

# SOLID-STATE PHYSICS: CONDUCTION

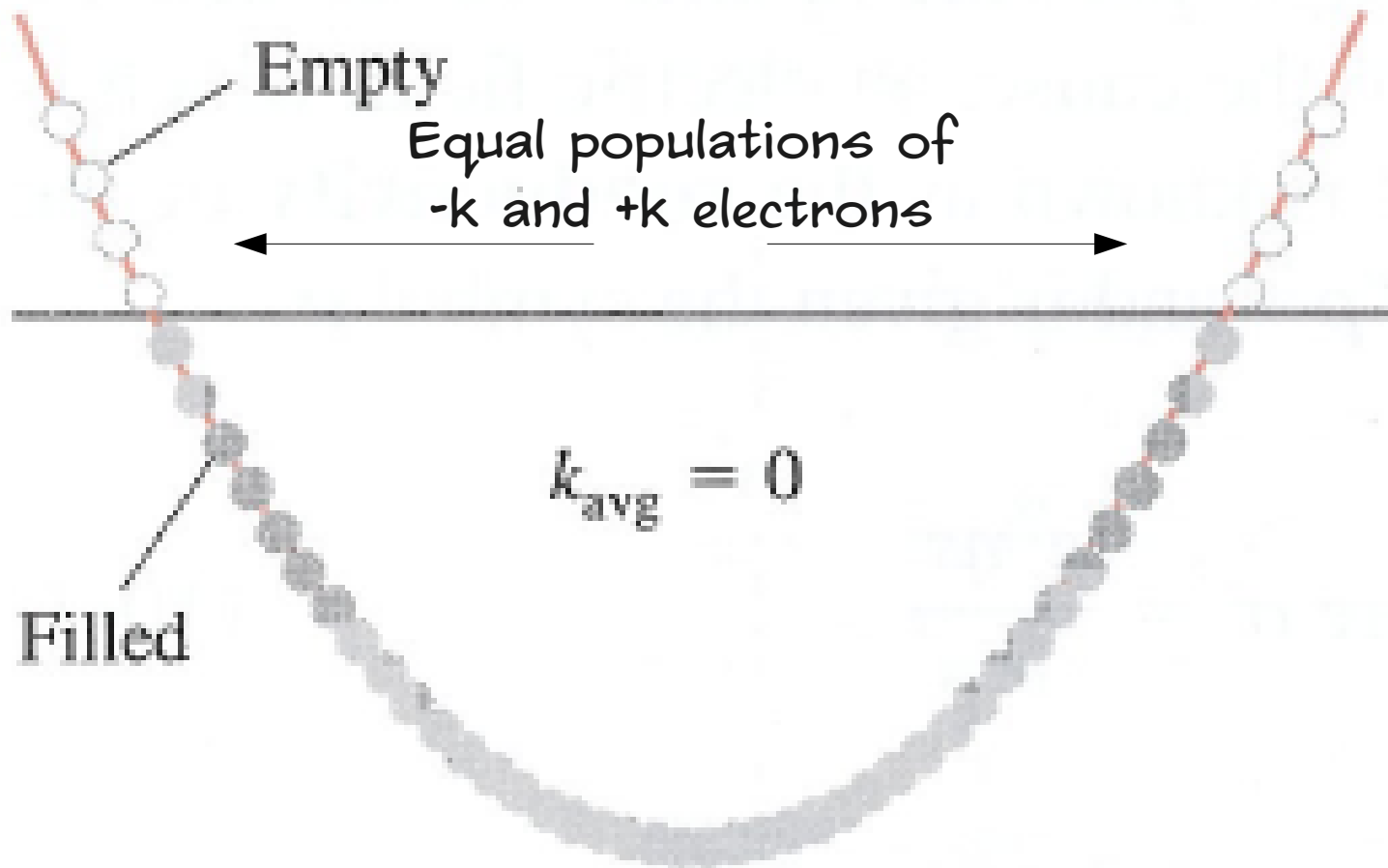
Prof. Stephen Sekula  
(3/30/2010)

Supplementary Material for  
PHY 3305 (Modern Physics)  
Harris, Ch. 10.6-10.8

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# SOLID, NO ELECTRIC FIELD APPLIED

