide-ranging applications and implications in various fields of science and technology. Here are some of its key applications:

1. Quantum Mechanics: The Heisenberg Uncertainty Principle is a fundamental principle of quantum mechanics and plays a central role in understanding the behavior of particles at the quantum level. It sets limits on the precision with which we can measure certain properties of particles, such as position and momentum, and is essential for predicting the behavior of subatomic particles.

2. Atomic and Molecular Physics: In the study of atoms and molecules, the uncertainty principle helps explain phenomena such as the energy levels of electrons in atoms, the shapes of atomic orbitals, and the behavior of chemical bonds.
3. Particle Physics: Particle physicists rely on the Heisenberg Uncertainty Principle when studying subatomic particles. It helps in understanding particle interactions, the creation and annihilation of particles in high-energy collisions, and the behavior of particles in accelerators and colliders.

QUEST8: What is the condition of quantum mechanics?

ANS The condition of quantum mechanics is:

E = h¥

E = energy, h = planks constant, ¥ =frequency

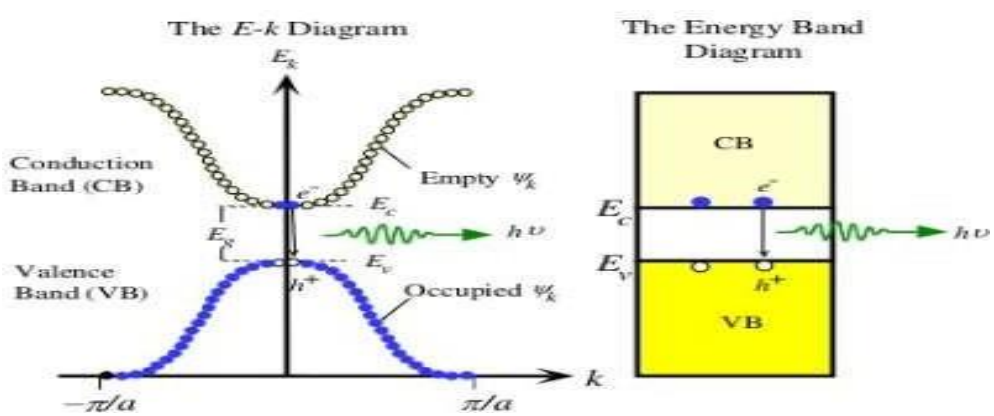
QUEST9: What are the types of E-K Diagram?

ANS There are three types of E-K Diagram:

1) PERIODIC ZONE
2) EXTENDED ZONE ·
3) REDUCED ZONE.

QUEST10: Draw the diagram for reduced zone picture of E-K diagram.

ANS



QUEST11: Draw diagram for brillouin zones for EK diagram.

ANS