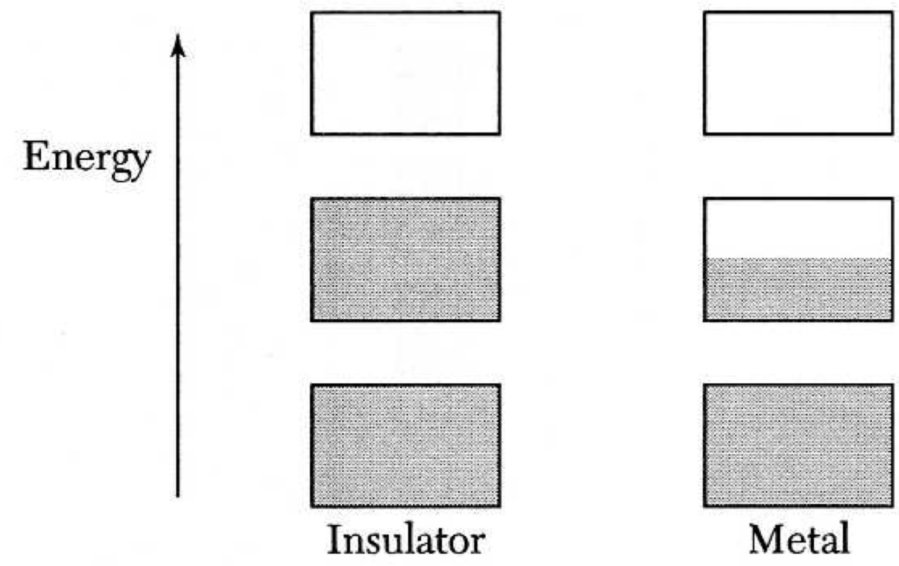
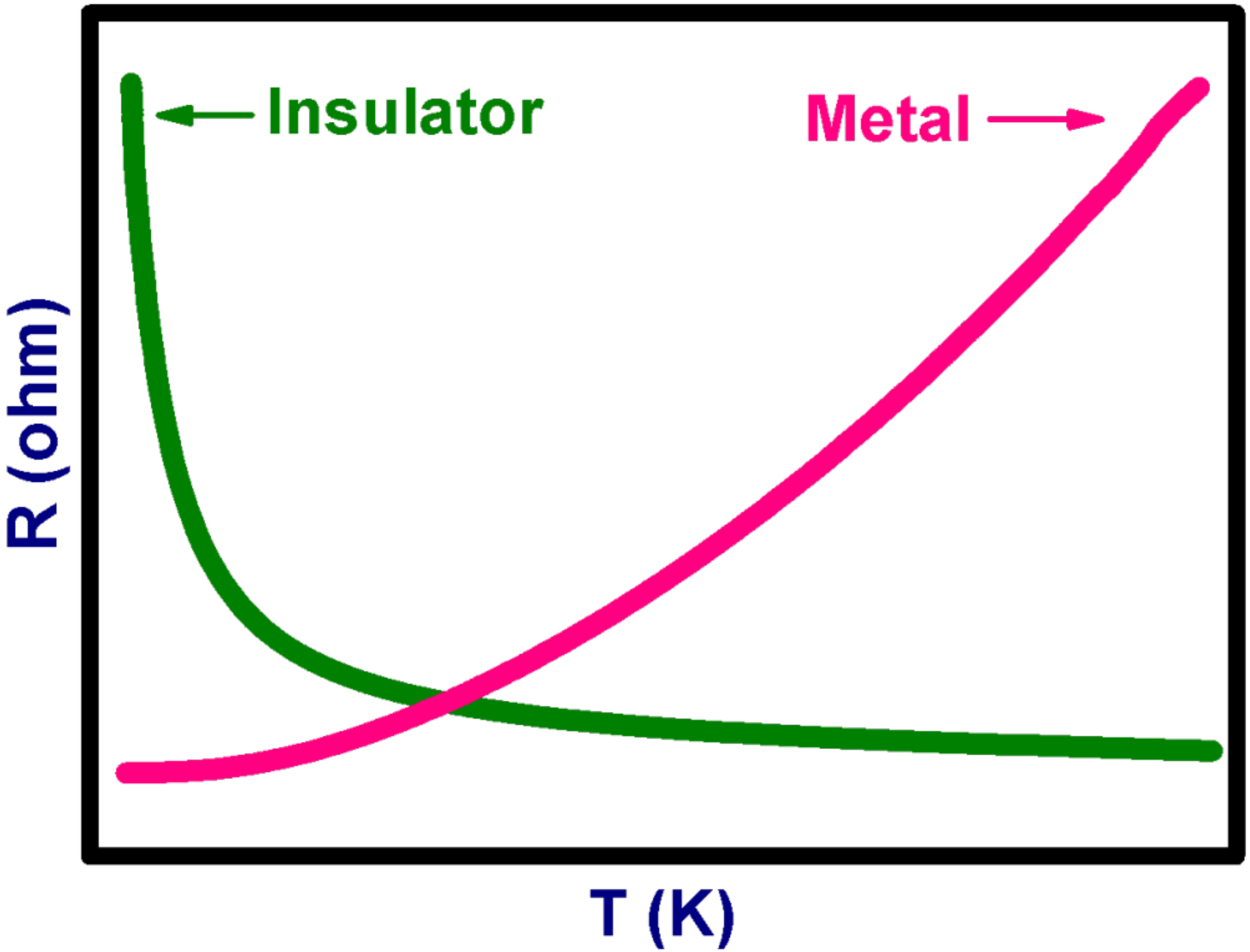
#	Dates	Title	Exercise	(1=easy, 10=hard)	Tasks
1	22.2	Introduction	VESTA	**2-3**	**Read Chap. 1**
2	01.3	Crystal structures	Daniel - info	**4**	**Read Chap. 2, Ex. 1**
3	08.03	Reciprocal space	Discuss Ex. 1	**6**	**Read Chap. 2, Ex. 2**
4	15.03	Scattering Theory	Discuss Ex. 2	**8-9**	**Read Chap. 3, Ex. 3**
5	22.03	Crystal bindings	Discuss Ex. 3	**5**	**Read Chap. 4, Ex. 4**
6	29.03	Phonons	Discuss Ex. 4	**5-6**	**Read Chap. 5, Ex. 5**
7	05.04	Thermal properties	Discuss Ex. 5	**5-6**	**Read Chap. 6, Ex. 6**
8	12.04	Electron gasses, C_{el}	Discuss Ex. 6	**5-6**	**Read Chap. 7, Ex. 7**
--	19.04	EASTER HOLIDAY	-------------------	**0**	**RECAP**
9	26.04	Electronic band struc.	Discuss Ex. 7	**5-6**	**Read Chap. 8, Ex. 8**
10	03.05	Semi-conductors	Discuss Ex. 8	**6**	**Read Chap. 9, Ex. 9**
11	10.05	Fermi surfaces & Metals - I	Discuss Ex. 9	**8**	**Read Chap. 9, Ex. 10**
12	17.05	Fermi surfaces & Metals - II	Discuss Ex. 10	**8**	**Read Chap. 9, Ex. 11**
13	24.05	Guest lecture	Discuss Ex. 11	**--**	
14	31.05	Repetition		**4**	