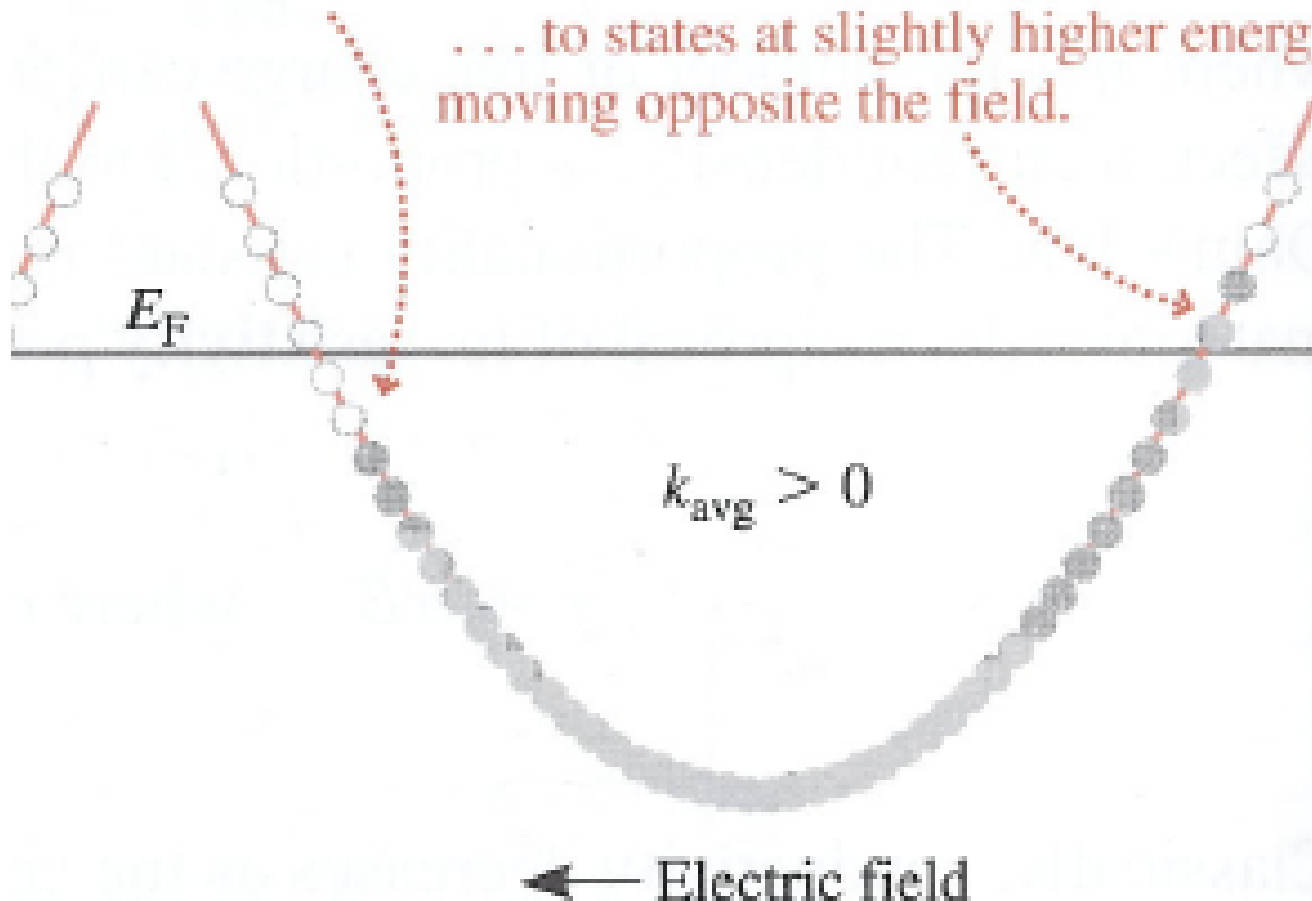


Electric field = 0

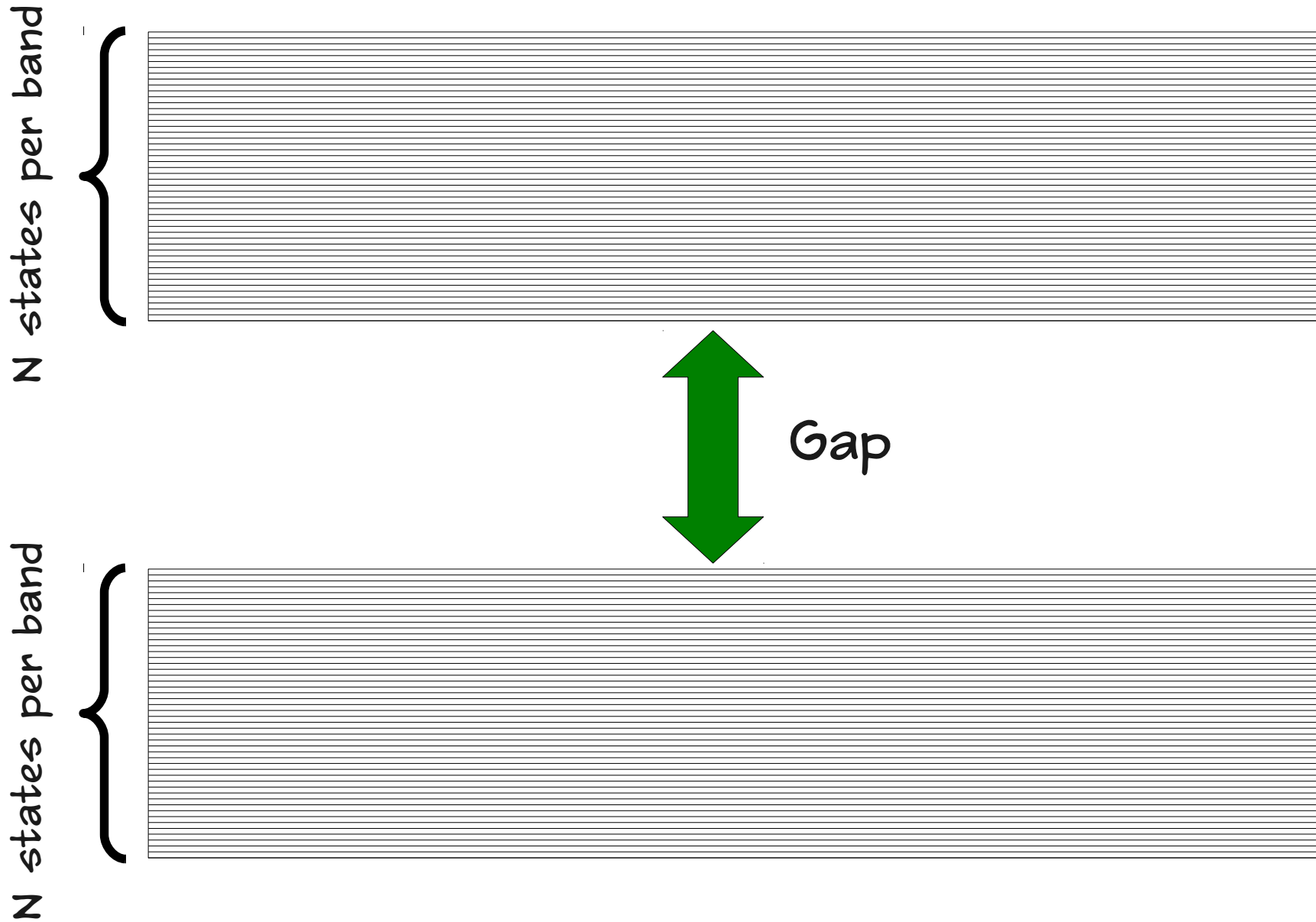
# SOLID, WITH ELECTRIC FIELD APPLIED

The net effect of a field is to shift some electrons moving in the field's direction . . .

