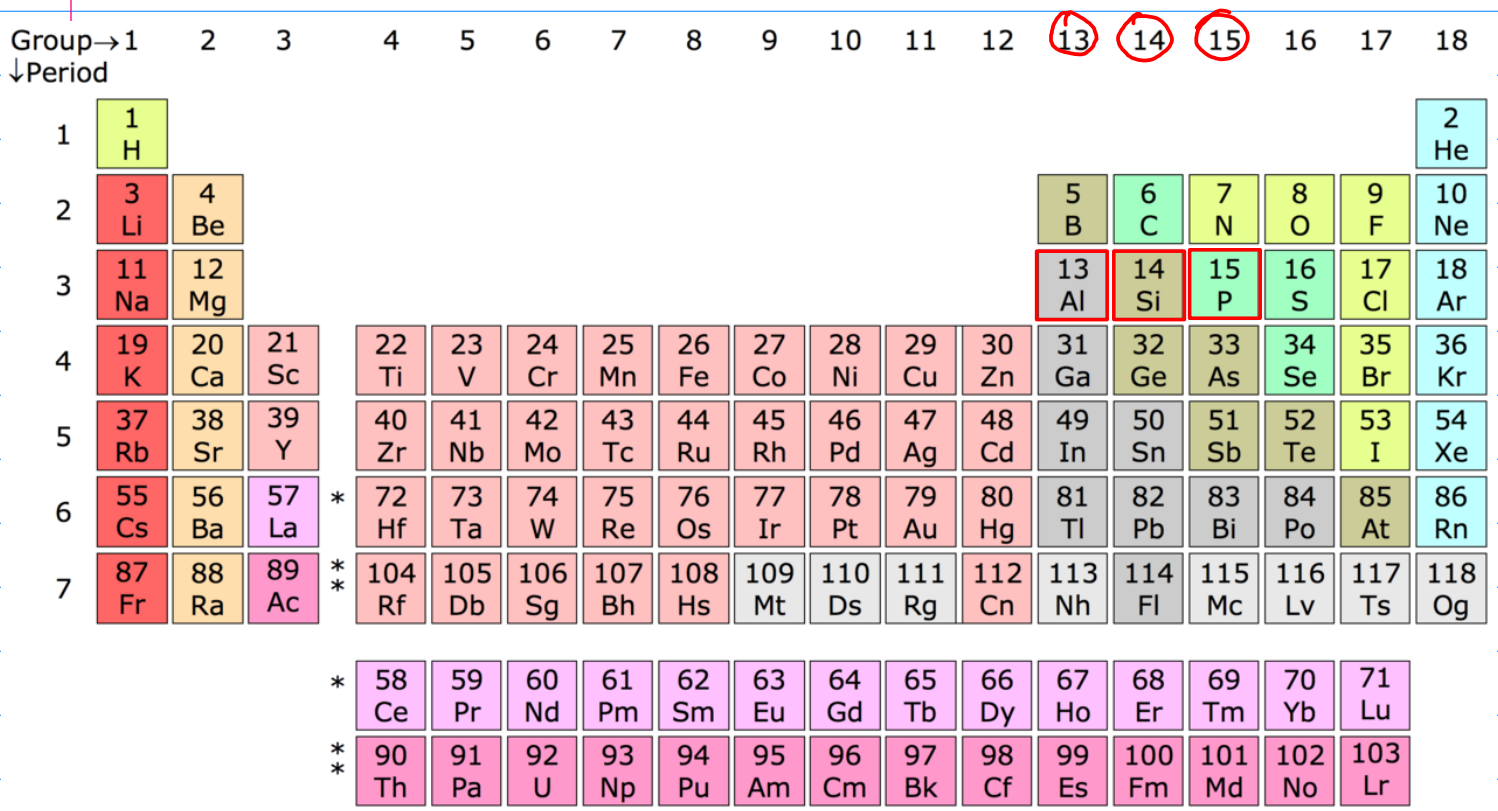
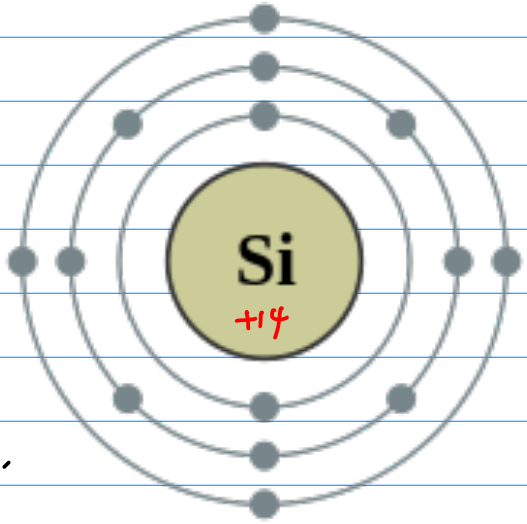
Semiconductor (H.1)

20170322

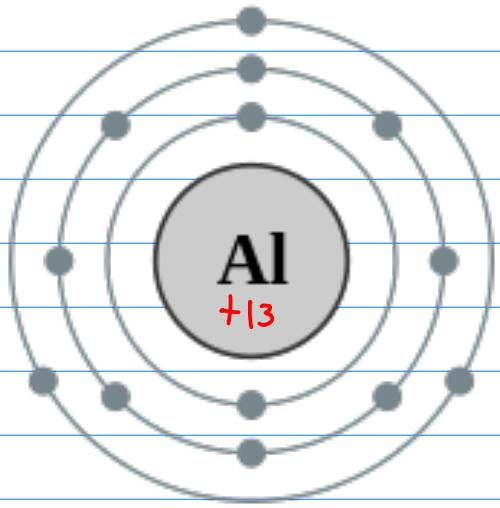

Group→ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
↓Period
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
57 La
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
87 Fr
88 Ra
89 Ac
104 Rf
105 Db
106 Sg
107 Bh
108 Hs
109 Mt
110 Ds
111 Rg
112 Cn
113 Nh
114 Fl
115 Mc
116 Lv
117 Ts
118 Og
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
71 Lu
90 Th
91 Pa
92 U
93 Np
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No
103 Lr

Number of Electrons

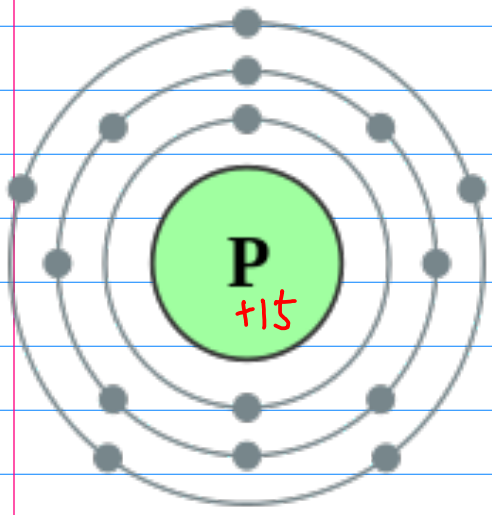
-14



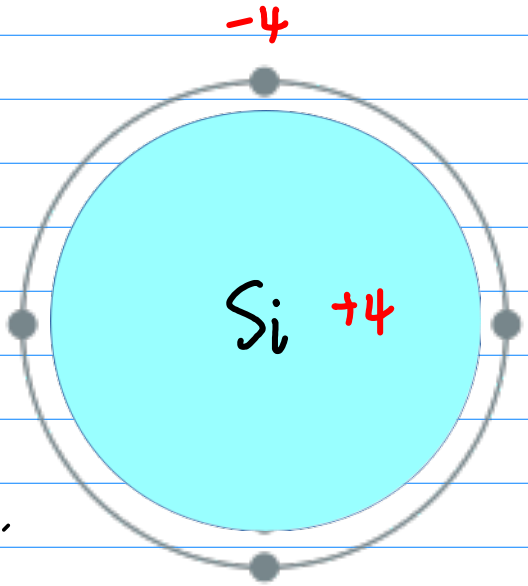
-13

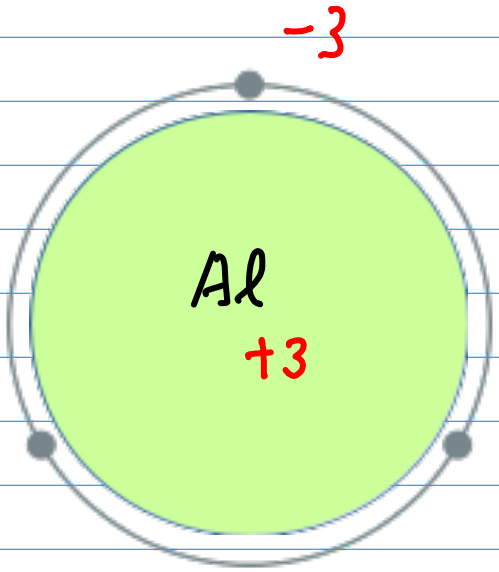


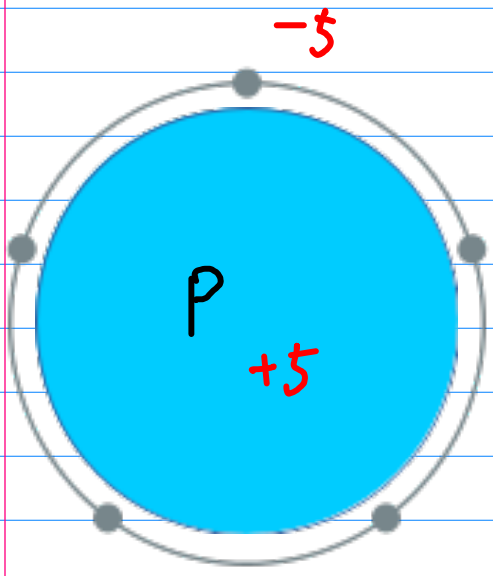
-15



Valence Electrons







Aluminum (Al), Boron (B)

(electron) acceptor

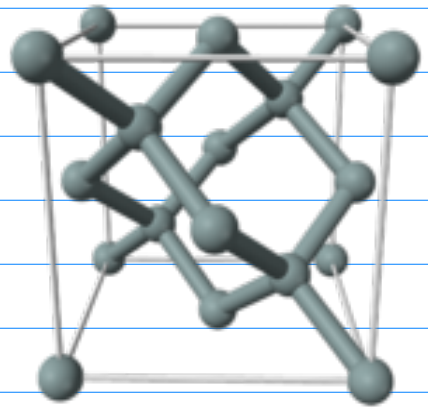
p-type impurity

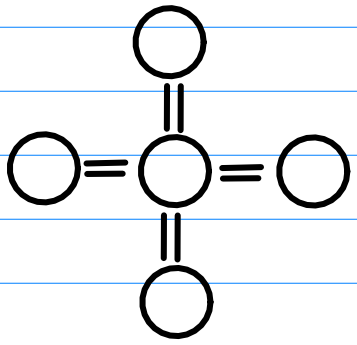
phosphorus (P), Antimony (Sb)