#	Dates	Title	Tasks
10	03.05	Semi-conductors	**Read Chap. 6: Motion in magnetic fields p. 163-167** **Read Chap. 9: Introduction to Fermi surfaces p. 235-244** **Read Chap. 9: Experimental methods in FS studies p. 255-265**
11	10.05	Fermi surfaces & Metals - I	**Read Chap. 9: Experimental methods in FS studies p. 255-265**
12	17.05	Fermi surfaces & Metals - II	**Read Chap. 9 : Calculation of energy bands 244 -255** **(Perhaps an extra exercise)**
13	24.05	Guest lecture	
14	31.05	Repetition	

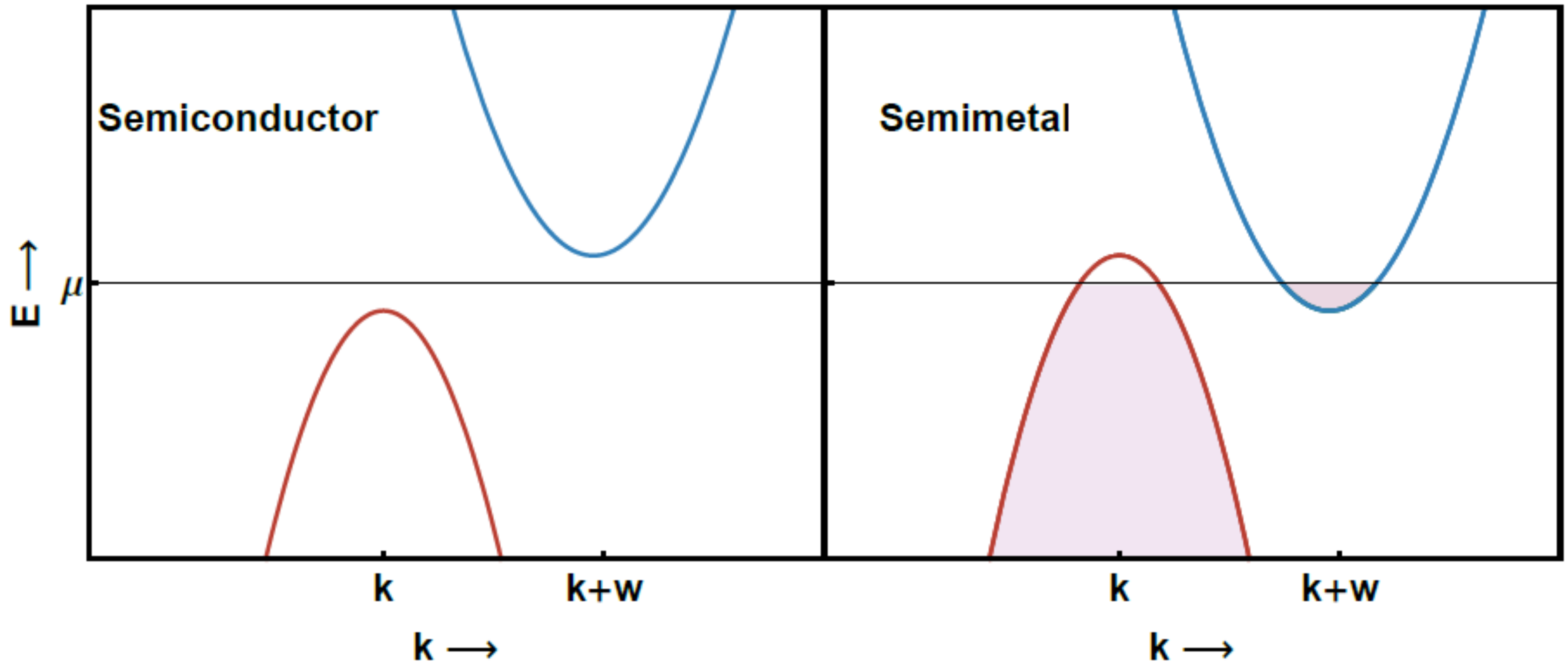
Metals & Insulators



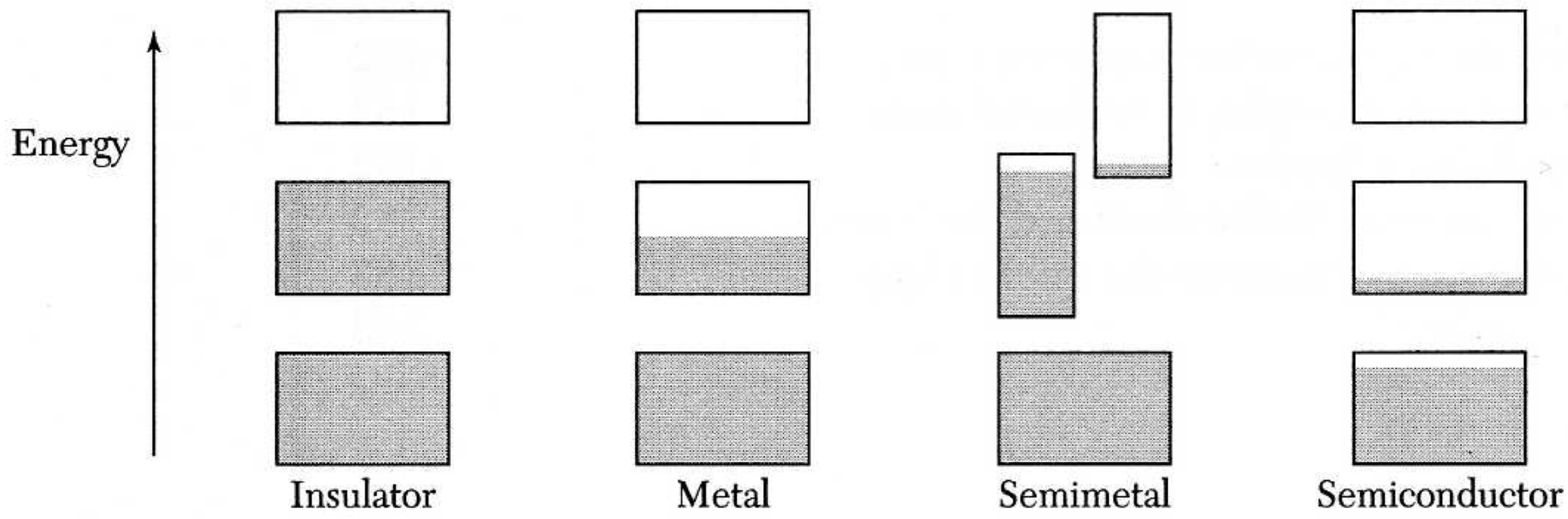
Metals and insulators: Resistivity



