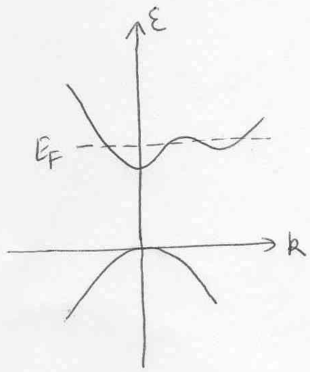
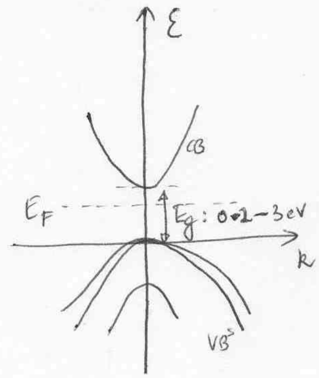
SOLID STATE DEVICES

ASSIGNMENT 1 : SOLUTIONS

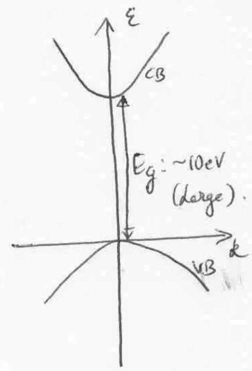
PROBLEM 1



METAL



SEMICONDUCTOR



INSULATOR

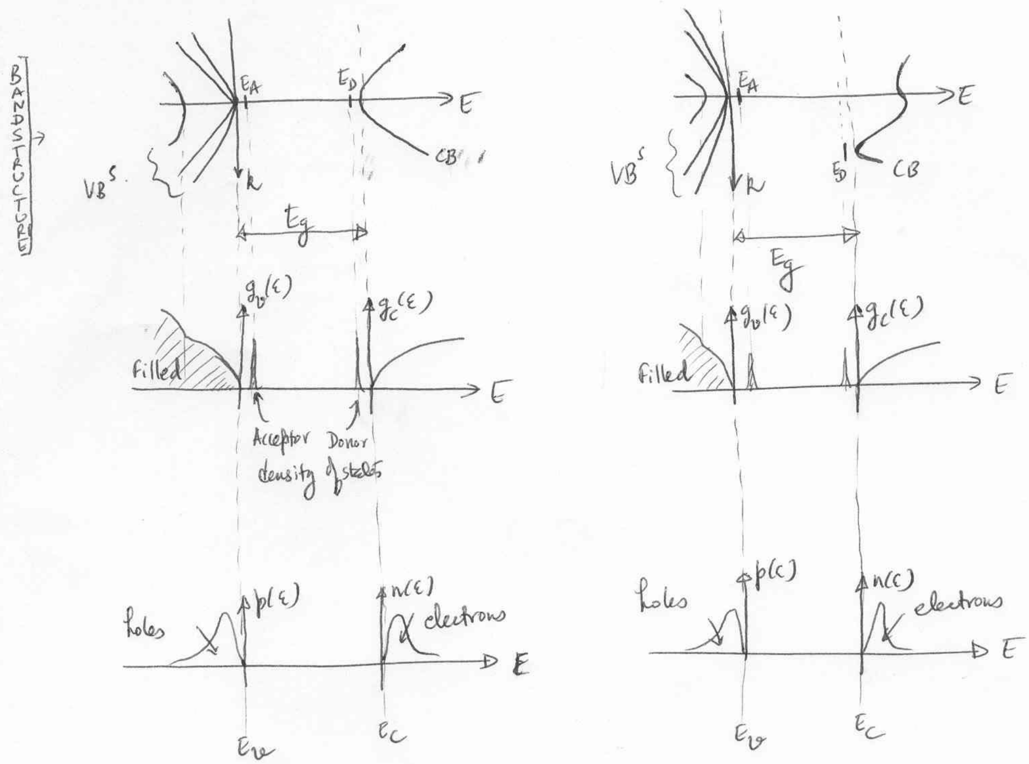
	METAL	SEMICONDUCTOR	INSULATOR
Atomic Density	$\sim 10^{22}/cm^3$	$\sim 10^{22}/cm^3$	$\sim 10^{22}/cm^3$
Mobile Carrier Density	$\sim 10^{22}/cm^3$	$\sim 10^{10}/cm^3$ (for Si)	~ 0
Electrical Conductivity	$\sim 10^{5}/\Omega\cdot cm$	$\sim 0.1/\Omega\cdot cm$	$\sim 0/\Omega\cdot cm$.

The large difference in electronic/optical properties stem from the bandgaps & the location of Fermi-level. In metals, E_F is inside a band, which being partially empty, leads to high conductivity. In a semi^c, E_F is in the gap; so carriers have to be thermally activated across the gap; only those carriers with energy $kT > E_g$ contribute. For insulators, E_g is too high for thermal activation

ASSGN I   EE566: Solid State Devices.

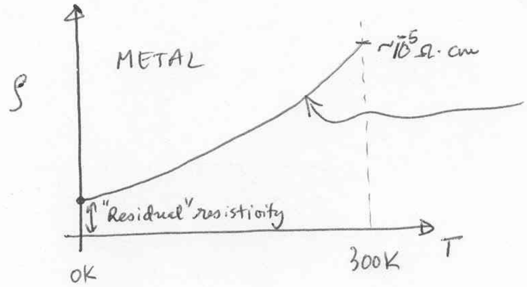
PROBLEM 2:

DIRECT GAP   INDIRECT GAP



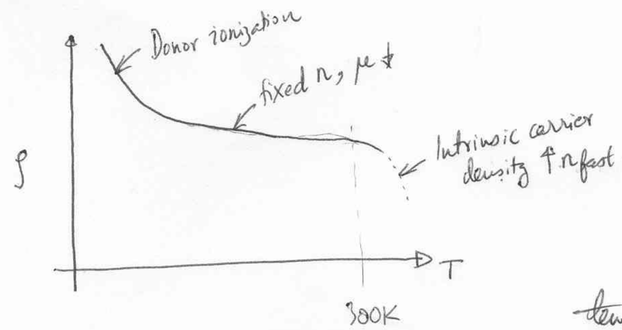
NOTE: DONORS & ACCEPTORS INTRODUCE STATES IN THE GAP. So, they have a "sharp" density of states at energies E_D & E_A respectively.

Problem 3



The mobile carrier density in metals does not change with T (it is degenerate).

As temperature increases, the atoms vibrate more ⇒ more phonon scattering ⇒ mobility of electrons reduces. Therefore, ρ↑.



Since carriers are thermally activated in semiconductors, at lowest temperatures, it behaves like an insulator. ~~At~~ Once all donors are ionized, n stays fixed, but μ↓ (phonon scattering), so ρ↑ slightly.

At even higher temperatures, when $n_i \gg N_D$, the intrinsic carrier density is very high, and resistivity drops. The semiconductor becomes like a metal (provided it does not melt!)