(electron) donor

n-type impurity

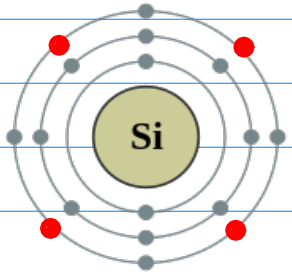
Silicon Crystal

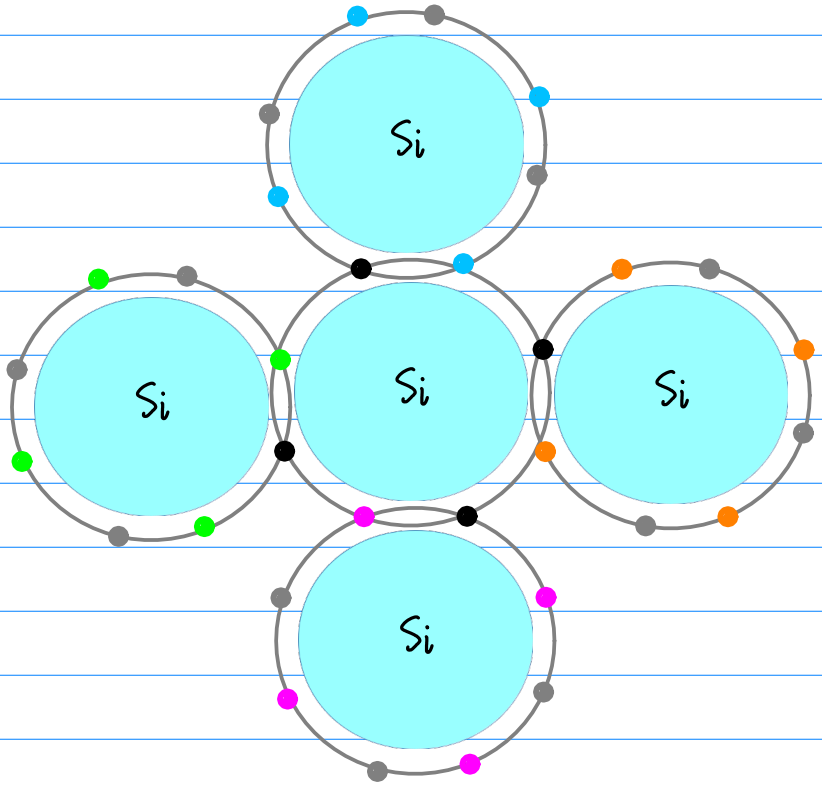




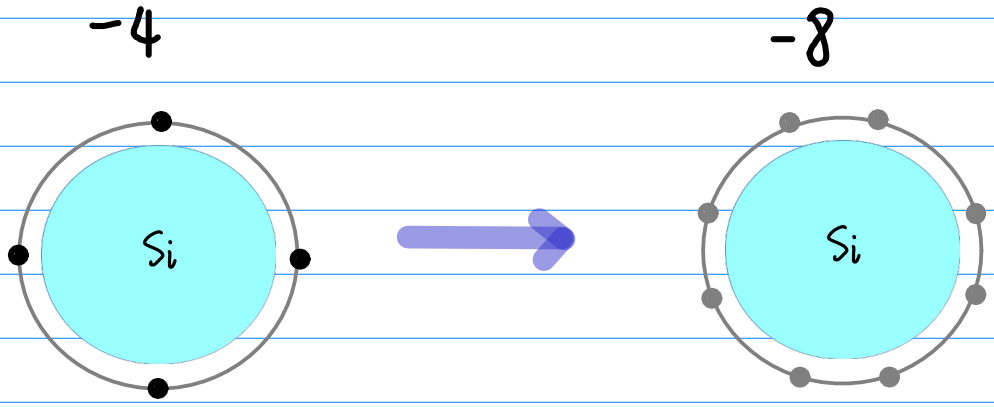
share electrons of neighor atoms

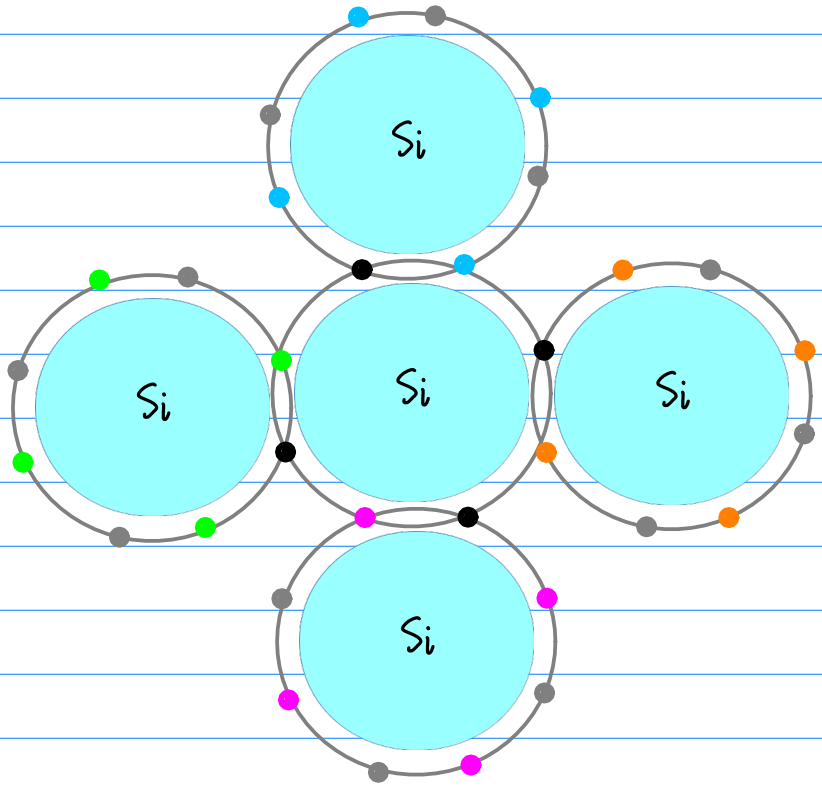
covalent bond



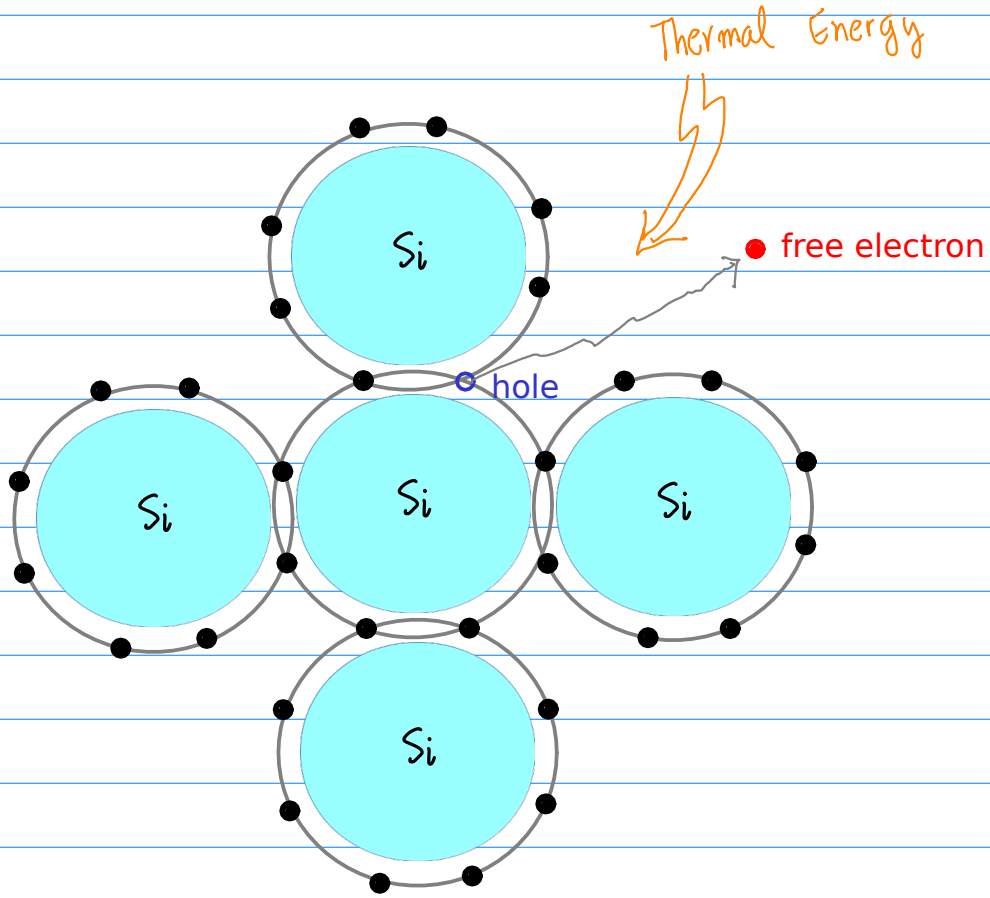