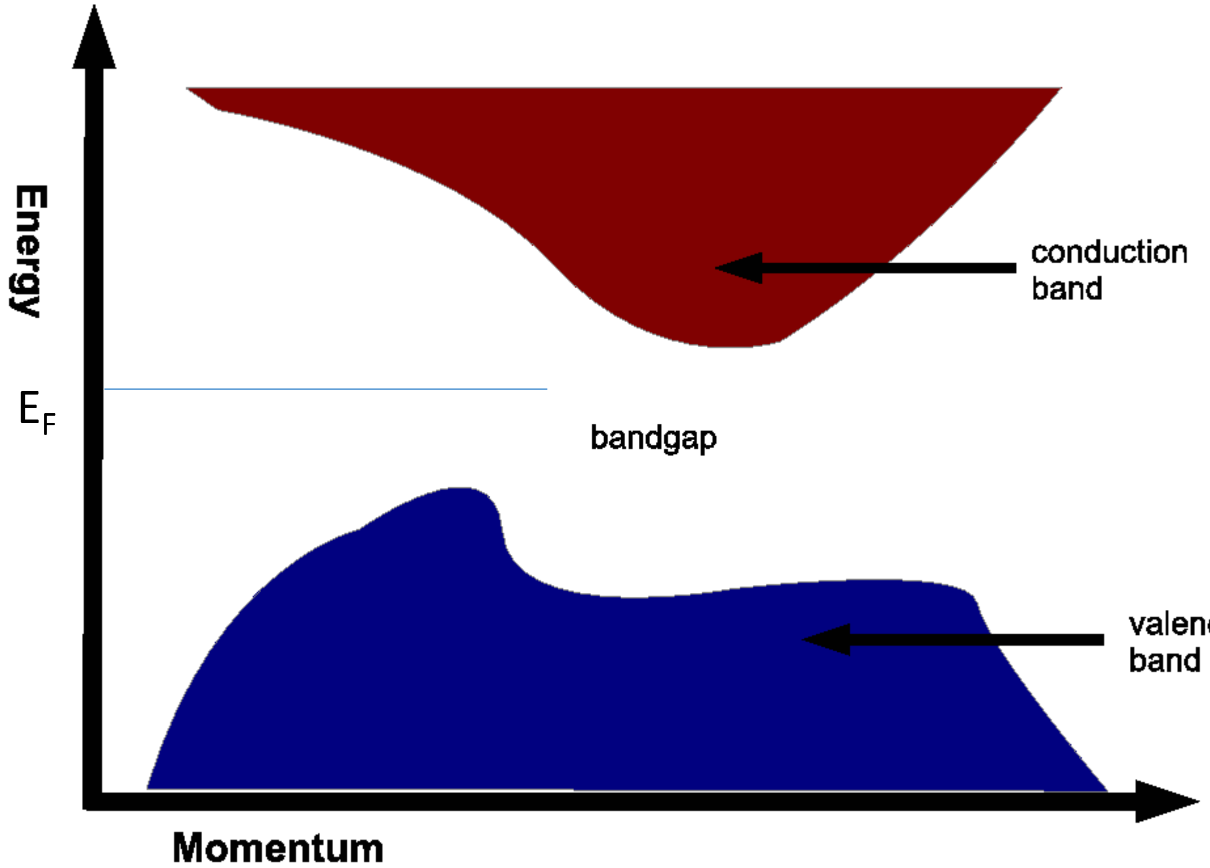
Semimetals & Semiconductors



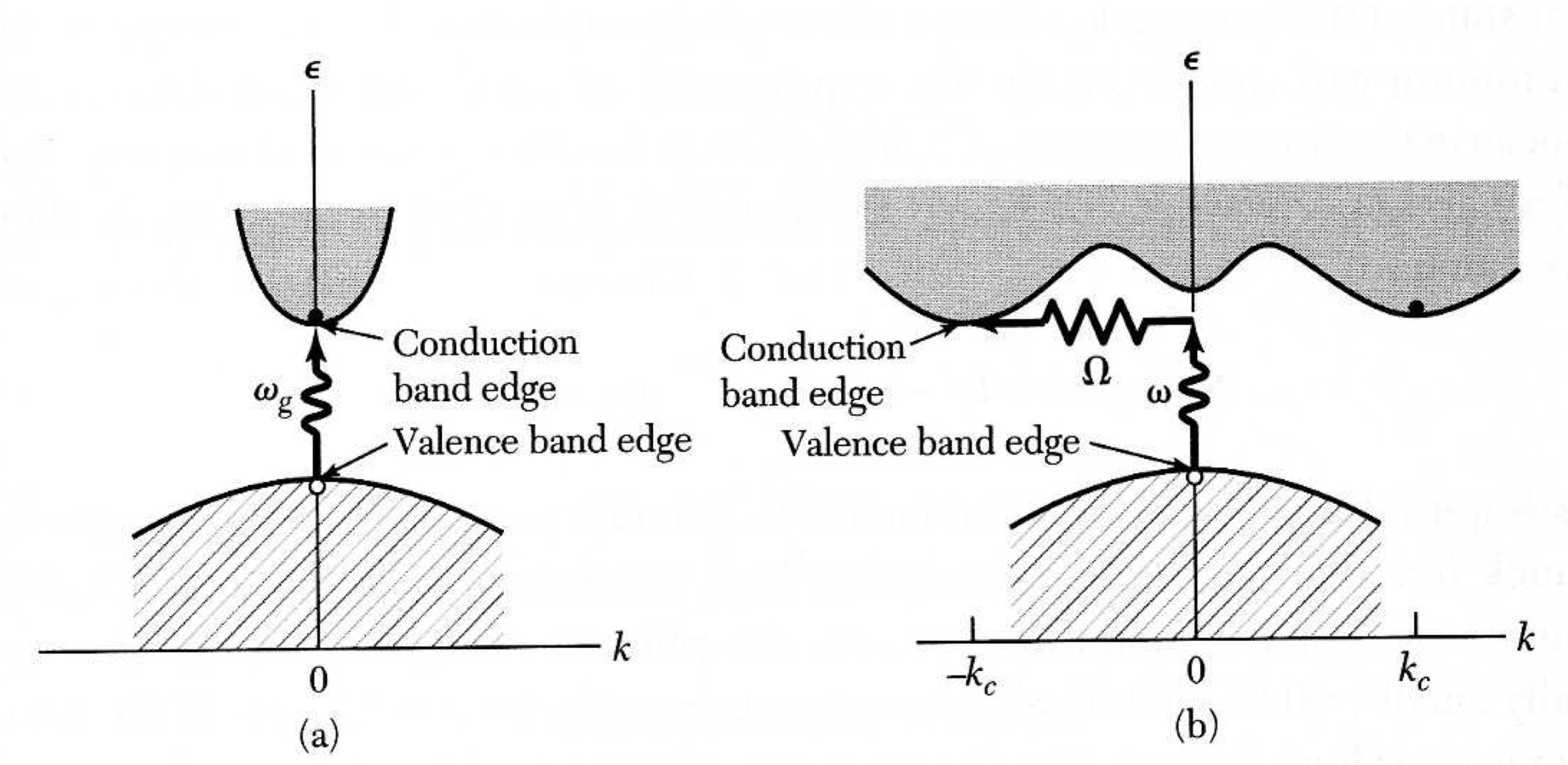
Semimetals & Semiconductors



Valence and conduction band



Direct and indirect gap



Semiconductor gaps versus k_BT

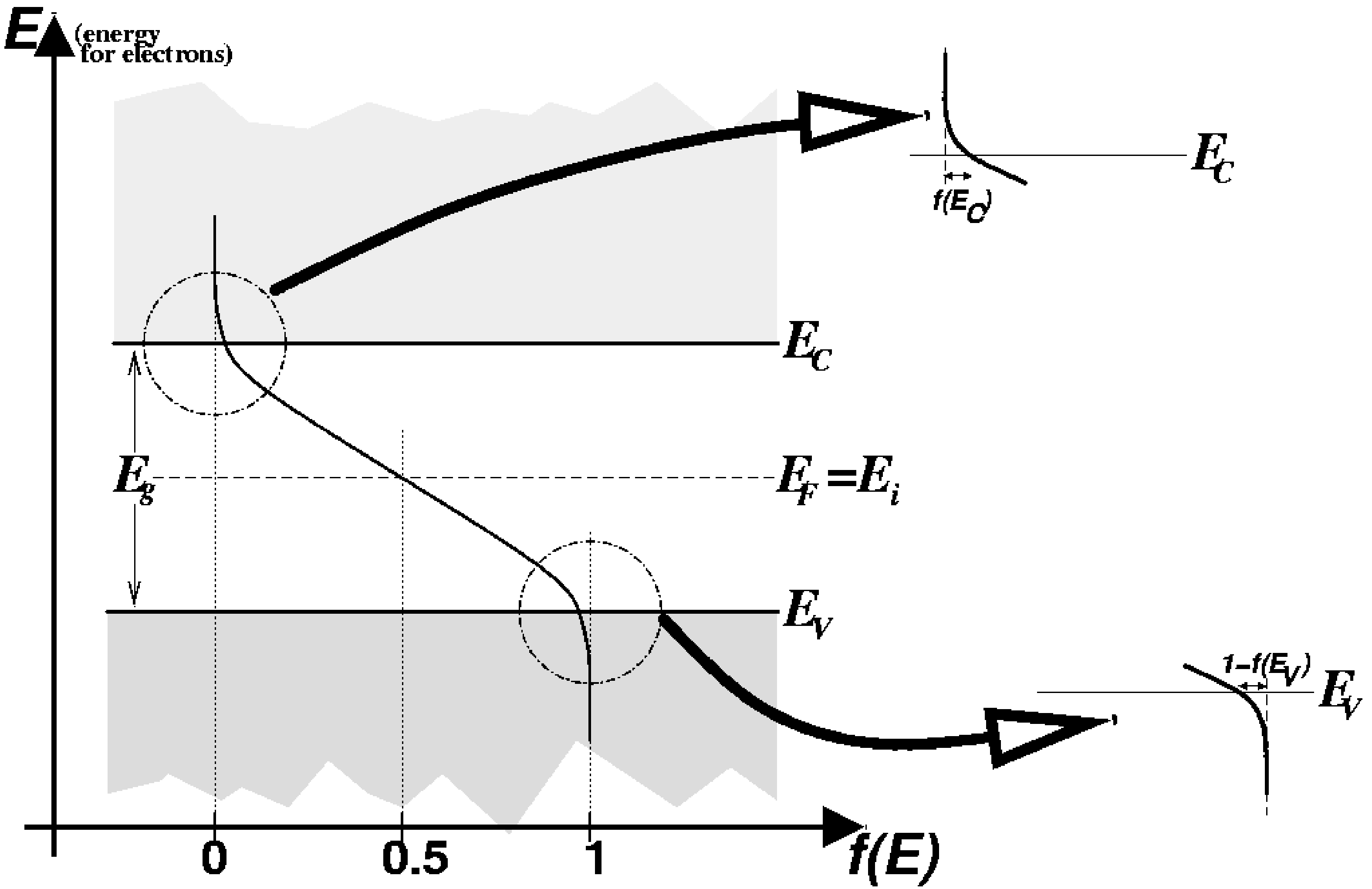
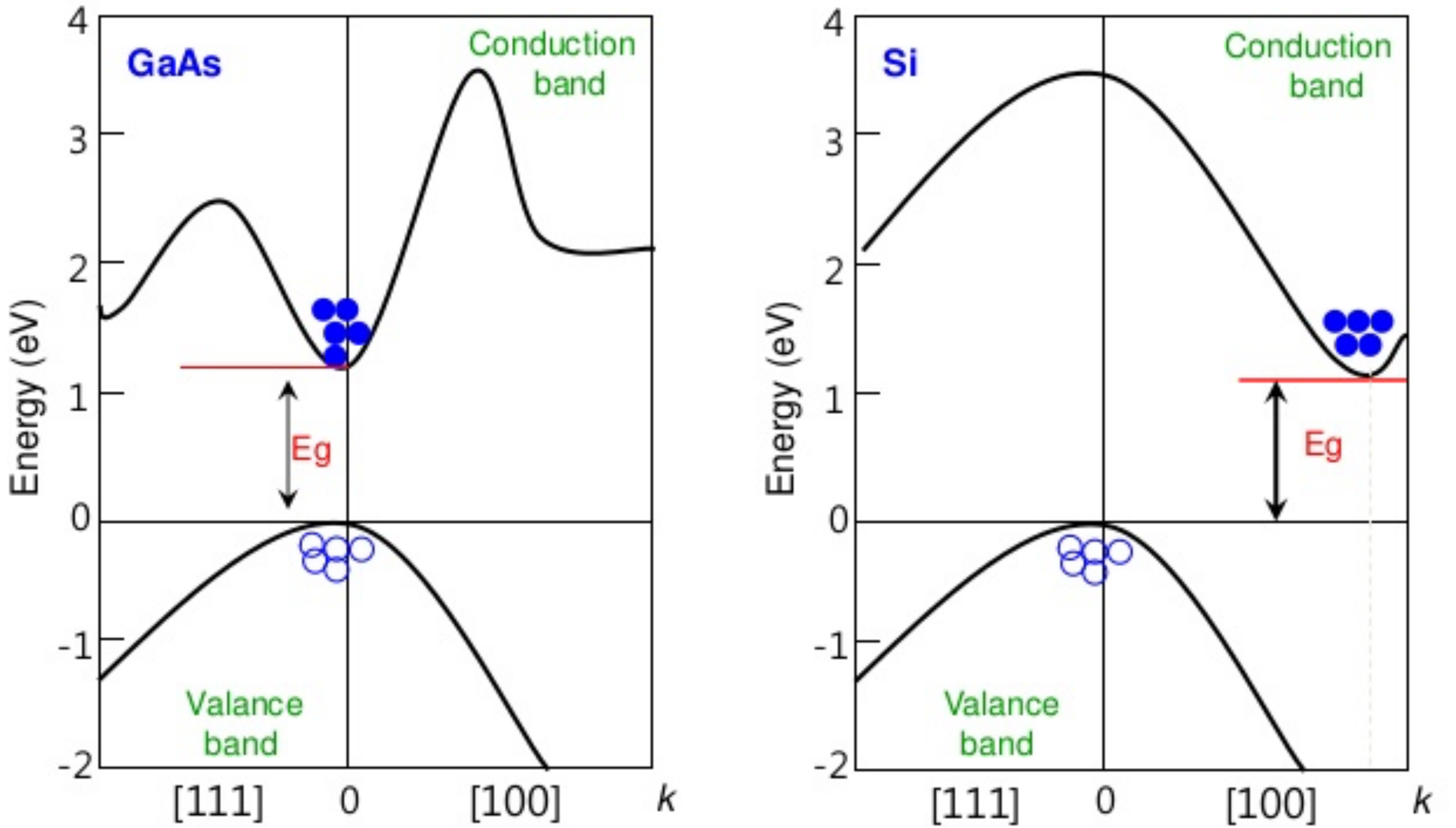


