Week 1 Practice Assignment

Sanjeev Patil

PhD scholar

Dept. of Metallurgical and Materials Engineering

IIT – Madras

NOC22 MM11

Fundamentals of Electronic Materials and Devices

Jan 2022

Prerequisites

- Calculator
- Attempted sample problems

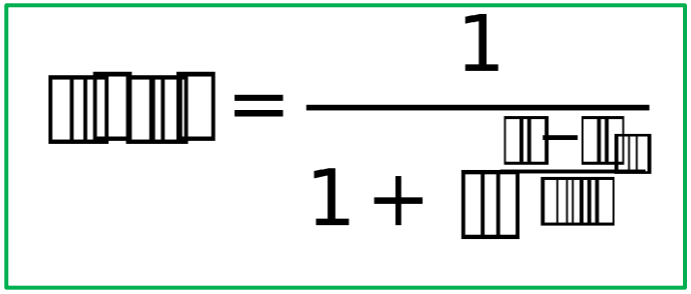
1. Unknown element X has resistivity 10^11 Ωm at 300 K. Is X
   a) Conductor
   b) Insulator
   c) Semiconductor

2. Unknown material Y has band gap of 1.5 eV. Is Y
   a) Conductor
   b) Insulator
   c) Semiconductor

Problem 1

1) In a metal, at some temperature ***T***, the probability of finding an electron **0.2 eV above the Fermi energy** is **1%** of the probability of finding the electron at the Fermi energy. What is the approximate value of ***T***? Give your answer in K and use the FEG model.

- ○ 200
- ○ 310
- ○ 440
- ○ 600



$E - E_F = 0.2$ eV $k = 1.38 \times 10^{-23}$ $m^2.kg.s^{-2}.K^{-1}$

$$\frac{1}{1 + e^{\frac{0.2}{kT}}} = 0.01 \times \frac{1}{1 + e^{0}}$$

Tip: take care to convert eV to J

T = 439 K

Problem 2

2) What is the density of states (**g(E)**) of a free electron gas (FEG) metal at an energy of 3 eV? Give your answer in units of $J^{-1}m^{-3}$.

- ○ 9.5×10^{46}
- ○ 7.3×10^{46}
- ○ 2.9×10^{44}
- ○ 1.4×10^{40}

$$g(E) = 8\pi\sqrt{2}\left(\frac{m_e}{h^2}\right)^{3/2} E_F^{1/2}$$

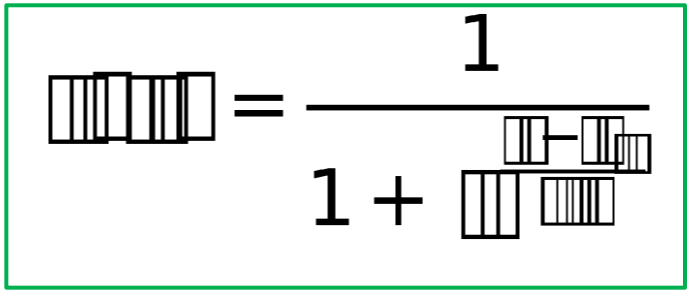
$m_e = 9.1\times10^{-31}$ kg; $h = 6.6\times10^{-34}$ $m^2.kg.s^{-1}$

$g(E) = 7.34\times10^{46}$ $J^{-1}m^{-3}$

Problem 4

4) In a FEG metal, what is the probability of finding an electron 25 meV **above** the Fermi energy? Take temperature to be 300 K.

- ○ 0.27
- ○ 0.37
- ○ 0.63
- ○ 0.73



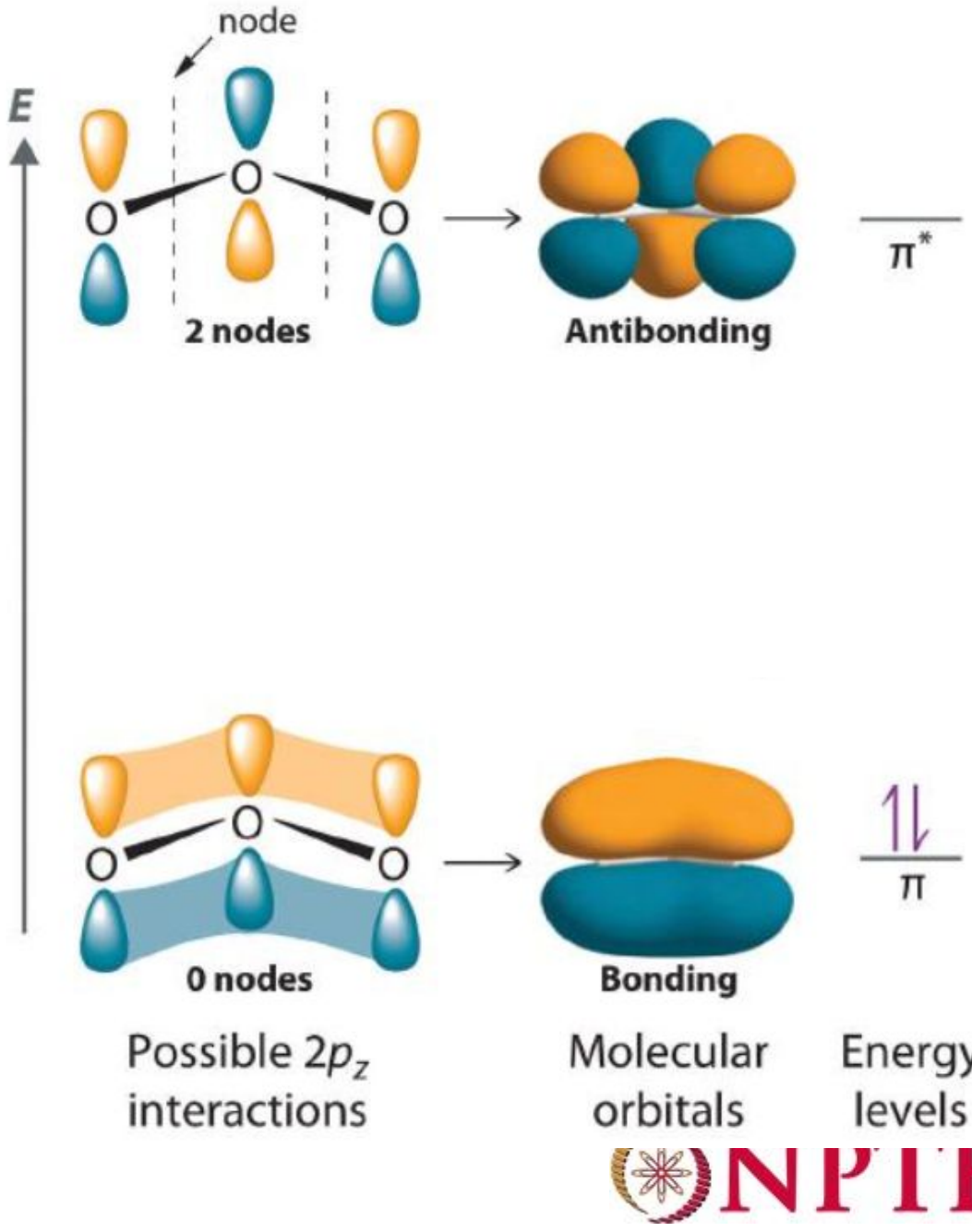
$E - E_F = 0.025$ eV

$$f(E) = \frac{1}{1+e}$$

f(E) = 0.27

Tip: $kT = 0.025$ eV for simpler calculation

Problem 3



Tip: *n* atomic orbitals = *(n-1)* nodes