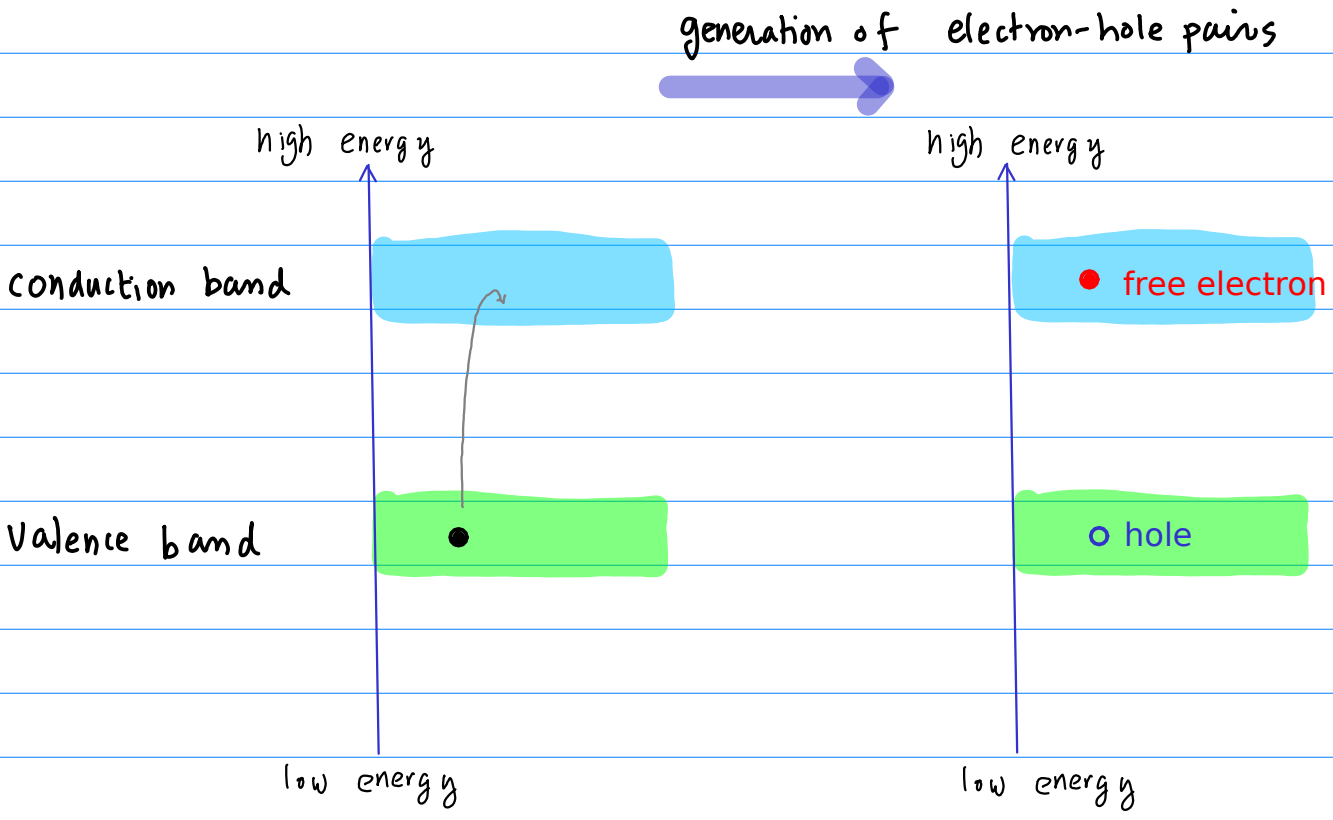
Covalent Bond



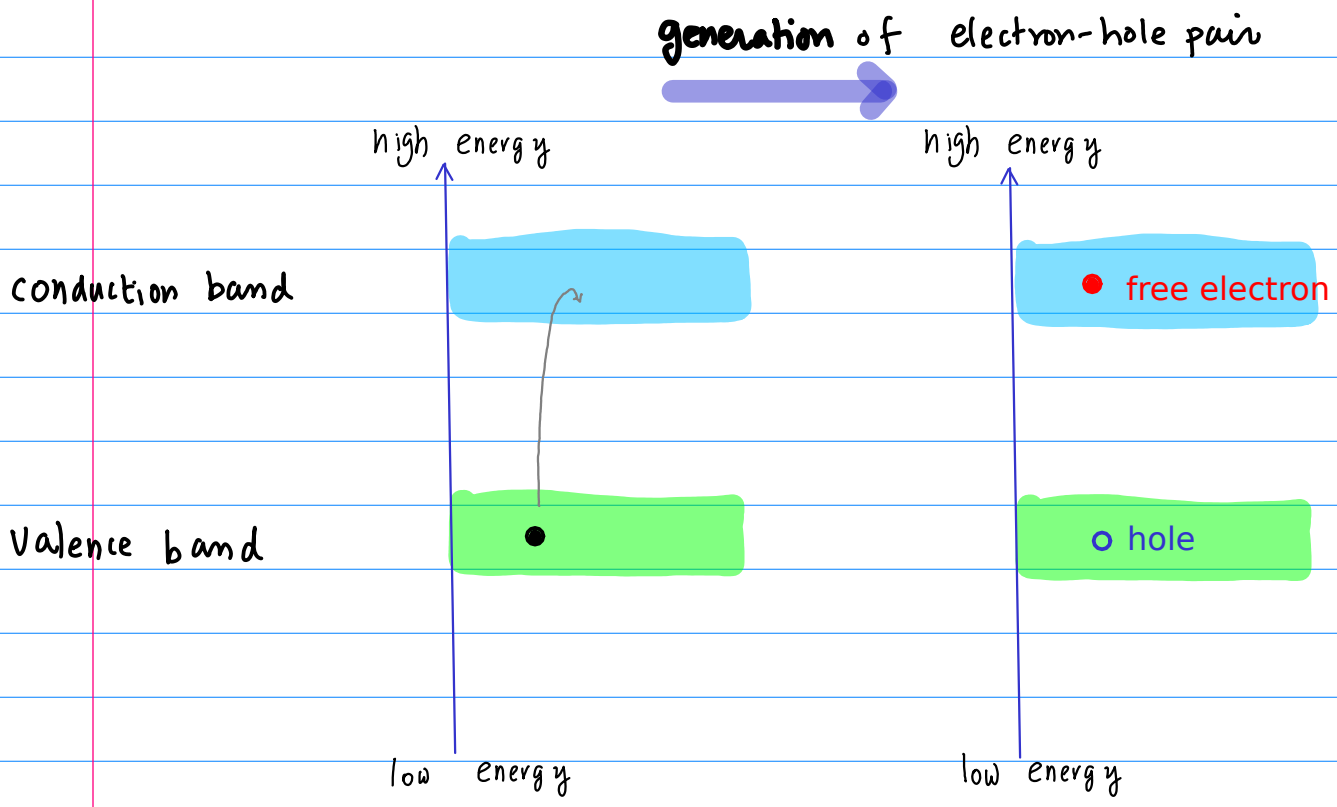


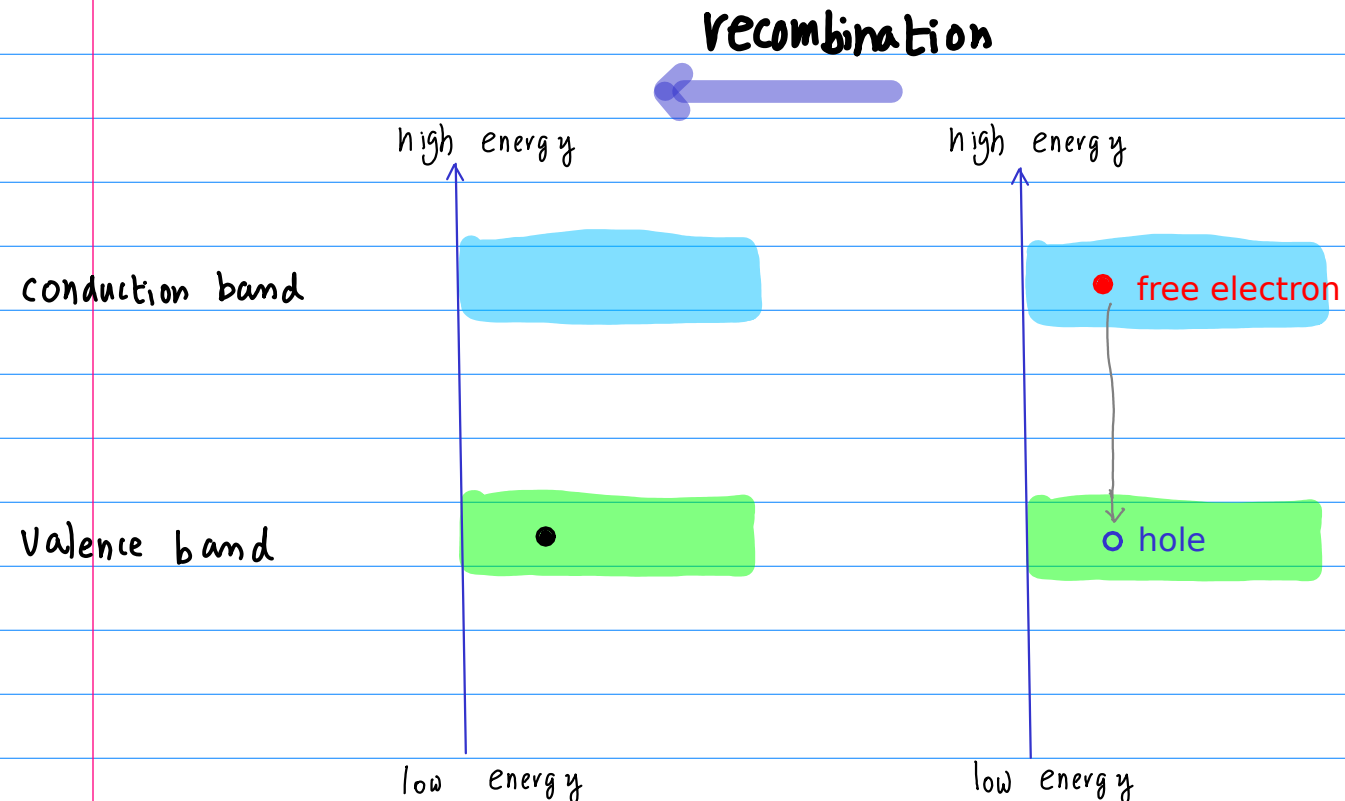
Thermal Energy

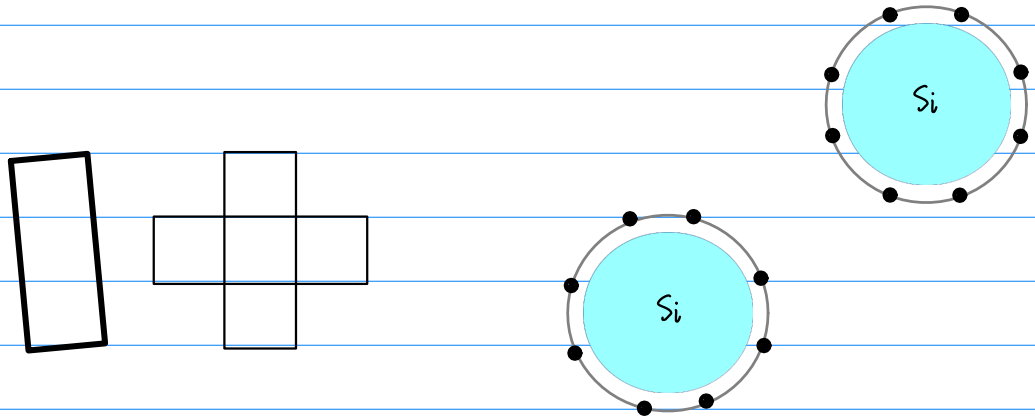


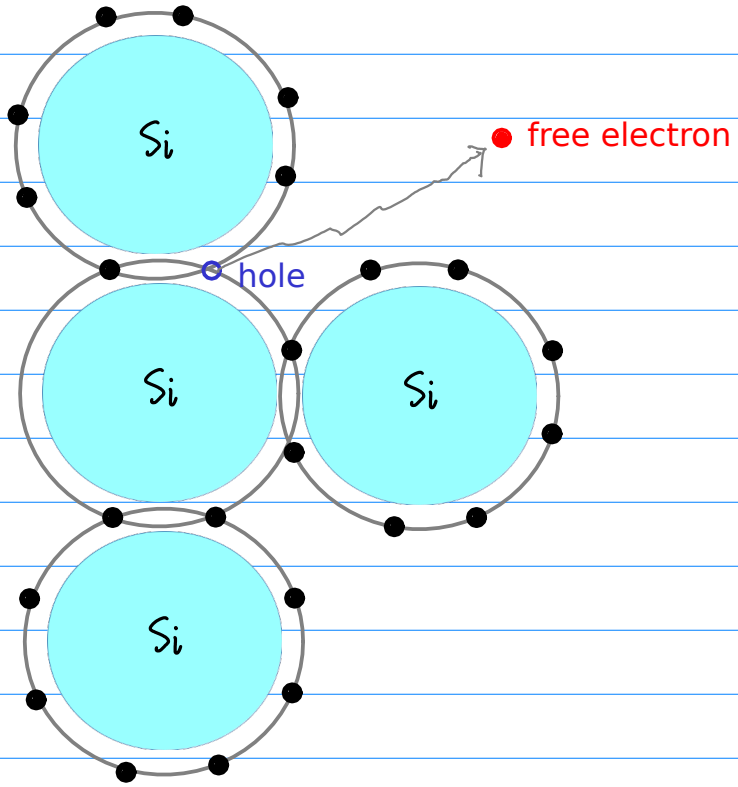


Electron - Hole Pair

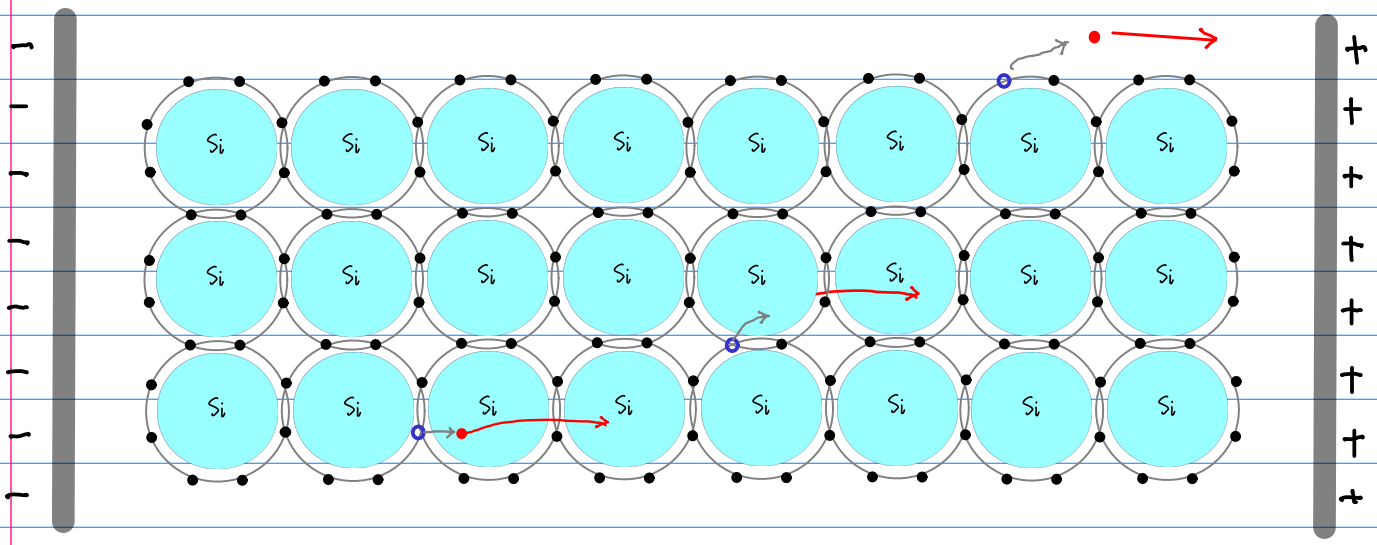