Figure 4:

Band Structure of Semiconductors



Energy band structures of *GaAs* and *Si*

Semiconductor gaps

Table 1 Energy gap between the valence and conduction bands
(i = indirect gap; d = direct gap)

		E_g, eV				E_g, eV	
Crystal	Gap	0 K	300 K	Crystal	Gap	0 K	300 K
Diamond	i	5.4		SiC(hex)	i	3.0	—
Si	i	1.17	1.11	Te	d	0.33	—
Ge	i	0.744	0.66	HgTe[a]	d	−0.30	
αSn	d	0.00	0.00	PbS	d	0.286	0.34–0.37
InSb	d	0.23	0.17	PbSe	i	0.165	0.27
InAs	d	0.43	0.36	PbTe	i	0.190	0.29
InP	d	1.42	1.27	CdS	d	2.582	2.42
GaP	i	2.32	2.25	CdSe	d	1.840	1.74
GaAs	d	1.52	1.43	CdTe	d	1.607	1.44
GaSb	d	0.81	0.68	SnTe	d	0.3	0.18
AlSb	i	1.65	1.6	Cu_2O	d	2.172	—

[a]HgTe is a semimetal; the bands overlap.

Electronic masses

Crystal	Electron m_e/m
InSb	0.015
InAs	0.026
InP	0.073
GaSb	0.047
GaAs	0.066
Cu_2O	0.99

Reading Kittel carefully,
following notation is adopted.
m = is the free electron mass.
m_e = effective crystal electron mass

