Answer on Question #37526 – Physics - Quantum Mechanics

Question: write down the operator associated with the total energy.

Solution: in classical mechanics total energy of the particle is described by the Hamilton function $H = T + V$, where T is the kinetic energy of this particle and $V$is the potential energy. In quantum mechanics total energy H becomes an operator

$$\hat{H} = \hat{T} + \hat{V},$$

Where $\hat{T}$ is the operator of kinetic energy and $\hat{V}$ is the operator of potential energy. In the simplest case of one particle kinetic energy is $\hat{T} = \frac{\hat{p}^2}{2m}$, here $\hat{p}$ is the operator of the momentum, which is equal in one dimensional case $\hat{p} = -i\hbar\frac{\partial}{\partial x}$. Now operator $\hat{T}$ becomes

$$\hat{T} = \frac{\hat{p}^2}{2m} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$$

In three dimensional case it becomes

$$\hat{T} = -\frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right) = -\frac{\hbar^2}{2m} \cdot \Delta$$

$$\Delta = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

The look of the operator $\hat{V}$ depends on the specific problem. So finally we obtain

$$\hat{H} = -\frac{\hbar^2}{2m} \cdot \Delta + \hat{V}$$

Answer: $\hat{H} = -\frac{\hbar^2}{2m} \cdot \Delta + \hat{V}$.