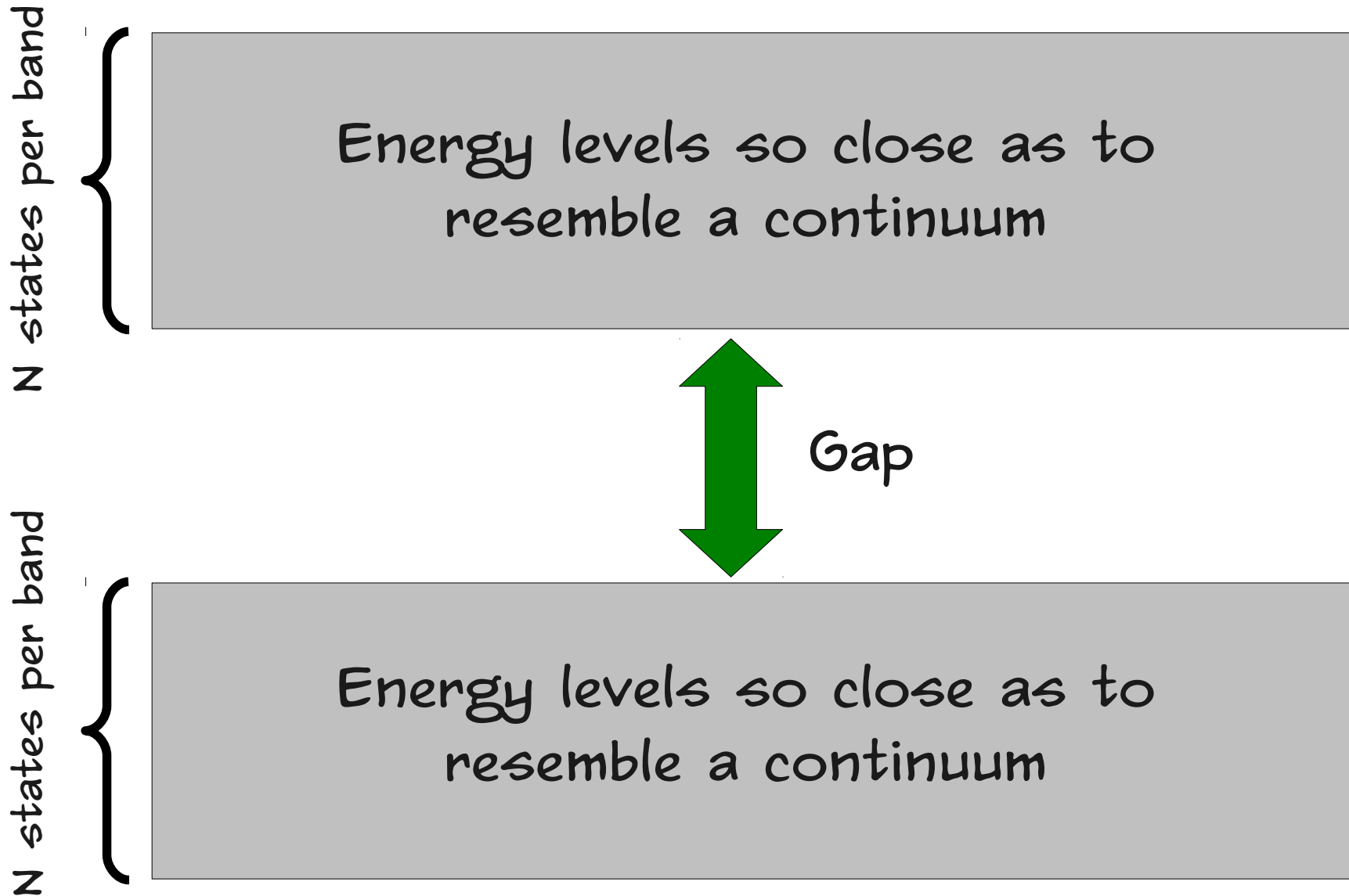
. . . to states at slightly higher energy moving opposite the field.



# A PICTURE: BANDS/GAPS



# A PICTURE: BANDS/GAPS



# QUESTIONS

- How many conduction electrons can each band hold?
- Which is a better conductor: Lithium or Beryllium?
  - Lithium has 3 electrons
  - Beryllium has 4 electrons