Conduction Electron Concentration

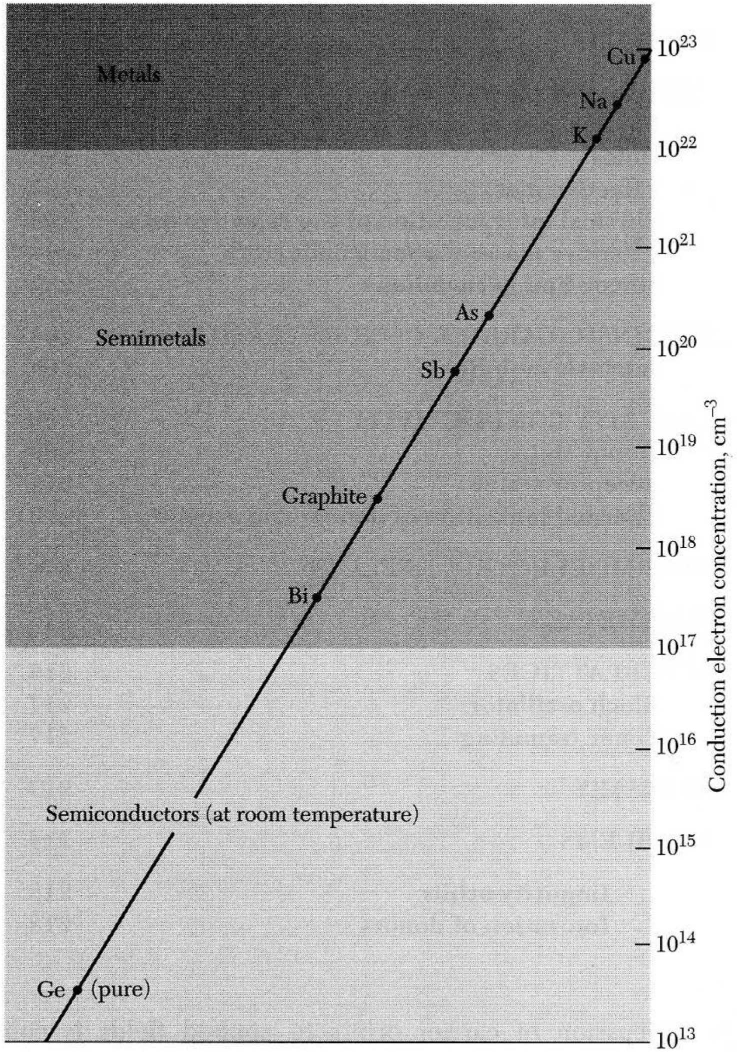


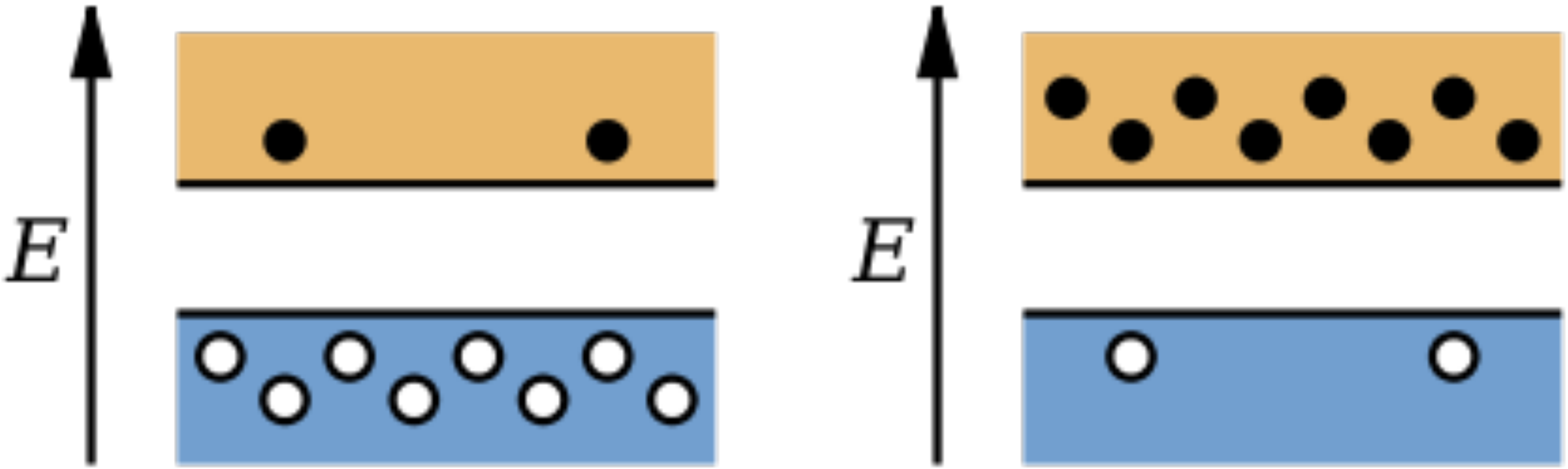
Figure 1 Carrier concentrations for metals, semimetals, and semiconductors. The semiconductor range may be extended upward by increasing the impurity concentration, and the range can be extended downward to merge eventually with the insulator range.

Electronic mobility

Table 3 Carrier mobilities at room temperature, in cm^2/V-s

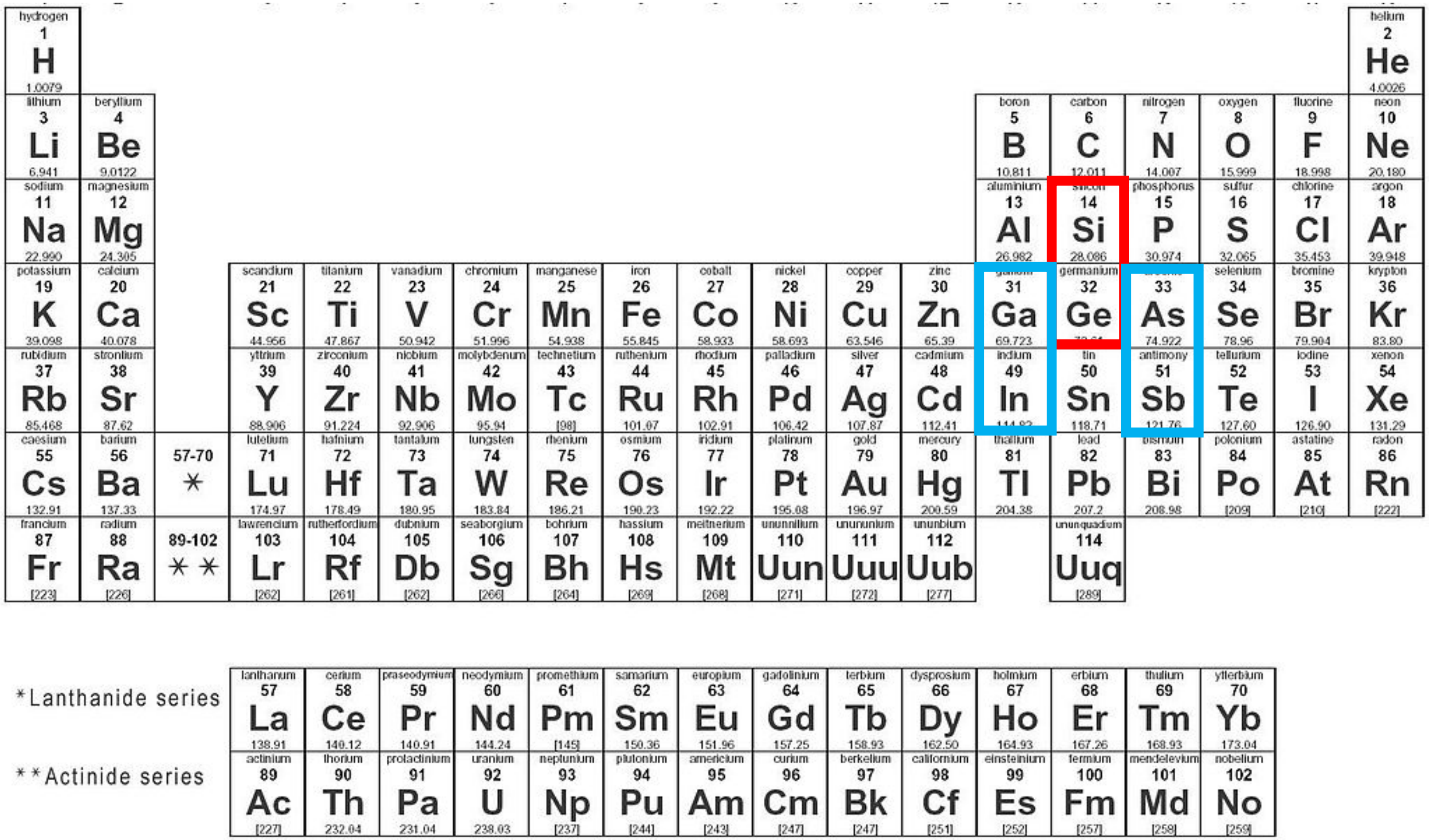
Crystal	Electrons	Holes	Crystal	Electrons	Holes
Diamond	1800	1200	GaAs	8000	300
Si	1350	480	GaSb	5000	1000
Ge	3600	1800	PbS	550	600
InSb	800	450	PbSe	1020	930
InAs	30000	450	PbTe	2500	1000
InP	4500	100	AgCl	50	—
AlAs	280	—	KBr (100 K)	100	—
AlSb	900	400	SiC	100	10–20