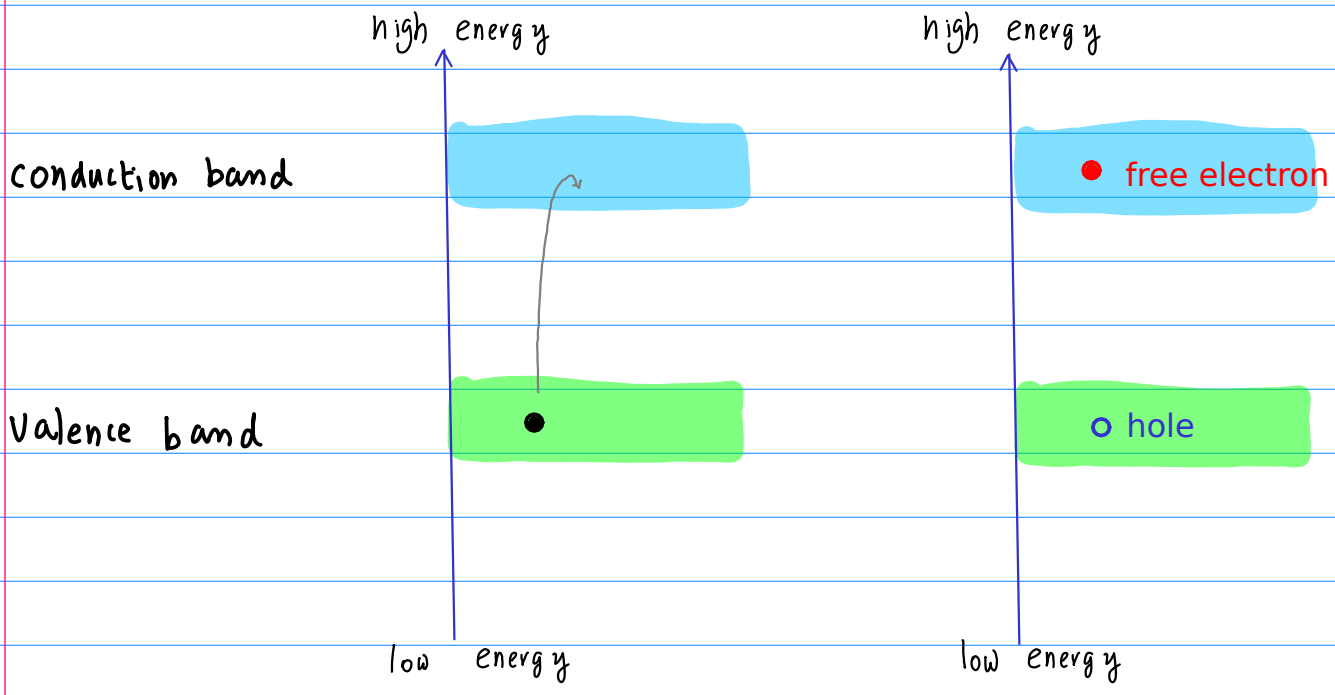



Si
Si


Si
free electron
hole
Si
Si
Si

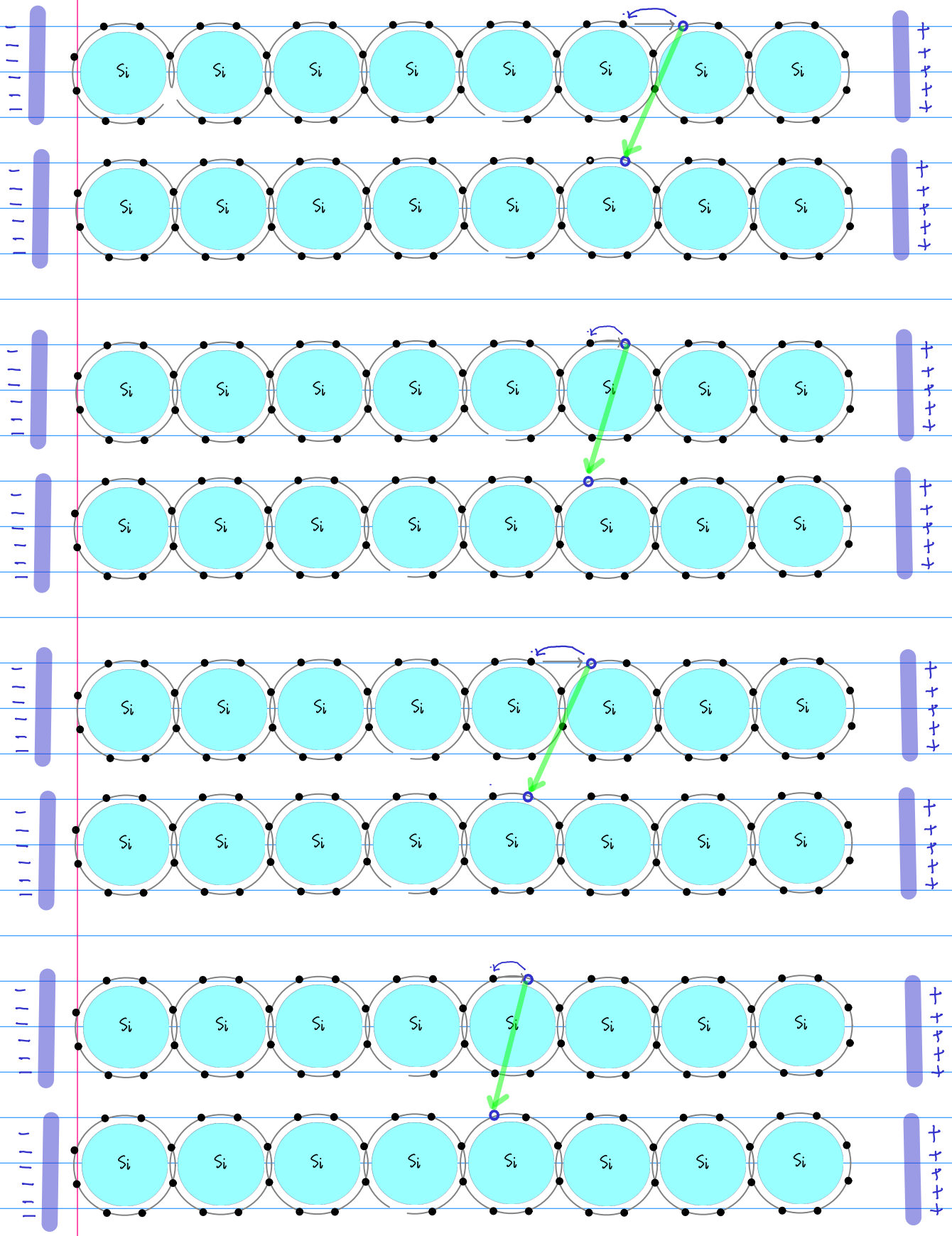
Free Electron Flow



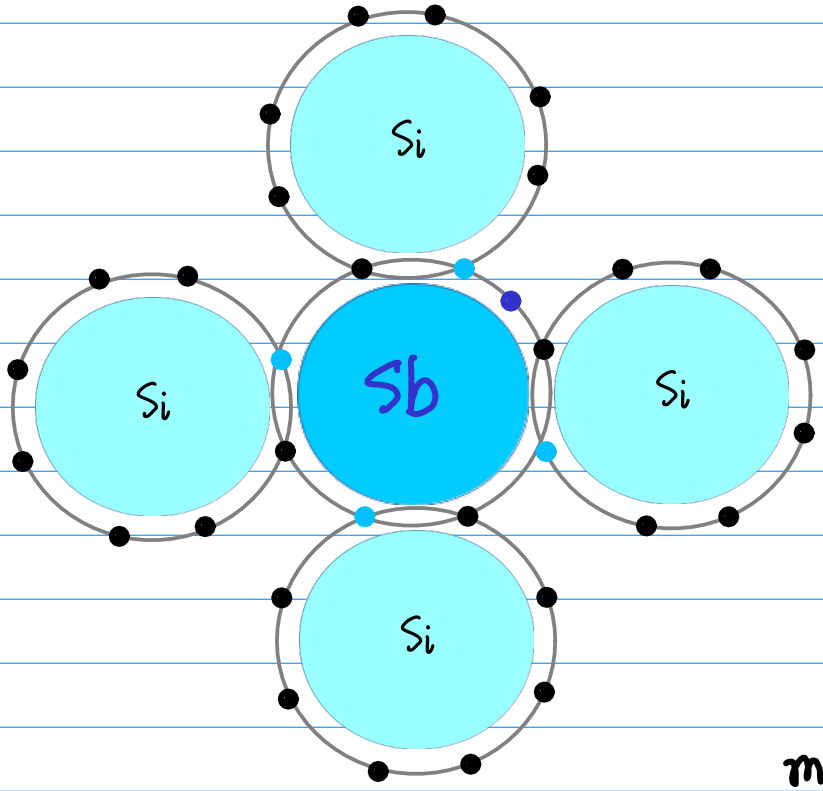


Hole Flow

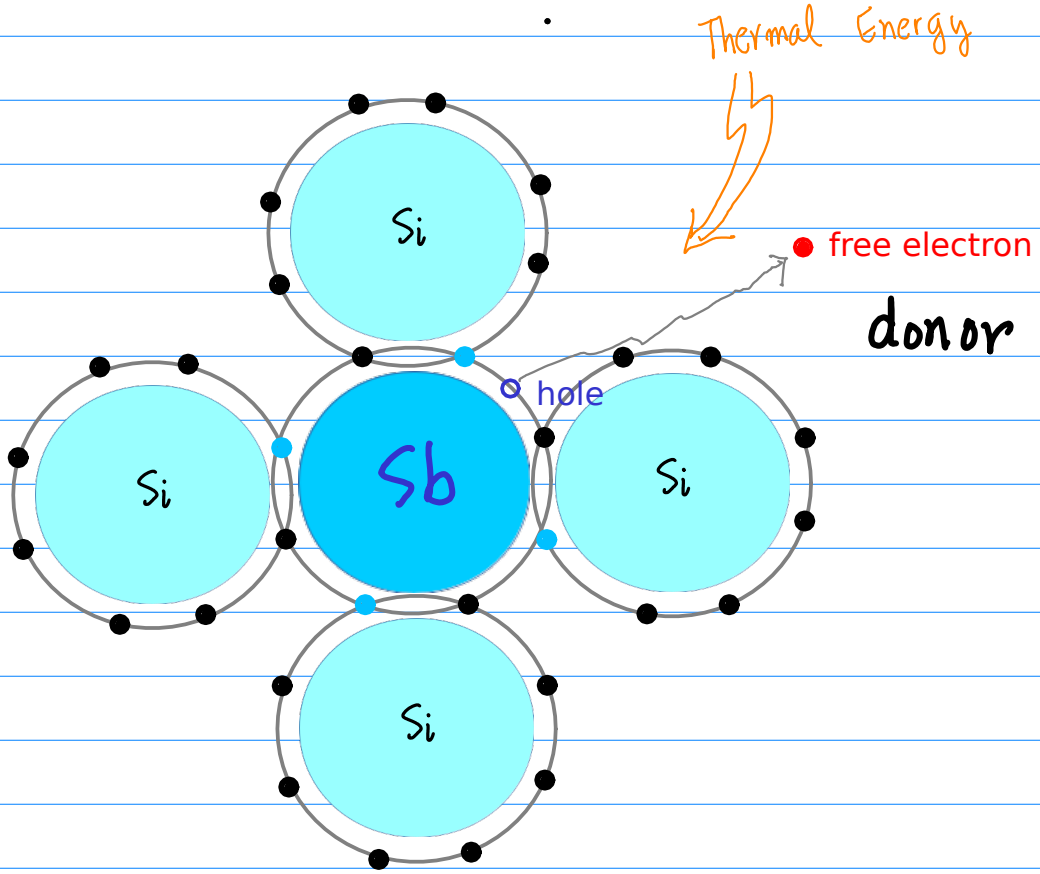
valence band holes (o)
valence band electrons (o)
conduction band electron (X)



