On a clear evening during the winter months, if you happen to be in the Northern Hemisphere and look up at the sky, you can see the constellation Orion (The Hunter). One star in this constellation, Rigel, flickers in a blue color and another star, Betelgeuse, has a reddish color. Which of these two stars is cooler, Betelgeuse or Rigel? Give reason for your answer.

In a region of space, a particle with mass m and with zero energy has a time-independent wave function

$$\psi(x) = Axe^{-x^2/L^2} \tag{19}$$

where A and L are constants.

- Determine the potential energy $U(x)$ of the particle.

Text Eq. (5.13) is the time-independent Schrödinger equation for the wavefunction $\psi(x)$ of a particle of mass m in a potential $U(x)$:

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + U(x)\psi(x) = E\psi(x) \tag{20}$$

When a particle with zero energy has wavefunction $\psi(x)$ given by Eq. (19), it follows on substitution into Eq. (20) that

$$U(x) = \frac{2\hbar^2}{mL^4}\left(x^2 - \frac{3L^2}{2}\right). \tag{21}$$

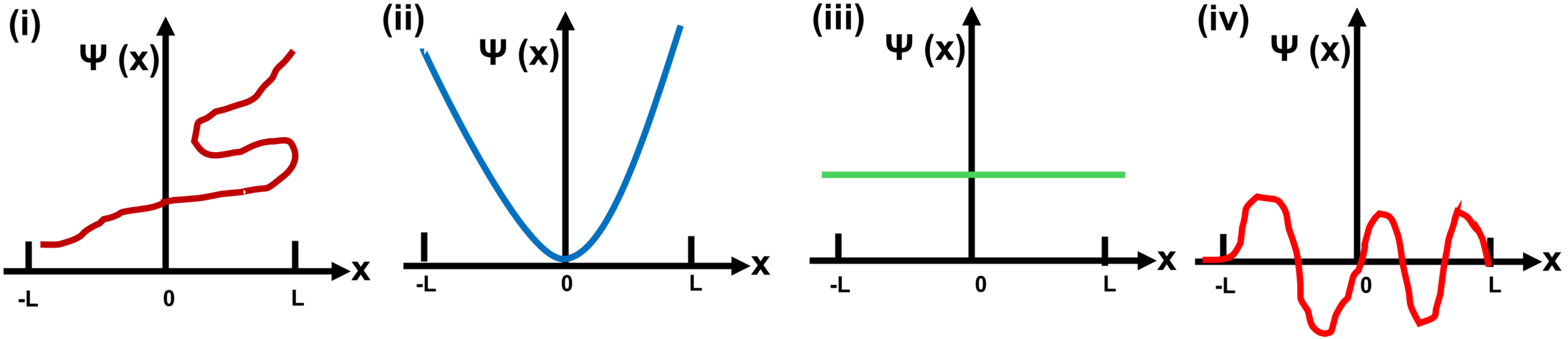
$U(x)$ is a parabola centred at $x = 0$ with $U(0) = -3\hbar^2/mL^2$.

Calculate the number of particles at any given energy level with energy KT above the ground state energy as per Maxwell-Boltzmann Statistics when the number of particles at ground state in N_0.

(a) Write down the Fermi-Dirac equation for the probability of occupation of an energy level E by an electron.

(b) How does it vary with temperature? Explain it with diagram.

(c) Find the temperature at which there is 99 % probability that a state with 0.5 eV energy above the Fermi energy is unoccupied.


(i)
Ψ (x)
x
-L
0
L
(ii)
Ψ (x)
x
-L
0
L
(iii)
Ψ (x)
x
-L
0
L
(iv)
Ψ (x)
x
-L
0
L

Suppose the velocity of an electron in an atom is known to an accuracy of 2.0×10^3 m/s (reasonably accurate compared with orbital velocities). What is the electron's minimum uncertainty in position, and how does this compare with the approximate 0.1-nm size of the atom?

What is the physical significance of wavefunction associated quantum particle. What are the properties that make this wavefunction an acceptable solution to Schrodinger's equation.

A free electron is confined in an infinite 1 D potential well of length L. Find the probability of locating it between 0.3L and 0.5L if it is in its first excited state.

What are degenerate states? Illustrate the concept of degeneracy by writing the wavefunctions and energy of the lowest triply degenerate state of a free particle of mass *m* confined in an infinite 3D cubical potential well of side *L*.

An electron is confined in an infinite 1 D potential well of length 15 A°. If its de Broglie wavelength is 10 A° , the electron is in its _____________ excited state within the potential well.

An electron is accelerated by a potential of 800V. It will exhibit wave nature when it interacts with structures of dimension close to _______________.

Ans: $\frac{h}{\sqrt{2meV}}$ = 43.4 pm

What is the ratio of the energy radiated at frequency of 193 THz at 500 K as per Planck's theory to that given by Rayleigh-Jeans? (Given h =6.63×10^{-34} J-s and k=1.38×10^{-23}J/K.

CO_2 molecule has a peak absorption at 4.2 microns. A CO_2 sensor that quantifies CO_2 through the absorption loss at this 4.2 micron is to be made using blackbody as the source with peak emission at this wavelength. What should be the temperature at which the blackbody should be kept for detecting CO_2? (The peak emission of blackbody at 5000 K is observed at 560 nm)

As per quantum theory, an electron moves in

(a) constant potential (b) periodic potential (c) zero potential (d) a potential well