n- and p-type semiconductors



Doping – Performance Enhancement

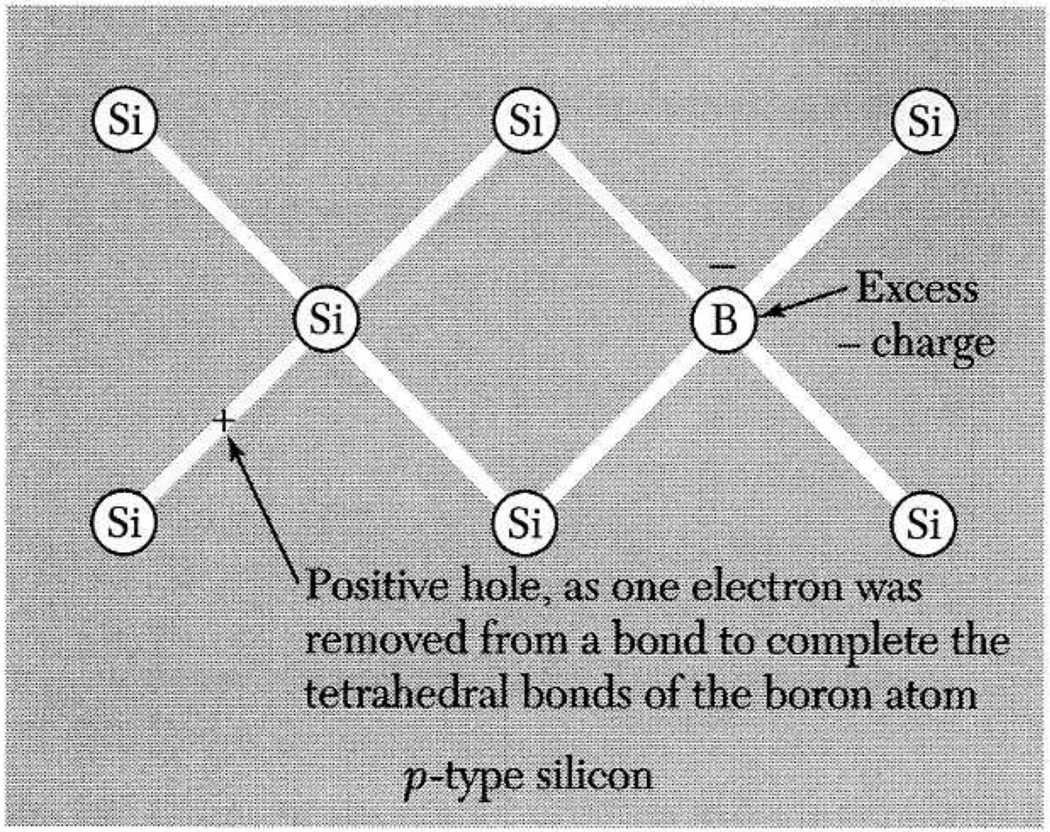
Semiconductor Materials

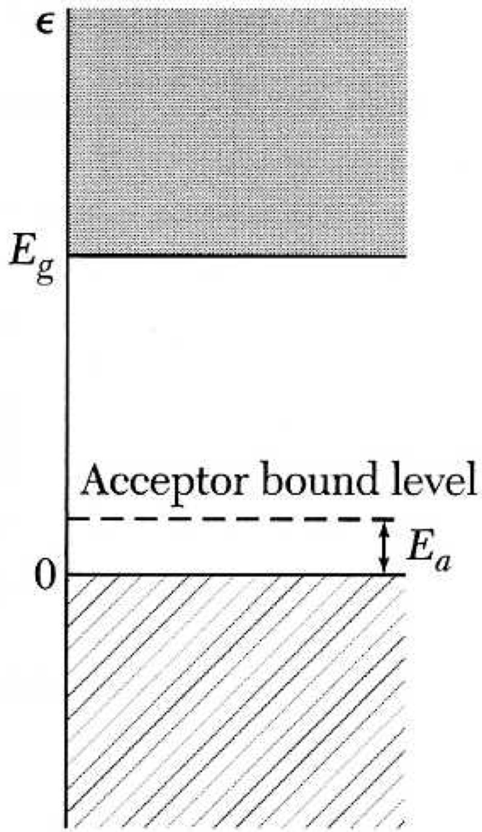


Diamond-type semiconductors

III – V compounds (GaAs, InSb)