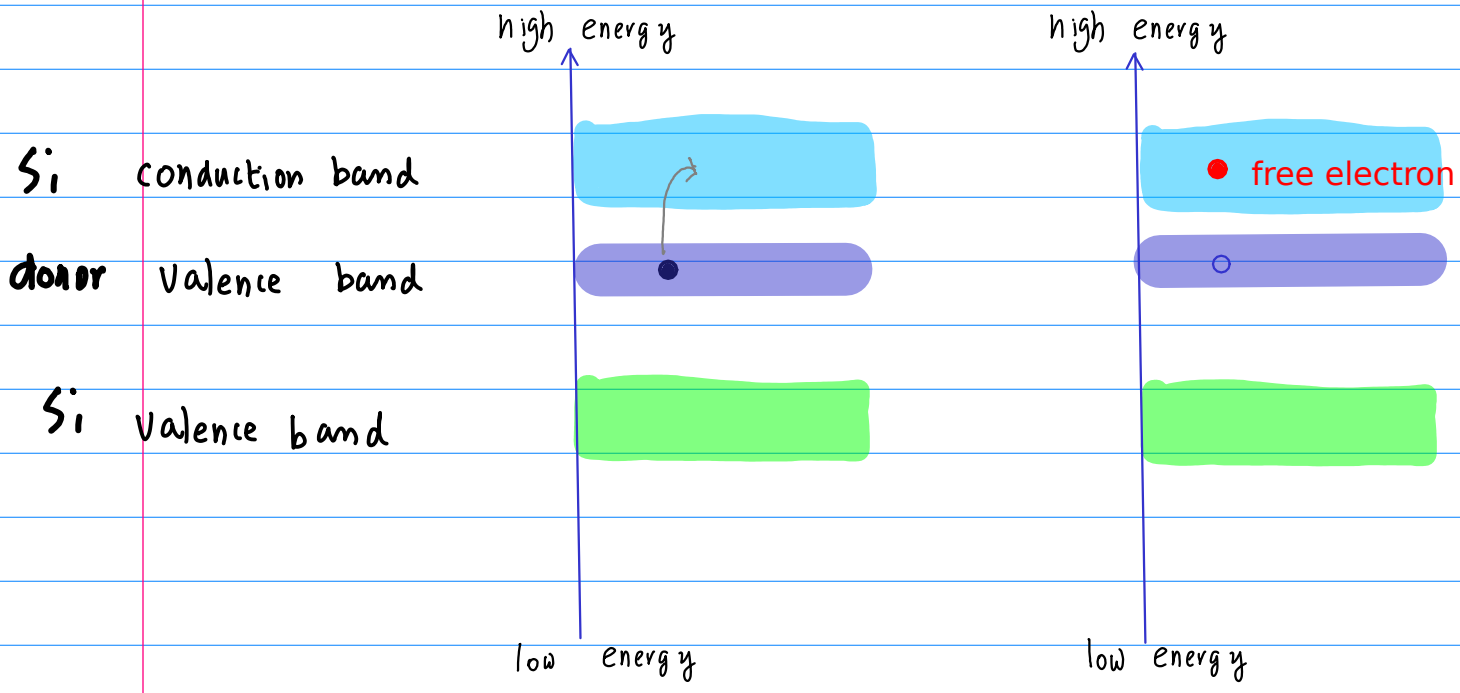
n-type Donor

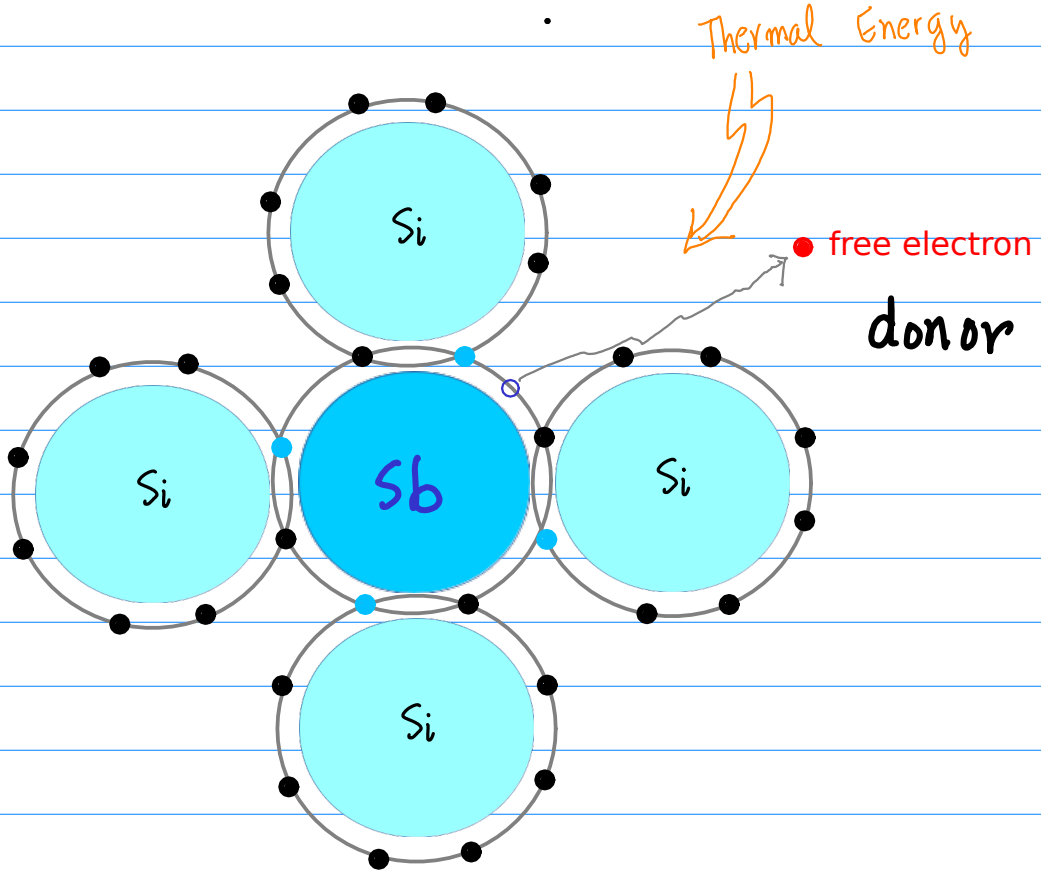


more easily

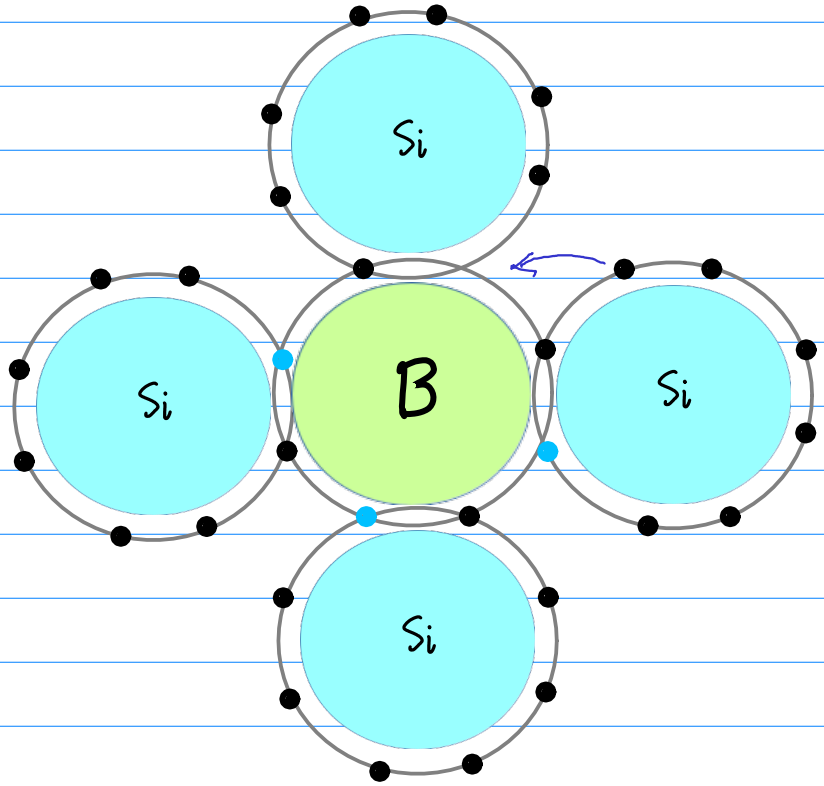


Donor Valence Band



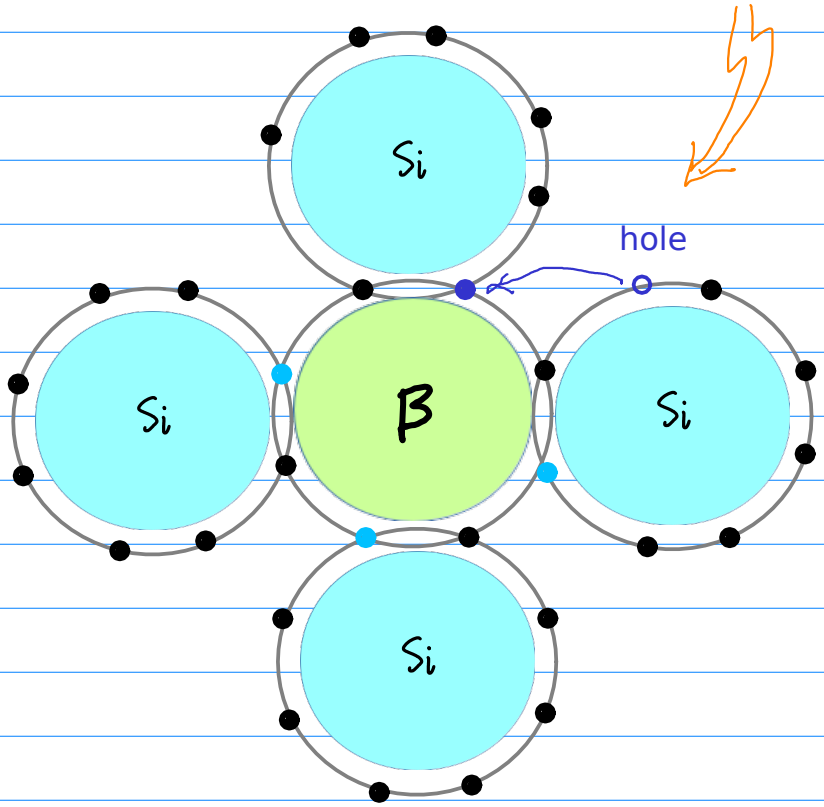


p-type Acceptor



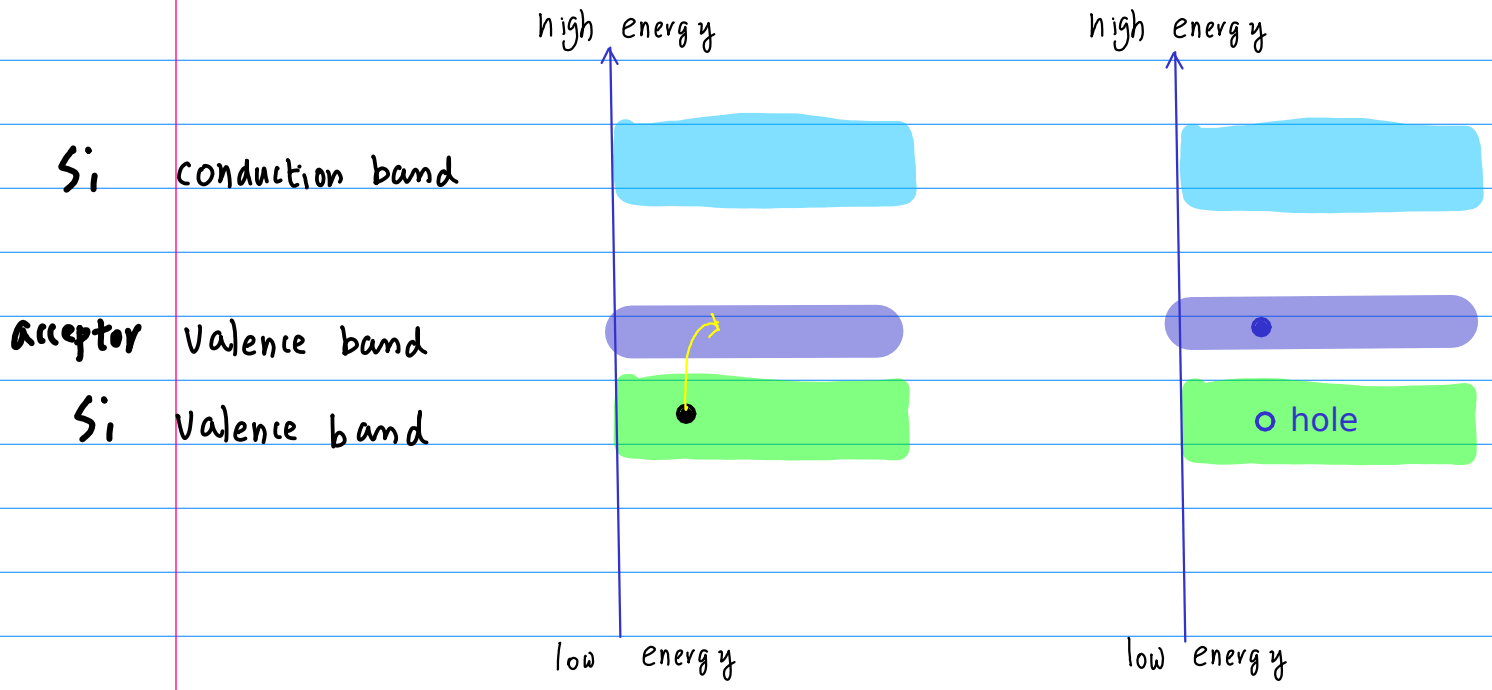
more easily

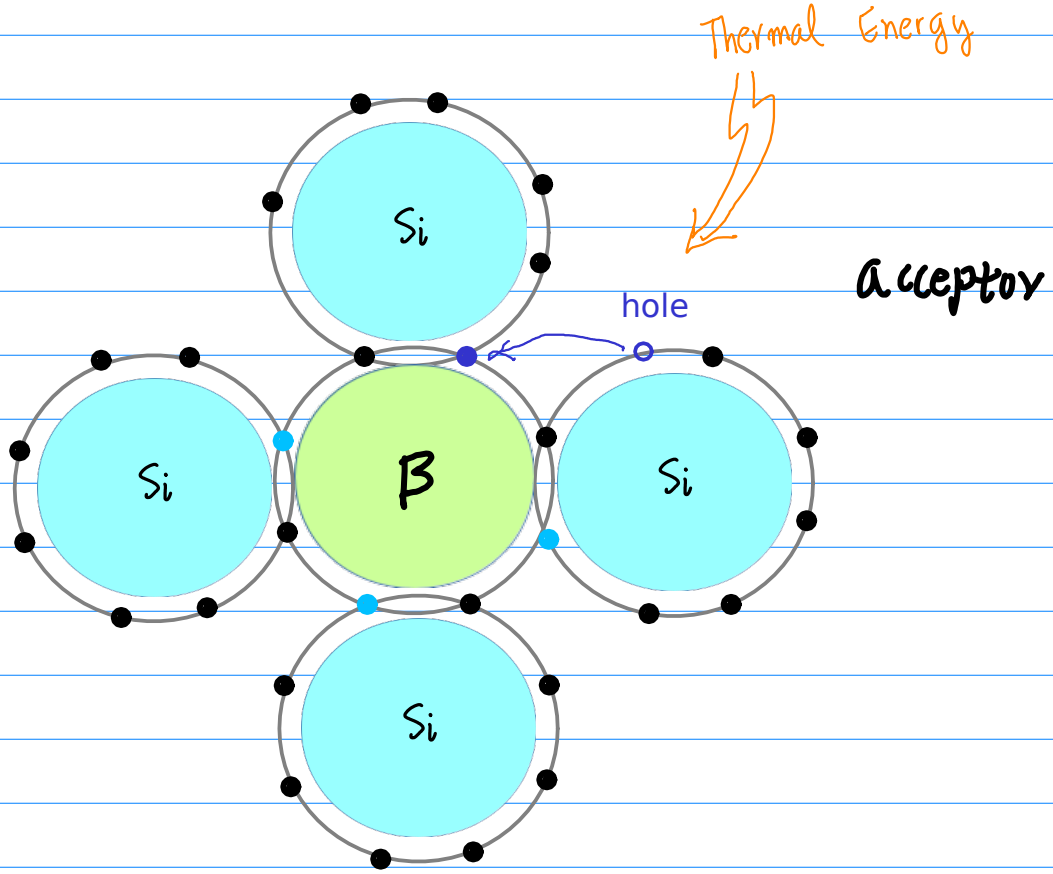
Thermal Energy

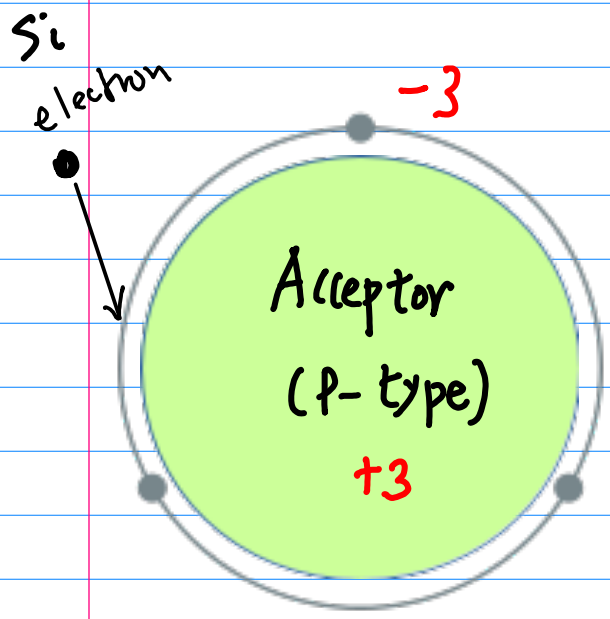


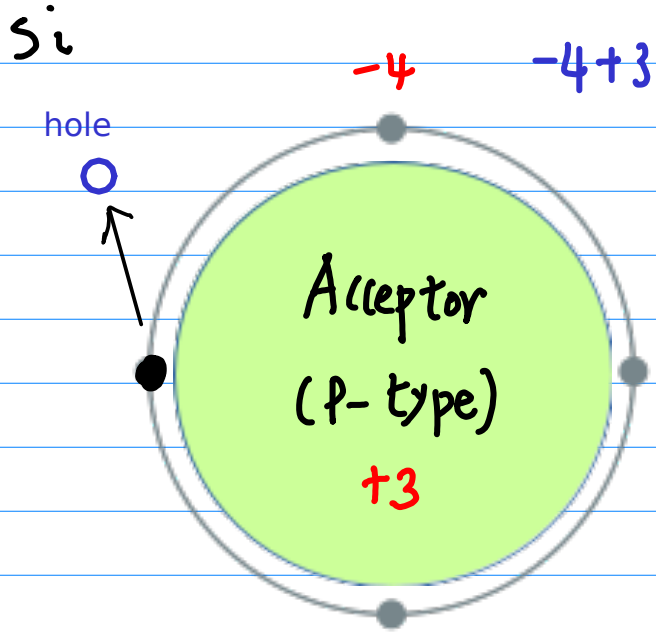
acceptor

Acceptor Conduction Band

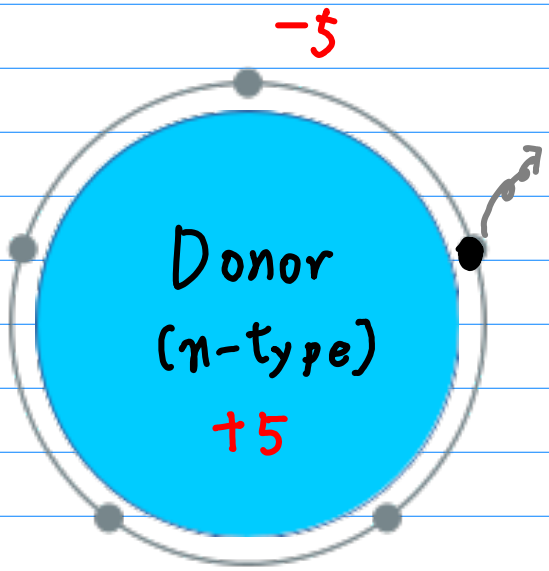


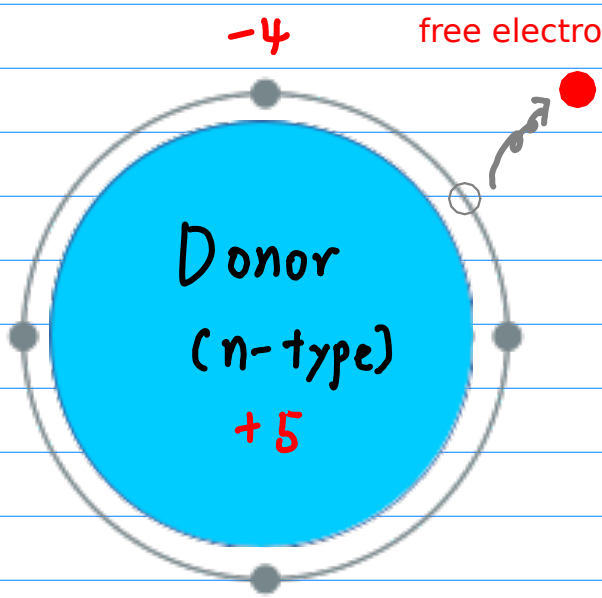



Si
electron
-3
Acceptor
(P- type)
+3


Si
-4
hole
Acceptor
(P- type)
+3

-4+3 = -1

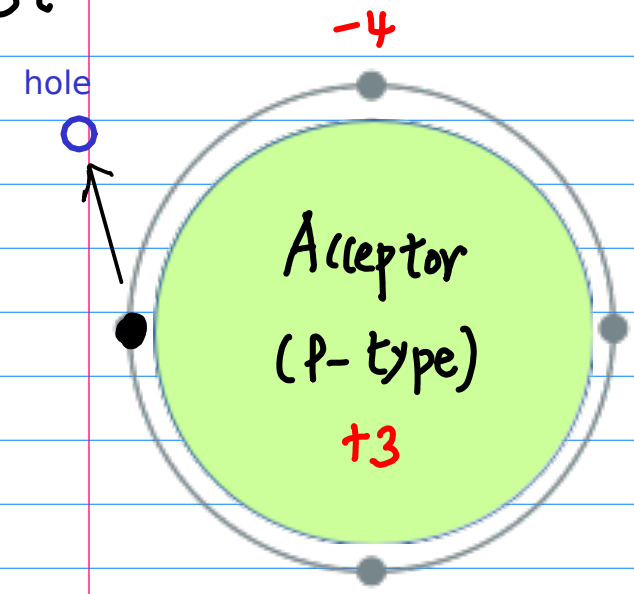