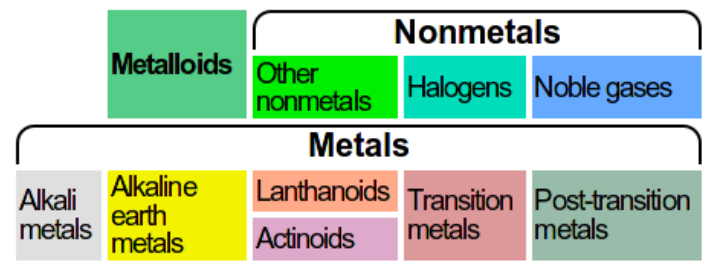
# Periodic Table of Elements



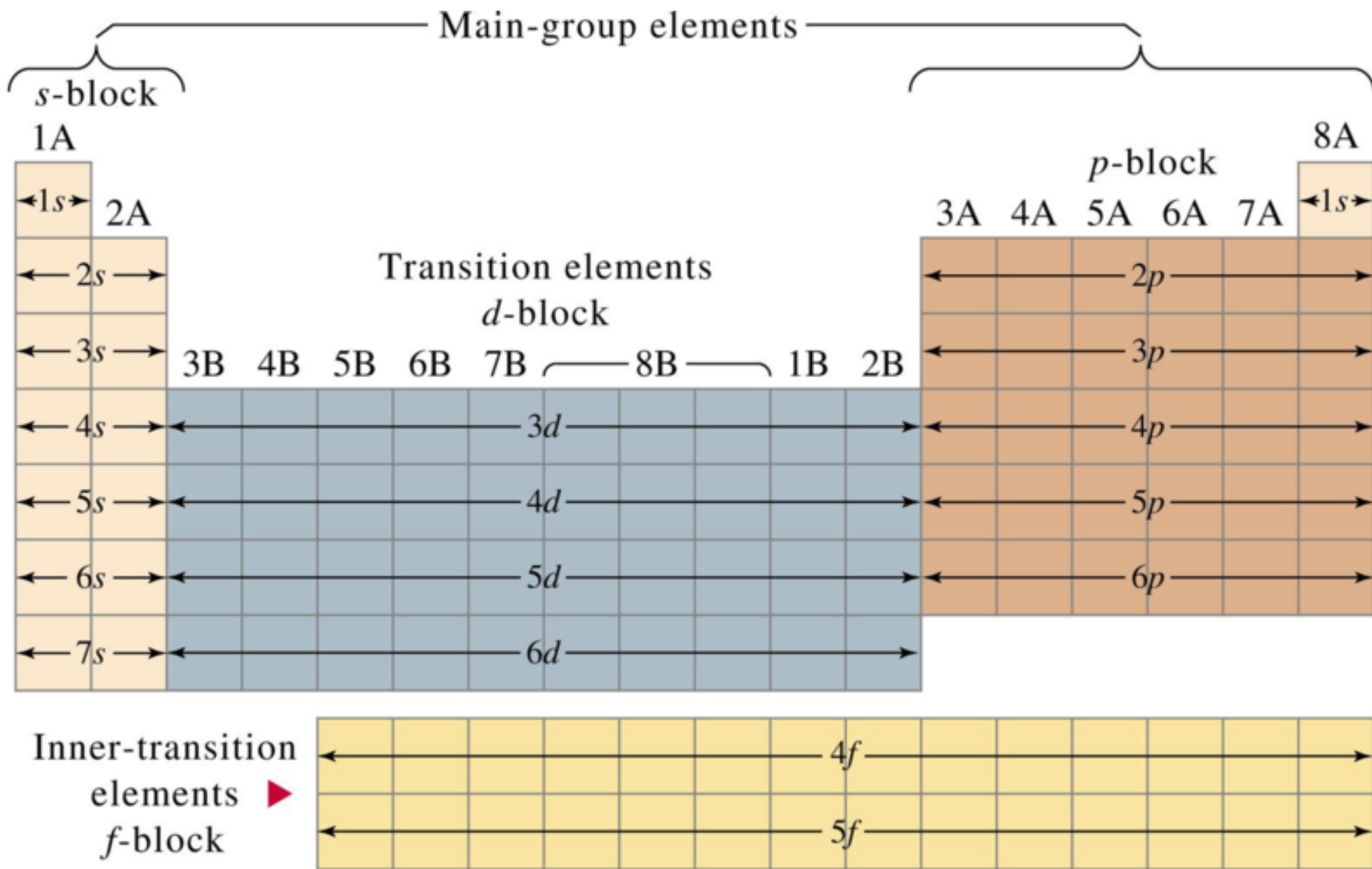


 Weight
  Names
  Electrons
  Wide

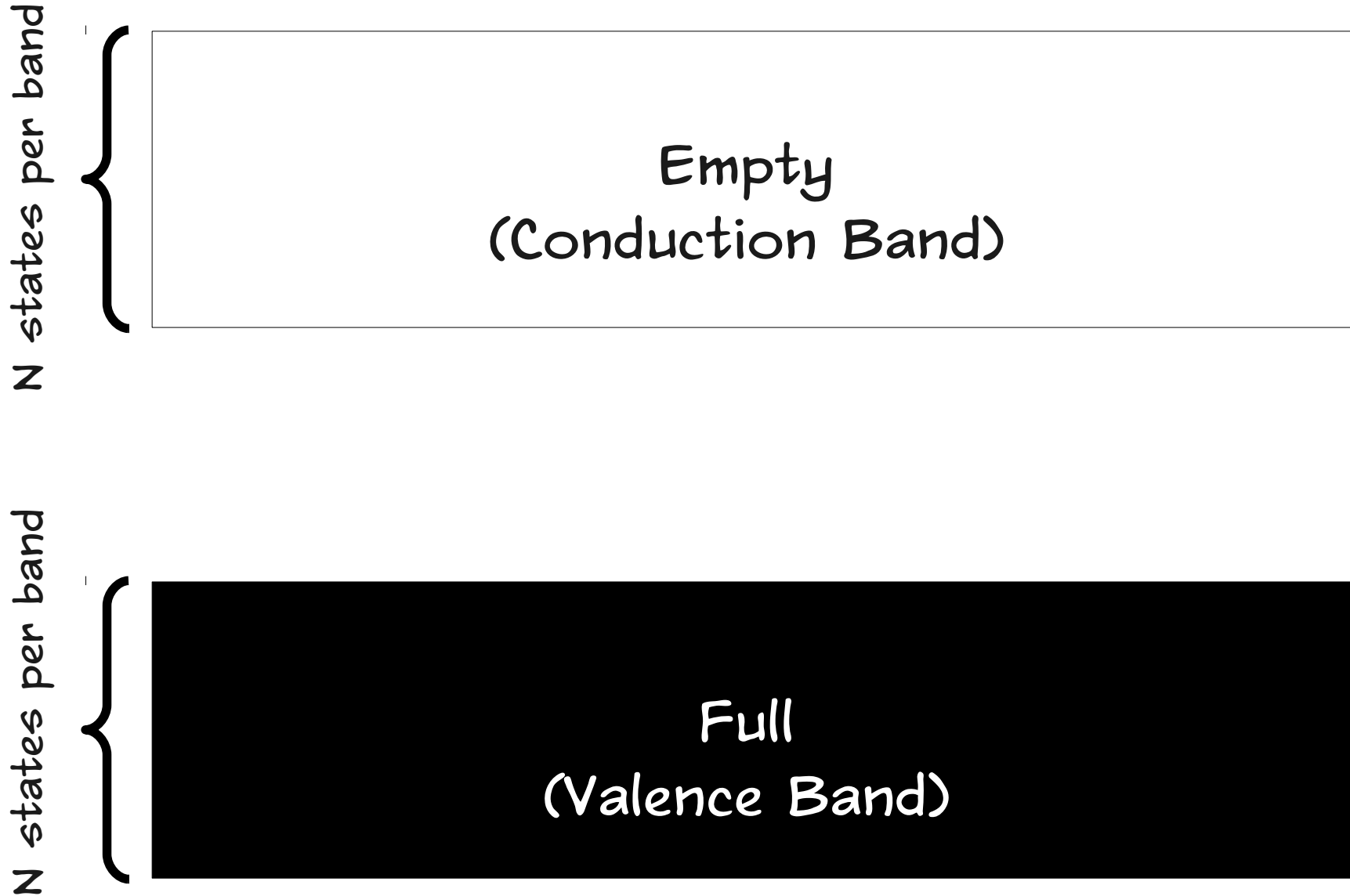
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18												
1	<b>H</b> Hydrogen 1.00794																	2	<b>He</b> Helium 4.002602											
2	<b>Li</b> Lithium 6.941	<b>Be</b> Beryllium 9.012182																	3	<b>Li</b> Lithium 6.941	4	<b>Be</b> Beryllium 9.012182								
3	<b>Na</b> Sodium 22.98976928	<b>Mg</b> Magnesium 24.3050																	5	<b>B</b> Boron 10.811	6	<b>C</b> Carbon 12.0107	7	<b>N</b> Nitrogen 14.0067	8	<b>O</b> Oxygen 15.9994	9	<b>F</b> Fluorine 18.9984032	10	<b>Ne</b> Neon 20.1797
4	<b>K</b> Potassium 39.0983	<b>Ca</b> Calcium 40.078	<b>Sc</b> Scandium 44.955912	<b>Ti</b> Titanium 47.867	<b>V</b> Vanadium 50.9415	<b>Cr</b> Chromium 