Hole - doping



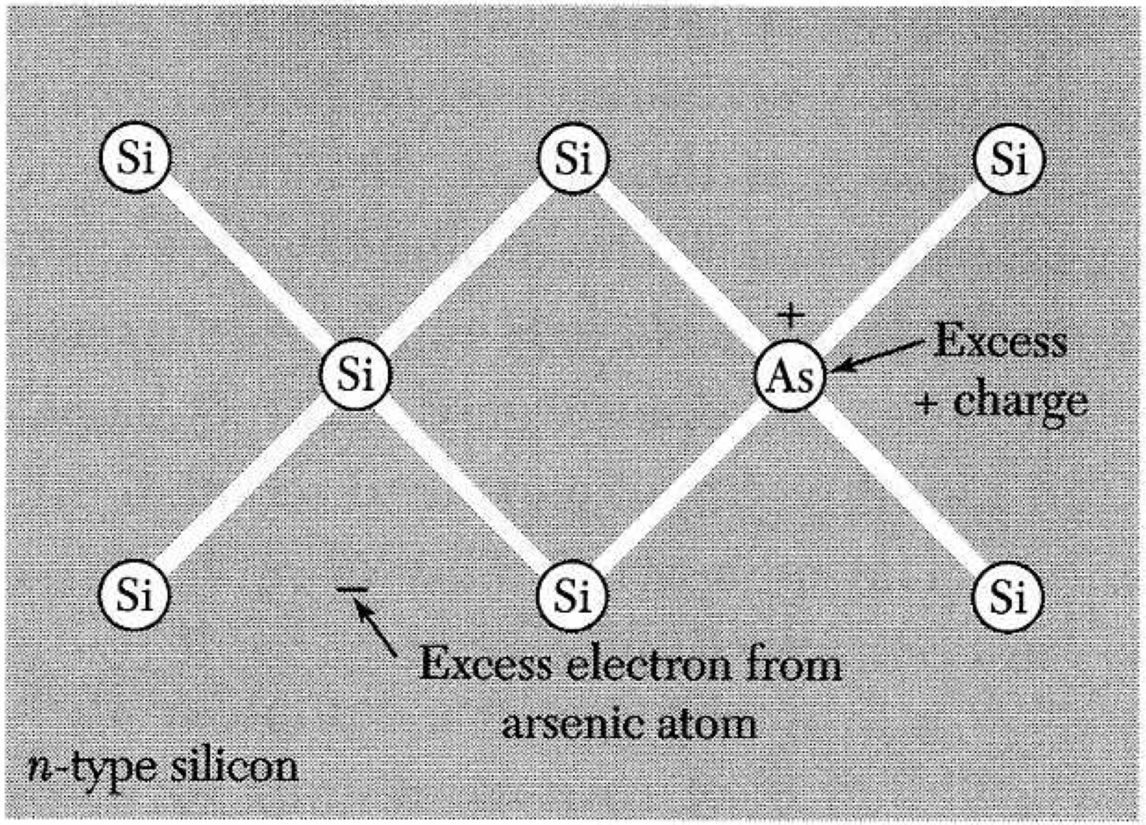


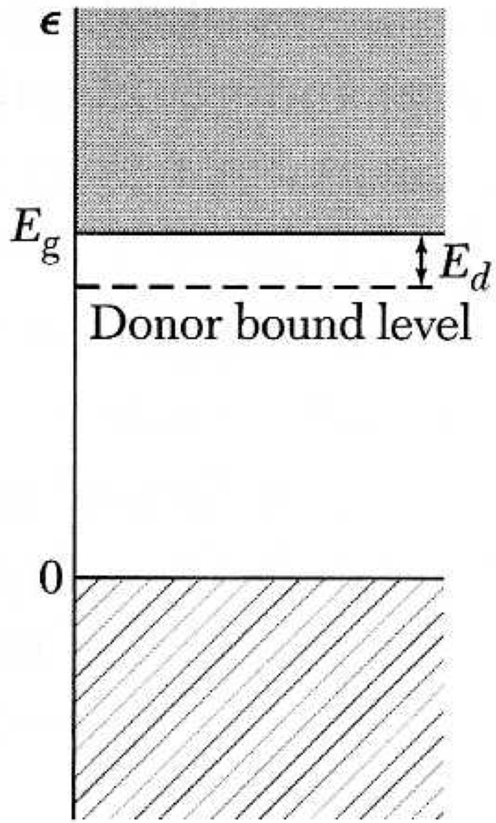
Si^{4+}

B^{3+}

From Kittel

Electron - doping





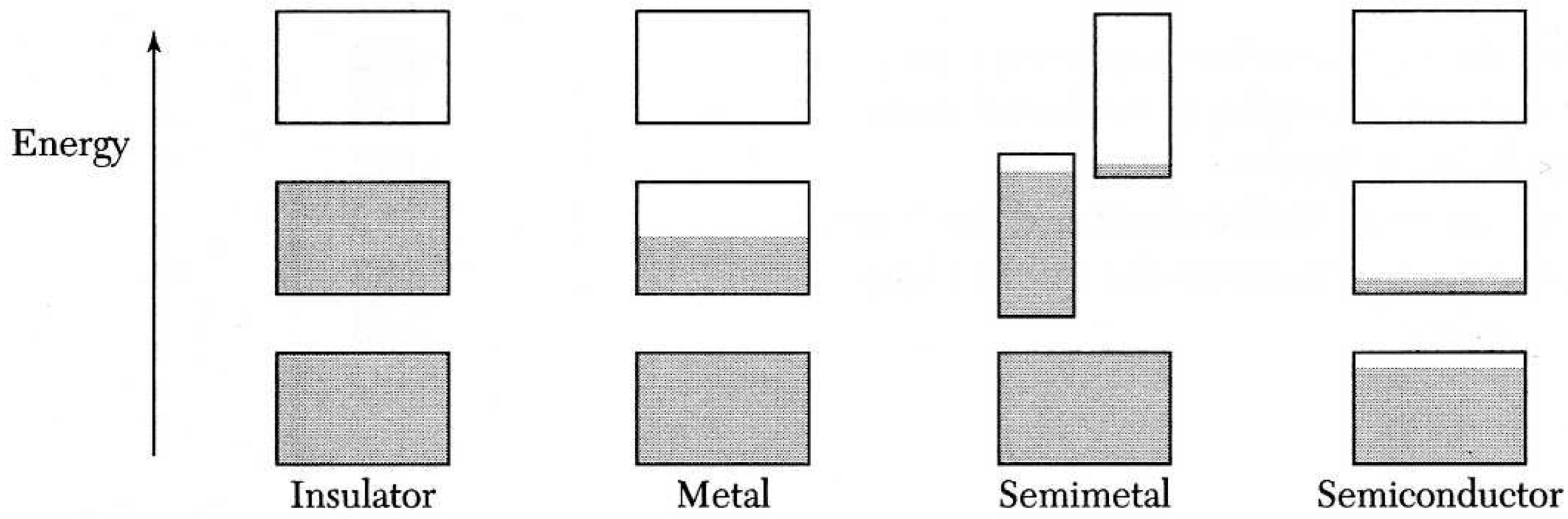
Si^{4+}

As^{5+}

From Kittel

Concluding quiz

Does a semiconductor have a Fermi surface? (yes/no)



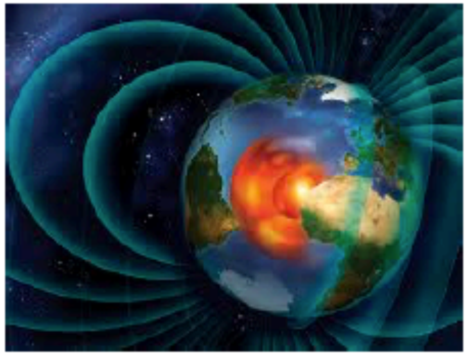
Does a semimetal have a Fermi surface? (yes/no)

Magnetic field

Human Brain

1 nG to 10 nG

Earth



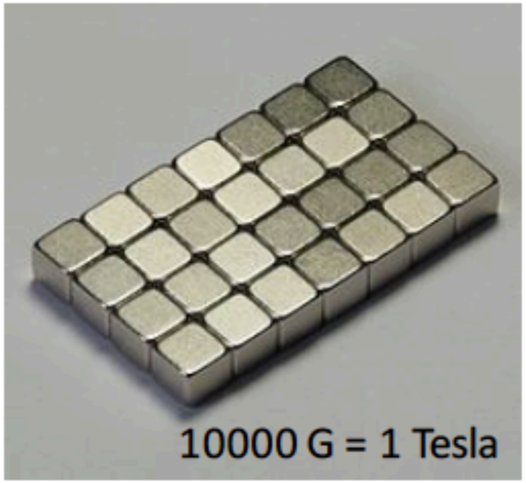
0.25 - 0.65 Gauss

Fridge Magnets

50 Gauss

Neodymium – iron – boron

$Nd_2Fe_{14}B$ Magnet



10000 G = 1 Tesla

Static 45 –Tesla

Hybrid magnet

100 Tesla

Pulsed magnet