-5
Donor
(n-type)
+5

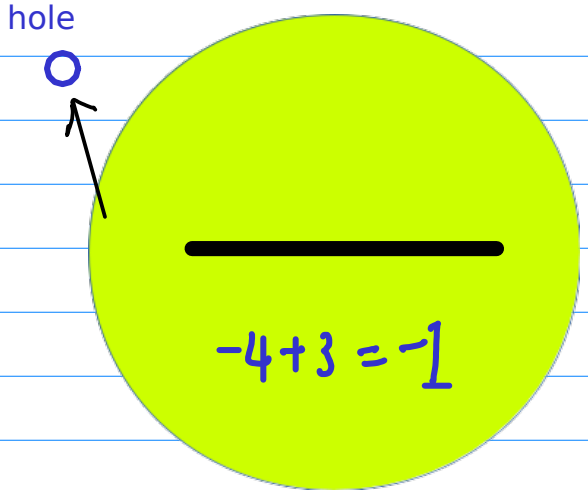

-4
free electron
Donor
(n-type)
+5

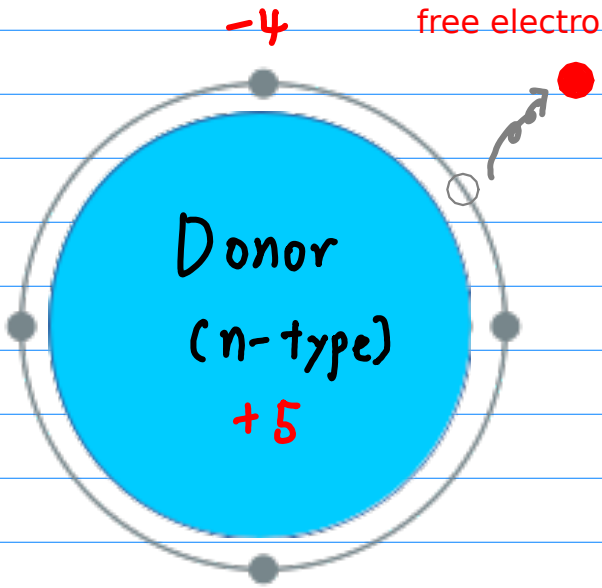
-4+5 = +1

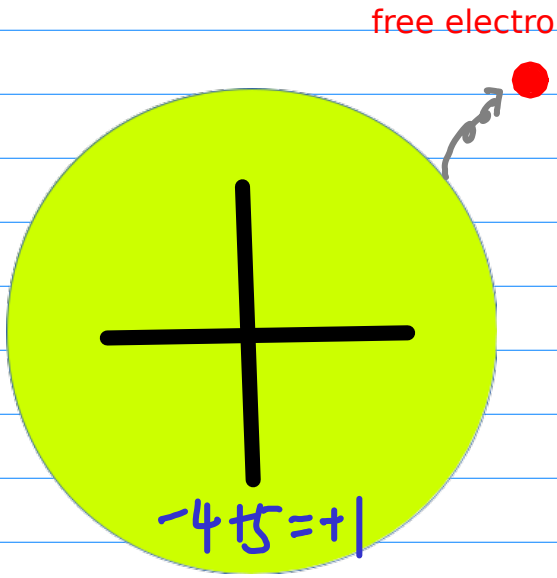
Si

Ion

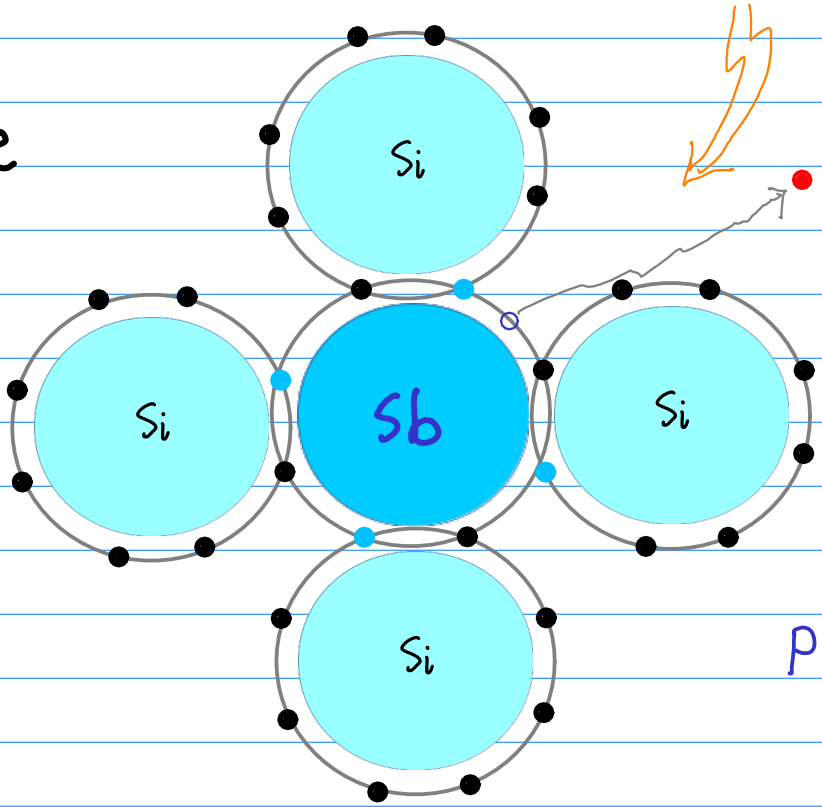

-4
hole
Acceptor
(P- type)
+3

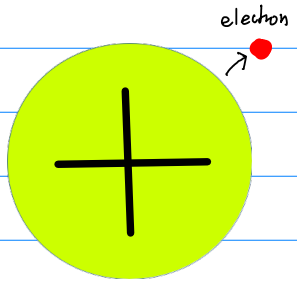

hole
-4+3 = -1


-4
free electron
Donor
(n- type)
+5


free electron
-4+5 = +1

donor
n-type



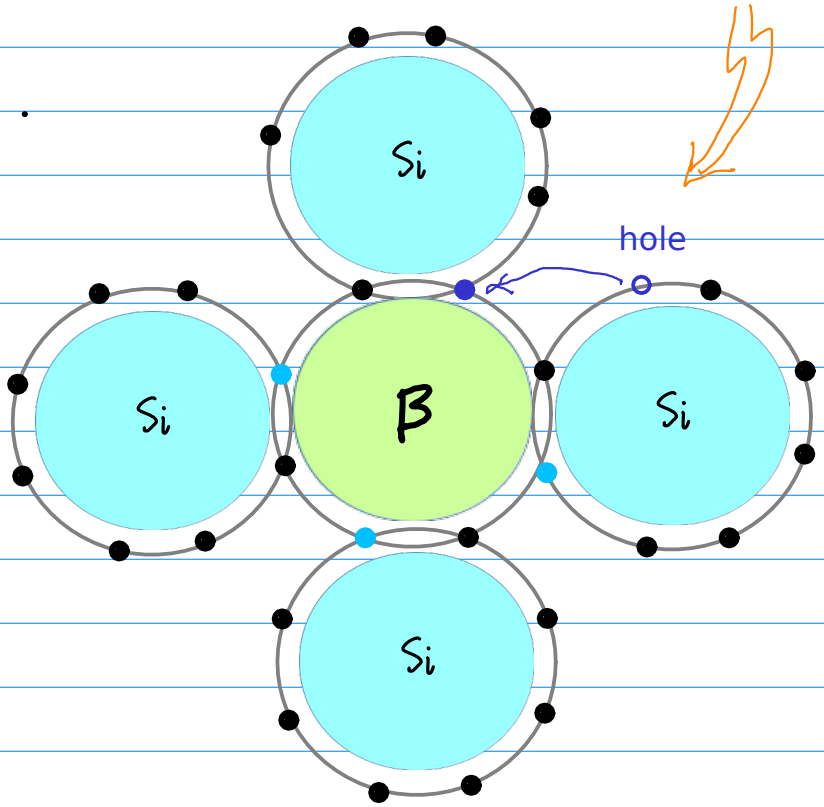


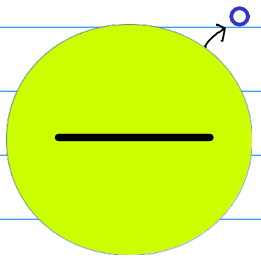
P = phosphorus

not p-type

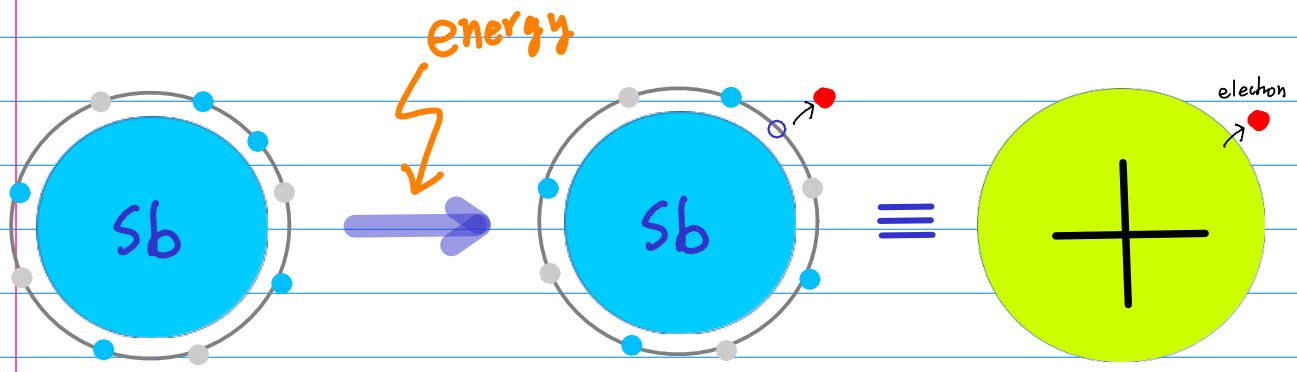
but n-type

acceptor
p-type





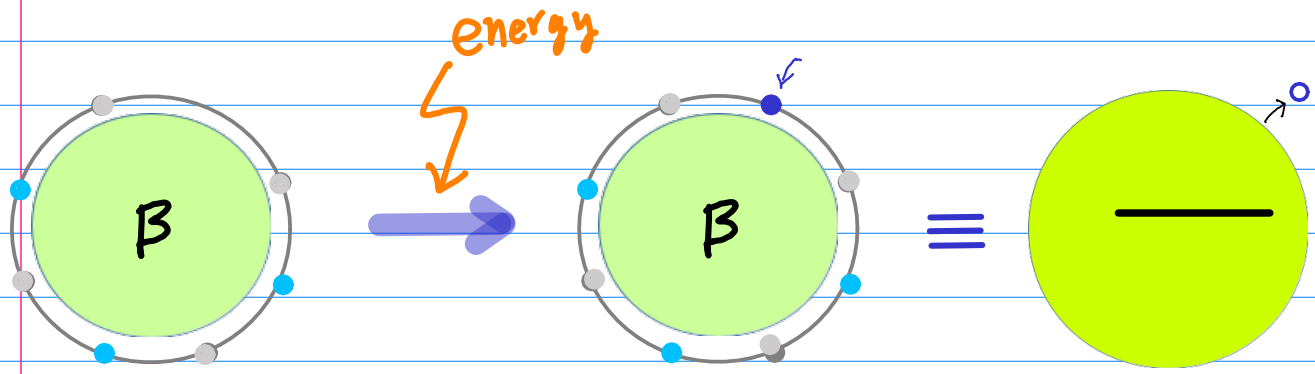
Donor (n-type)