51.9961	<b>Mn</b> Manganese 54.938045	<b>Fe</b> Iron 55.845	<b>Co</b> Cobalt 58.933195	<b>Ni</b> Nickel 58.6934	<b>Cu</b> Copper 63.546	<b>Zn</b> Zinc 65.38	<b>Ga</b> Gallium 69.723	<b>Ge</b> Germanium 72.64	<b>As</b> Arsenic 74.92160	<b>Se</b> Selenium 78.96	<b>Br</b> Bromine 79.904	<b>Kr</b> Krypton 83.798												
5	<b>Rb</b> Rubidium 85.4678	<b>Sr</b> Strontium 87.62	<b>Y</b> Yttrium 88.90585	<b>Zr</b> Zirconium 91.224	<b>Nb</b> Niobium 92.90638	<b>Mo</b> Molybdenum 95.96	<b>Tc</b> Technetium (98)	<b>Ru</b> Ruthenium 101.07	<b>Rh</b> Rhodium 102.90550	<b>Pd</b> Palladium 106.42	<b>Ag</b> Silver 107.8682	<b>Cd</b> Cadmium 112.411	<b>In</b> Indium 114.818	<b>Sn</b> Tin 118.710	<b>Sb</b> Antimony 121.760	<b>Te</b> Tellurium 127.60	<b>I</b> Iodine 126.90447	<b>Xe</b> Xenon 131.293												
