

DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

Module-I, Lecture-16

**Numericals Based on Fermi Level
and Fermi Distribution Function**

1. The Fermi level for potassium is 2.1eV. Calculate the velocity of the electron at the Fermi level.

Solution:-

We have the formula, $E_F = \frac{1}{2} m v_F^2$

Therefore, $v_F = (2E_F / m)^{1/2}$

$$= (2 \times 2.1 \times 1.602 \times 10^{-19} / 9.11 \times 10^{-31})^{1/2}$$

$$v_F = 8.6 \times 10^5 \text{ m/s.}$$

2 . Evaluate the Fermi function for energy $K_B T$ above the Fermi energy.

Solution:

We know Fermi Function $F(E) = \frac{1}{1 + e^{(E-E_F)K_B T}}$

For an energy $K_B T$ above Fermi energy

$$E - E_F = K_B T$$

$$F(E) = \frac{1}{1 + e^1} = \frac{1}{1 + 2.7183}$$

Fermi distribution function $F(E) = 0.2689$

3. The Fermi temperature of a metal is 24600 K. Calculate the Fermi velocity.

Solution:

Given data:

$$\text{Temperature} = 24600 \text{ K}$$

The relation between Fermi energy, Fermi velocity and Fermi temperature is given by

$$E_F = \frac{3}{2} K_B T_F = \frac{1}{2} m V_F^2$$

$$V_F = \sqrt{\frac{3 K_B T_F}{m}} = \sqrt{\frac{31.38 \times 10^{-23} \times 24600}{9.11 \times 10^{-31}}}$$

Fermi velocity

$$V_F = 863.30 \times 10^3 \text{ ms}^{-1}$$

4. Use the Fermi distribution function to obtain the value of $F(E)$ for $E - E_F = 0.01 \text{ eV}$ at 200K .

Given data:

Fermi Function $F(E) = \frac{1}{1 + e^{(E - E_F)/K_B T}}$

Boltzman constant $K_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$

$E - E_F = 0.01 \text{ eV} = 0.01 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-21} \text{ J}$

$T = 200 \text{ K}$

$$F(E) = \frac{1}{1 + e^{1.6 \times 10^{-21} / (1.38 \times 10^{-23} \times 200)}}$$

$$= \frac{1}{1 + e^{0.5797}}$$

$$= \frac{1}{1 + 1.7855} = \frac{1}{2.7855}$$

Fermi function

$F(E) = 0.3589$

5. At what temperature we can expect at 10% probability that electrons in silver an energy which is 1% above the Fermi energy? The Fermi energy of silver is 5.5 eV.

Ans: 290.2 K

6. Free electron density of Aluminum is $18.10 \times 10^{28} \text{ m}^{-3}$. Calculate its Fermi energy at 0 K.

Ans: 11.66 eV