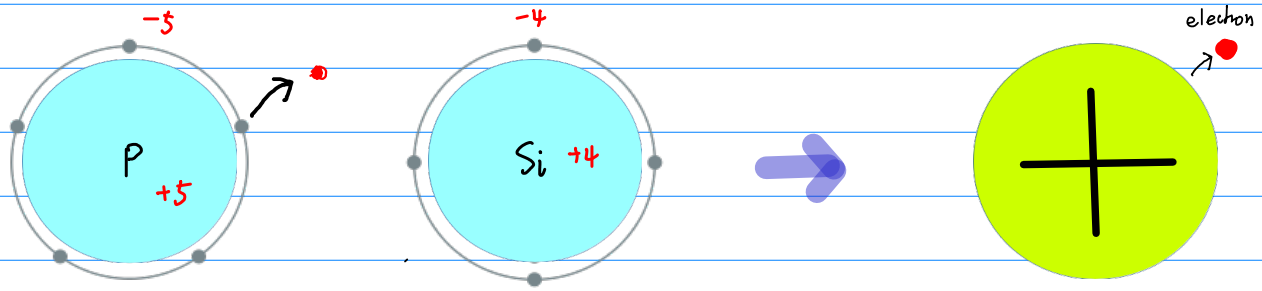
Atom

Ion + free electron

Acceptor (p-type)



n- type

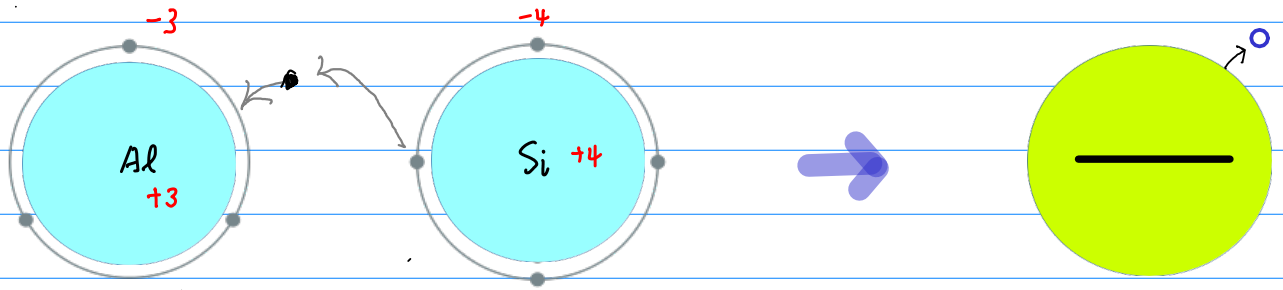


very few

many

draw only donor ion & free electron

P - type



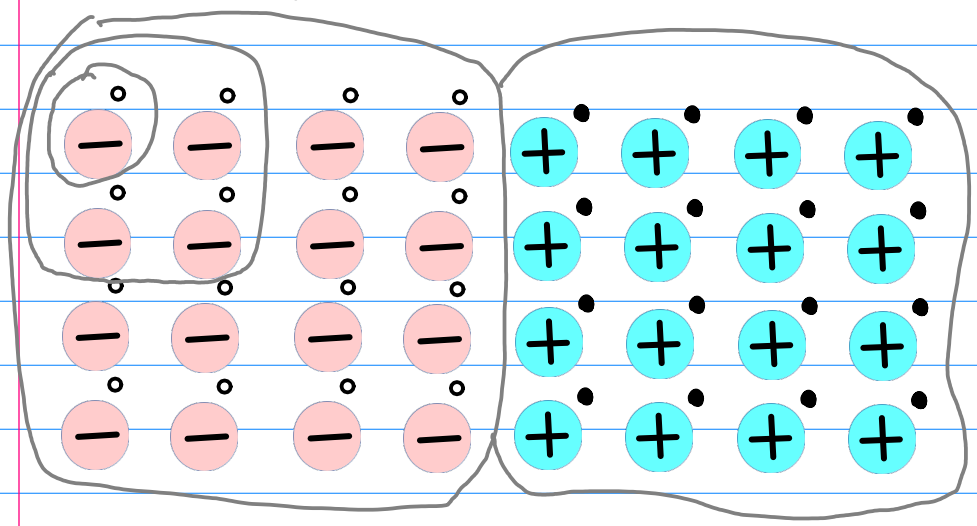
very few

many

draw only acceptor ion and free electron

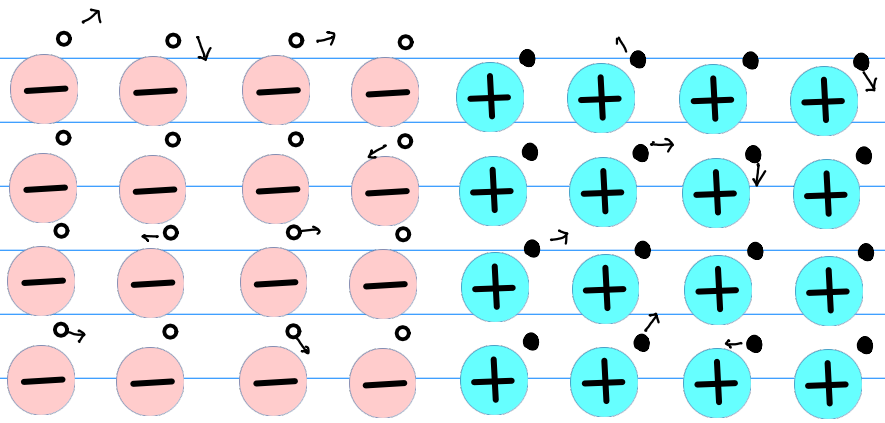
of ⊖ ions = # of holes # of ⊕ ions = # of free electrons

electrically neutral



+1 -1 = 0 -1 +1 = 0

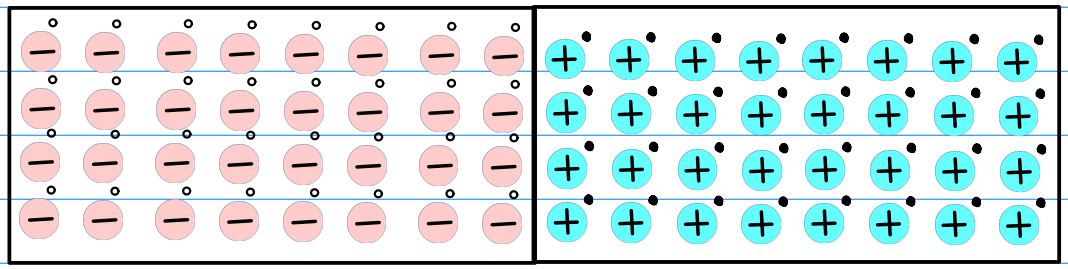
neutral electrically

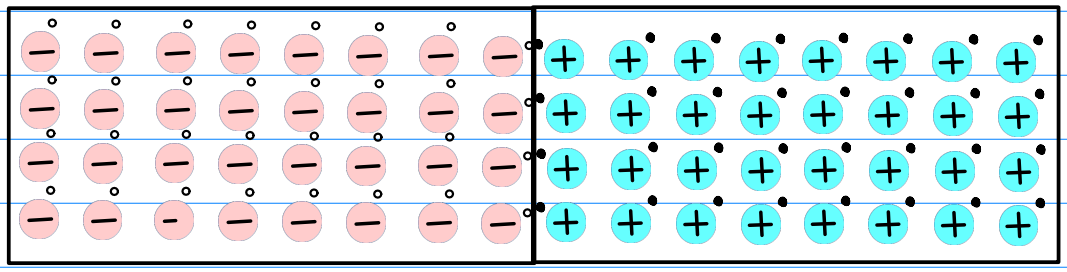


○ ● free → moving electrons & hole

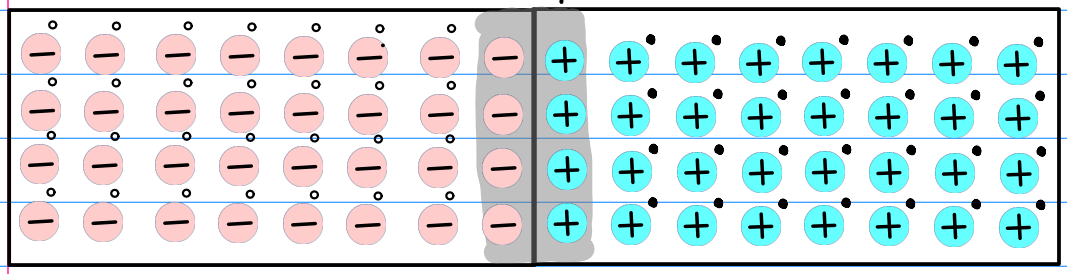
⊖ ⊕ fixed + ion & - ion

diffusion density difference



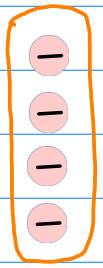


block electrons block holes



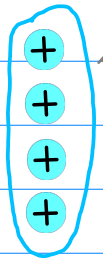
p-type n-type

the holes are removed, thus electrically negative



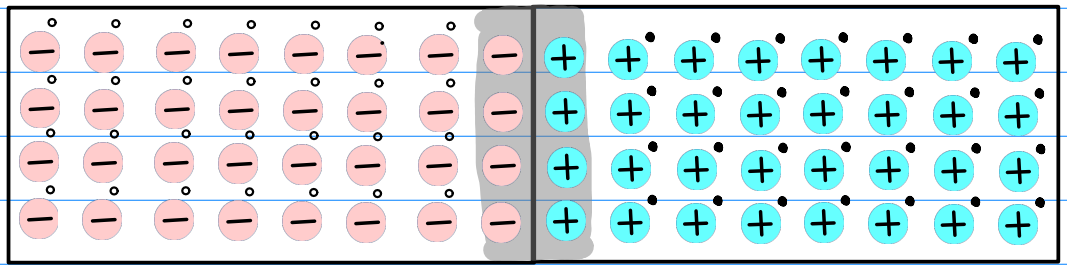
electrons in n-type are repelled by the negative space charge

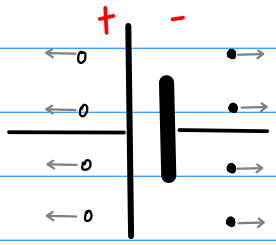
holes in p-type are repelled by the negative space charge