6	<b>Cs</b> Caesium 132.90545196	<b>Ba</b> Barium 137.327	57-71	<b>Hf</b> Hafnium 178.49	<b>Ta</b> Tantalum 180.94788	<b>W</b> Tungsten 183.84	<b>Re</b> Rhenium 186.207	<b>Os</b> Osmium 190.23	<b>Ir</b> Iridium 192.217	<b>Pt</b> Platinum 195.084	<b>Au</b> Gold 196.966569	<b>Hg</b> Mercury 200.59	<b>Tl</b> Thallium 204.3833	<b>Pb</b> Lead 207.2	<b>Bi</b> Bismuth 208.98040	<b>Po</b> Polonium (209)	<b>At</b> Astatine (210)	<b>Rn</b> Radon (222)												
7	<b>Fr</b> Francium (223)	<b>Ra</b> Radium (226)	89-103	<b>Rf</b> Rutherfordium (261)	<b>Db</b> Dubnium (268)	<b>Sg</b> Seaborgium (271)	<b>Bh</b> Bohrium (272)	<b>Hs</b> Hassium (270)	<b>Mt</b> Meitnerium (276)	<b>Ds</b> Darmstadtium (281)	<b>Rg</b> Roentgenium (280)	<b>Cn</b> Copernicium (285)	<b>Uut</b> Ununtrium (284)	<b>Uuq</b> Ununquadium (289)	<b>Uup</b> Ununpentium (288)	<b>Uuh</b> Ununhexium (293)	<b>Uus</b> Ununseptium (294)	<b>Uuo</b> Ununoctium (294)												