the electrons are removed, thus electrically positive

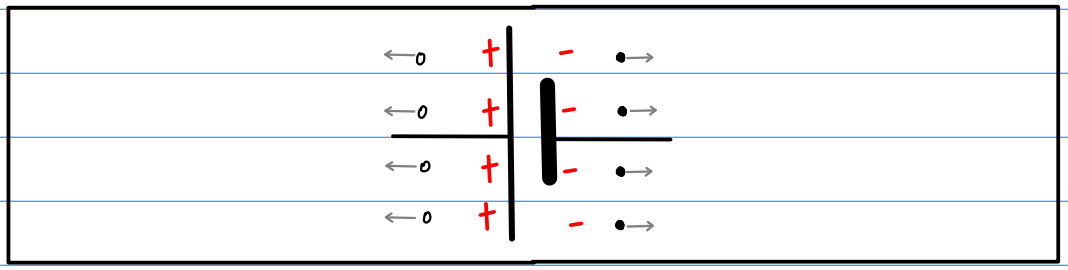
no - bias





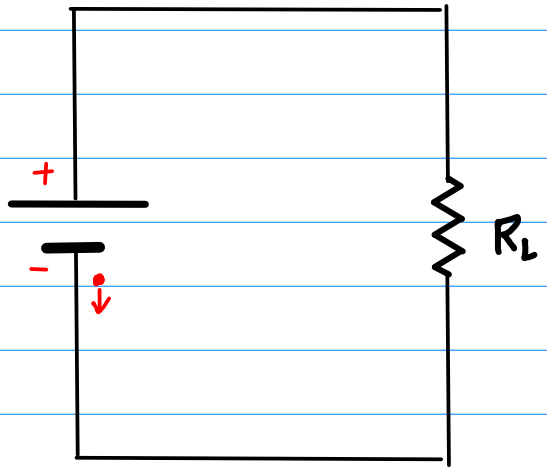
0.7 V

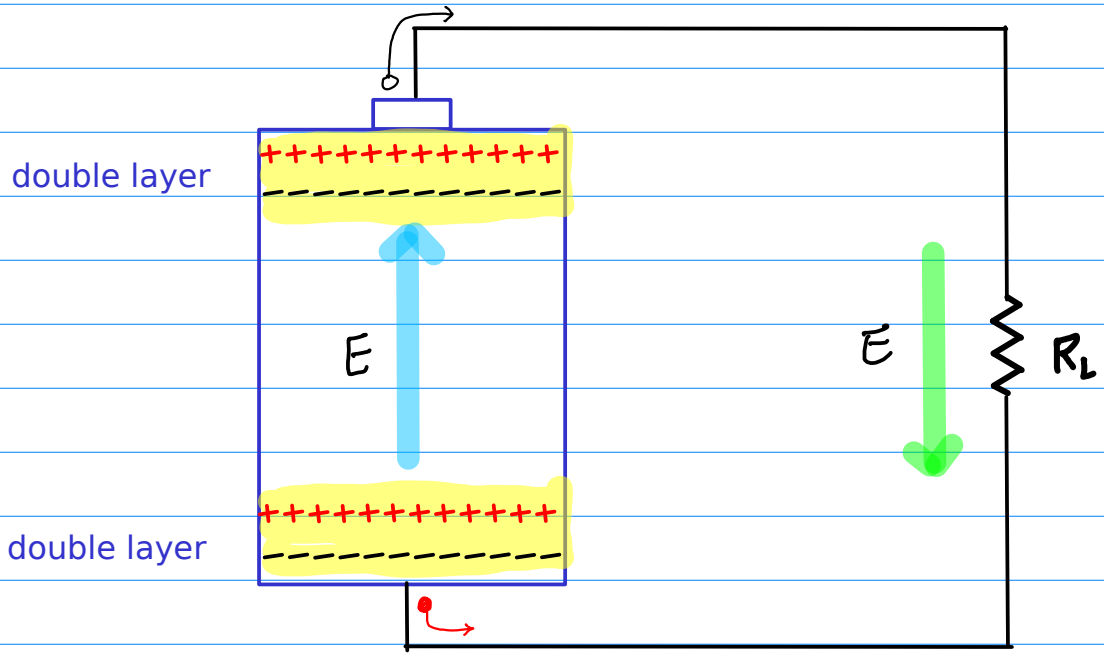
V



barrier potential

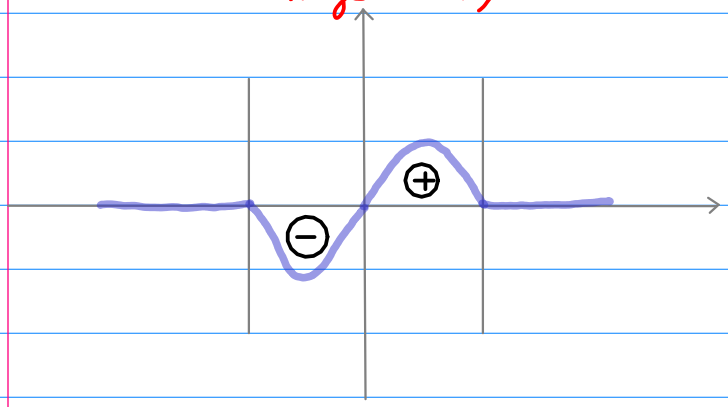
Electric field inside a battery



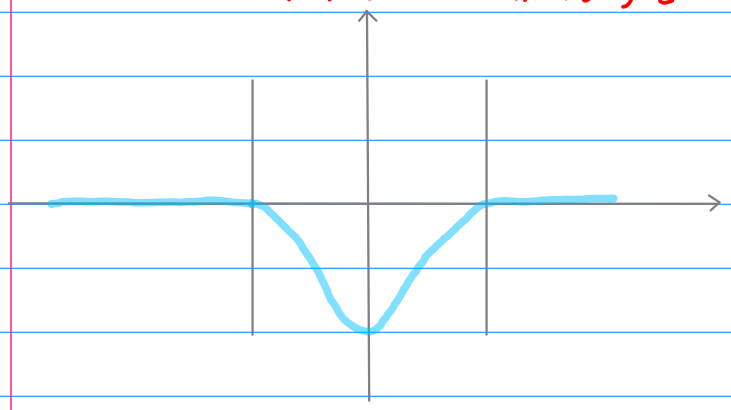


p - type depletion region n - type

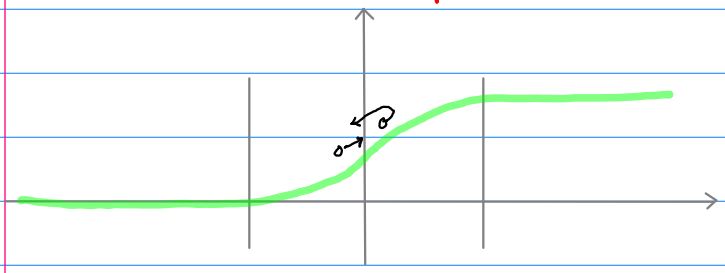
Charge density



electric field intensity $\mathcal{E}$



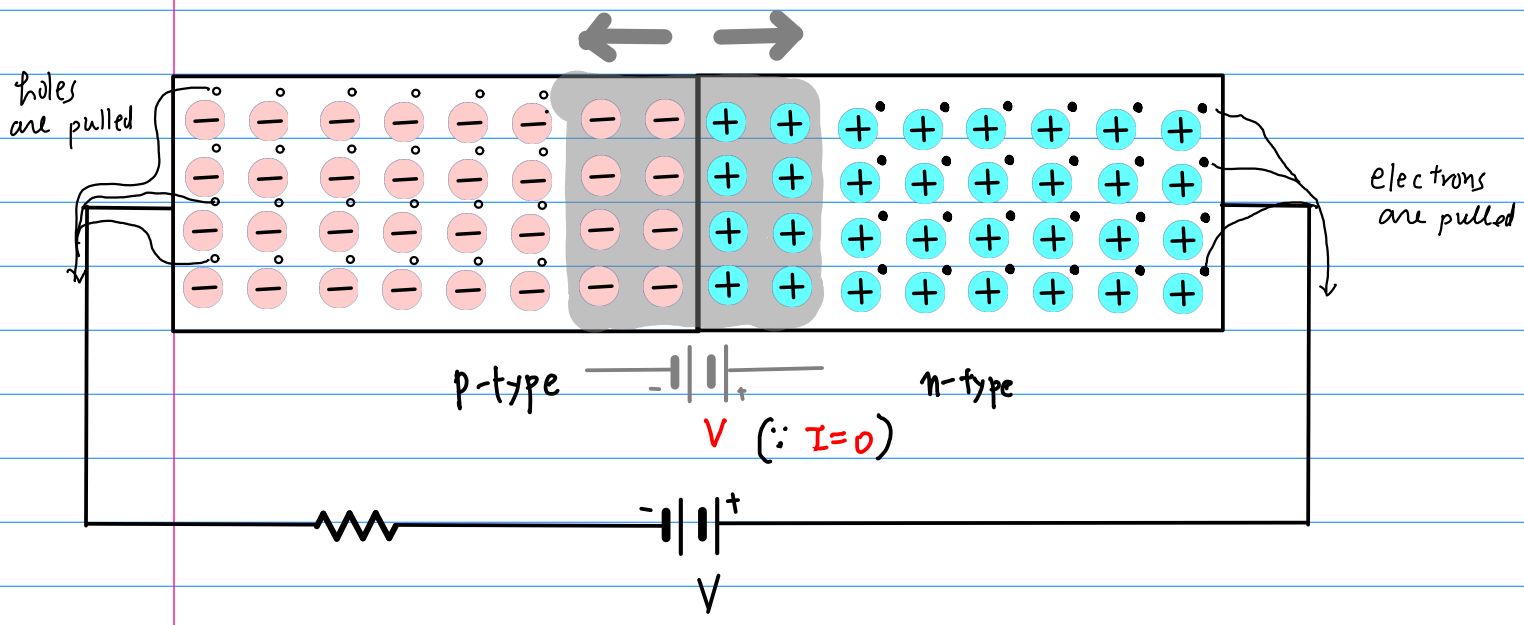
electrostatic potential V



potential barrier of electrons

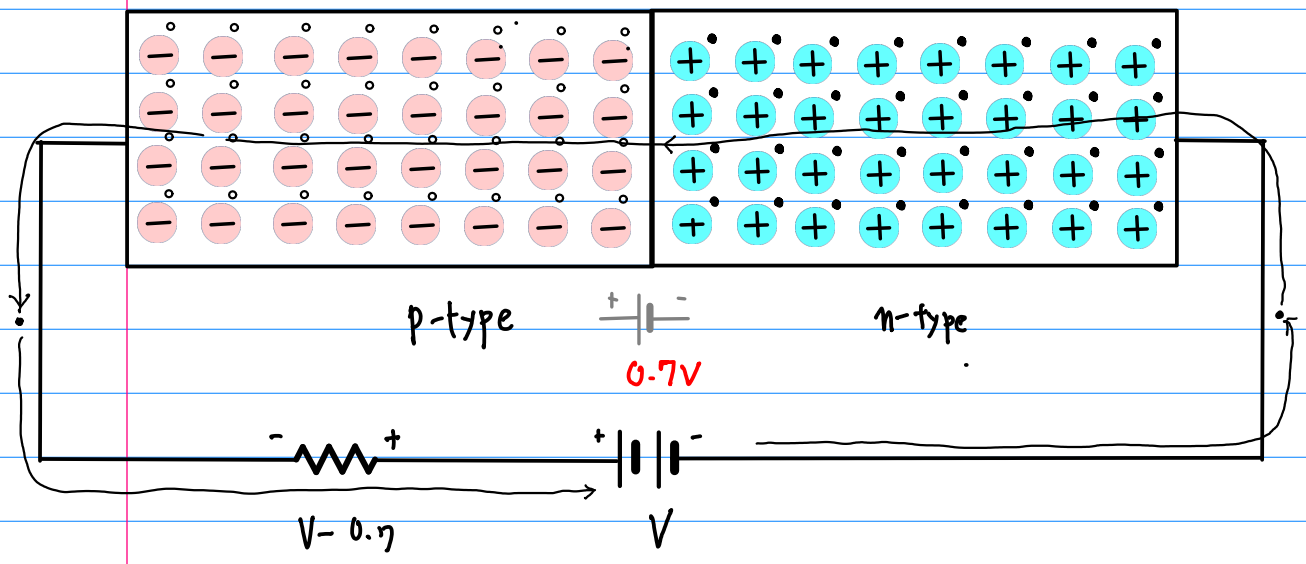
Reverse Bias

- increase depletion region
- no current flowing

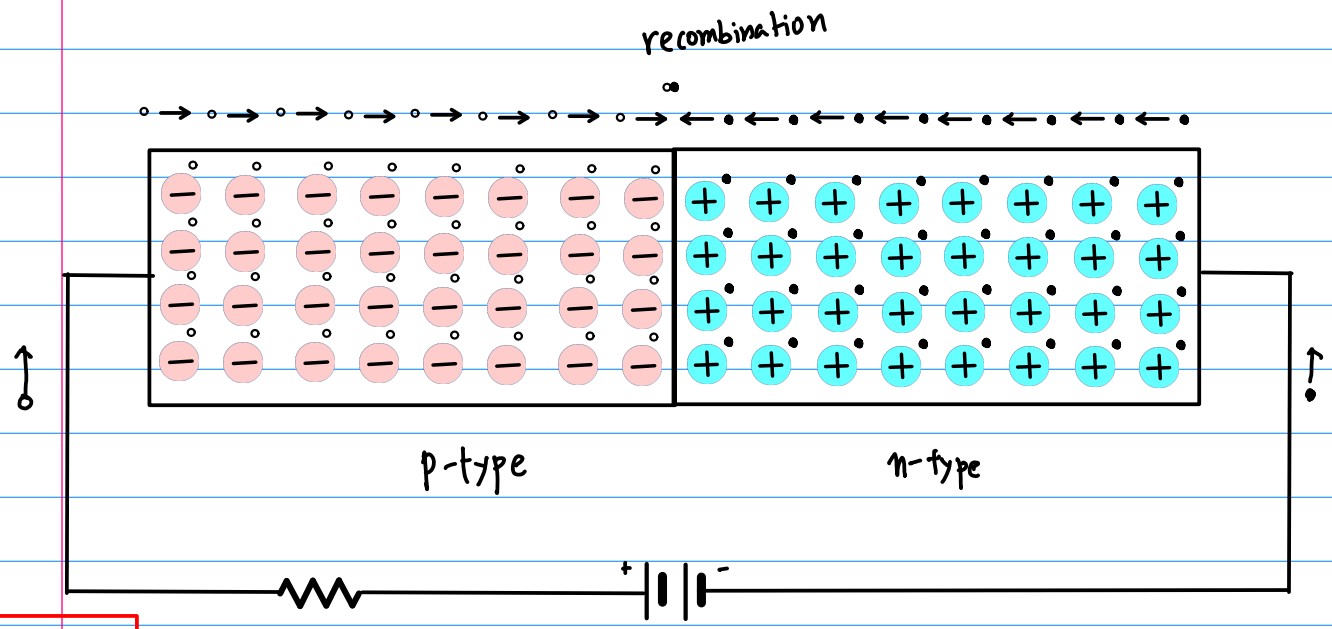


Forward Bias

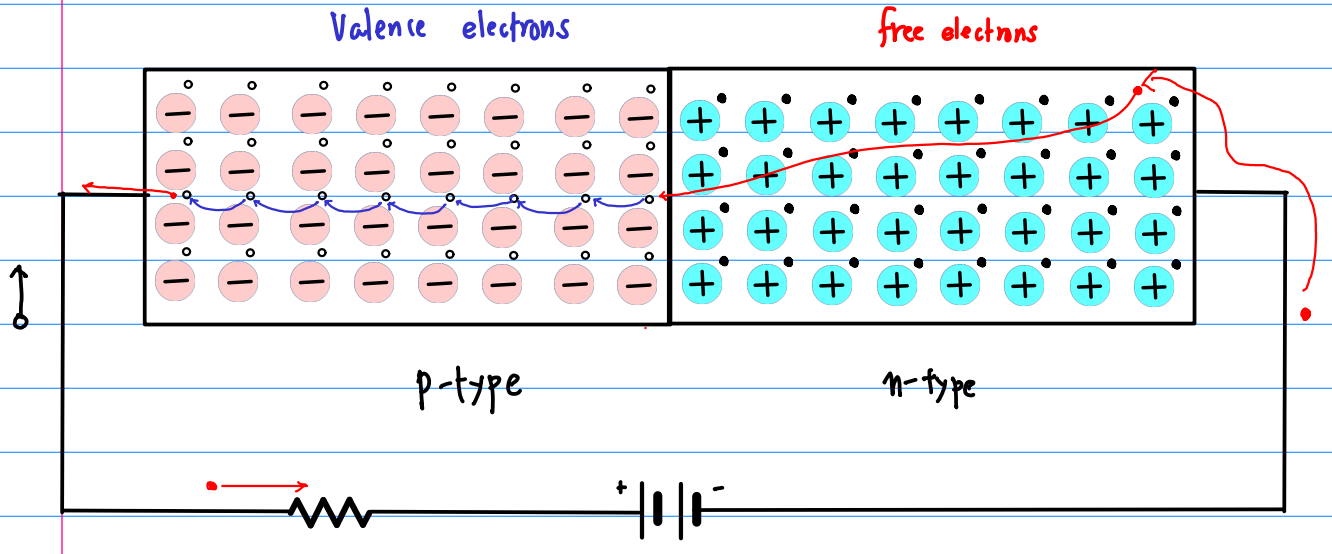
- no depletion region
- continuous current flow

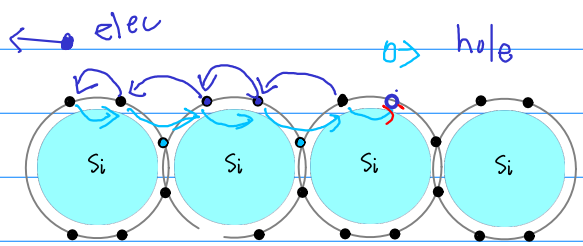


Forward Bias

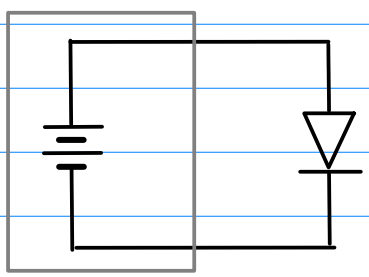


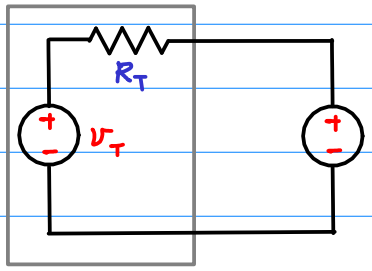
$V > 0.7$ continuous supply of holes to p-type and electrons to n-type





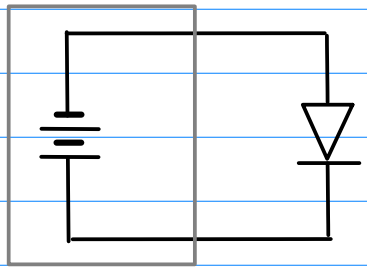
forward bias

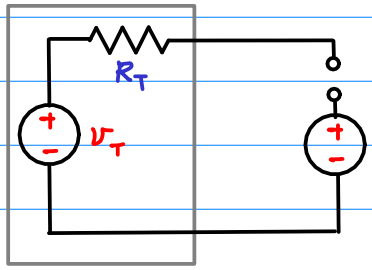




$V_T > 0.7$

reverse bias





$V_T < 0.3V$