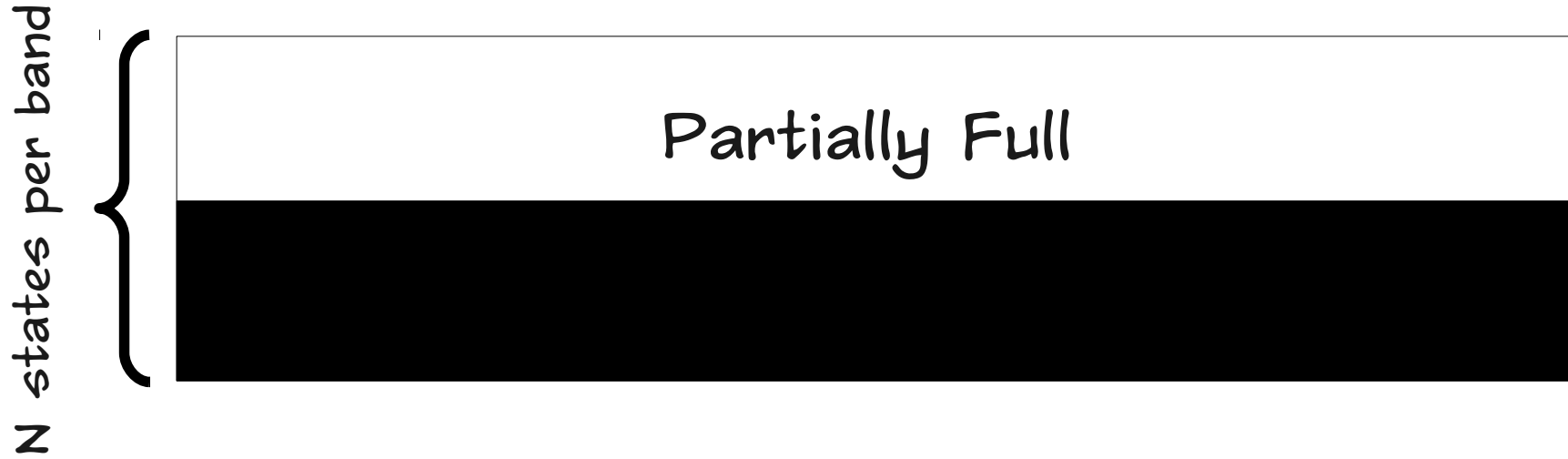




# INSULATOR ( $T=0$ )



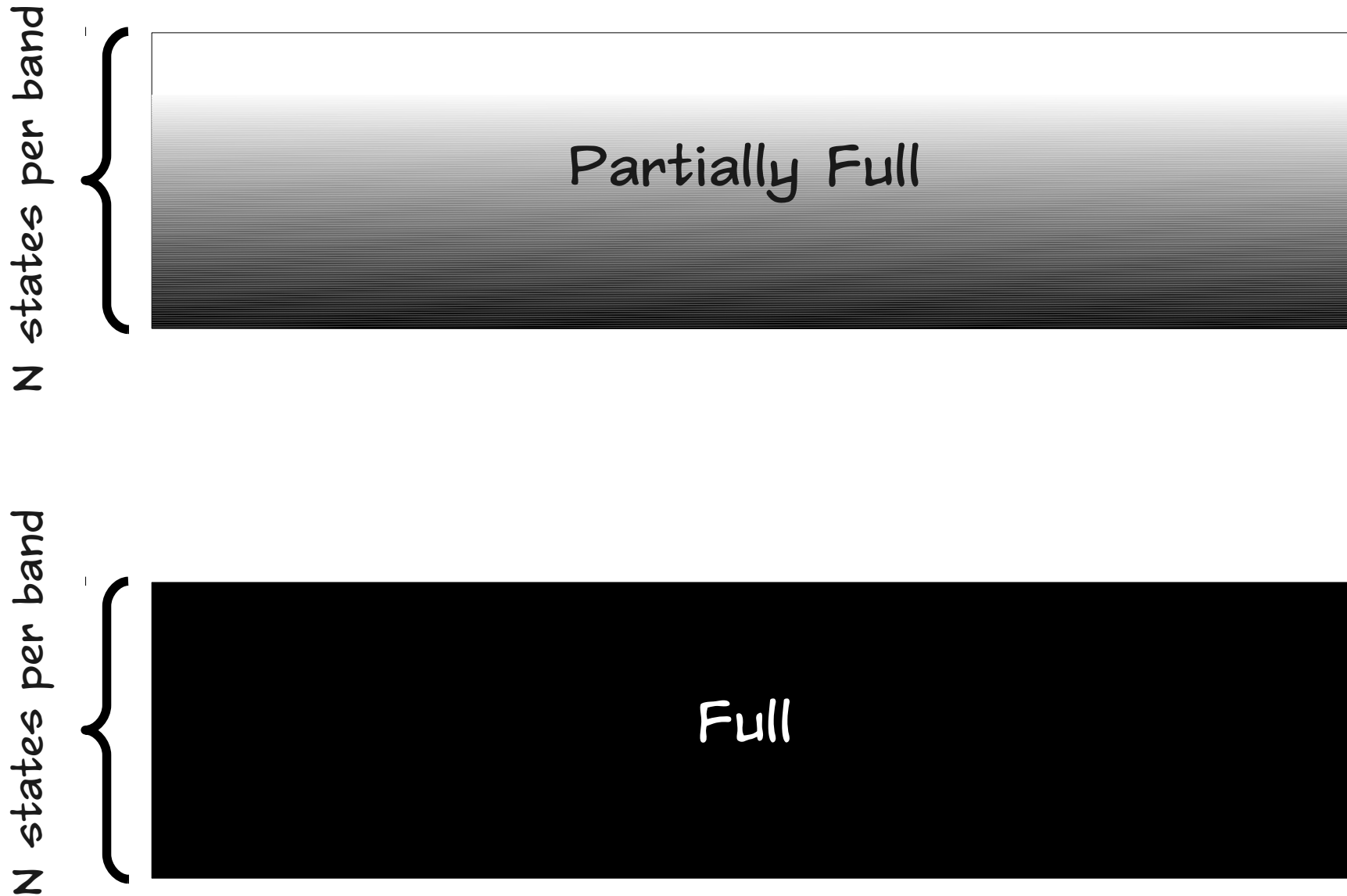
# CONDUCTOR ( $T=0$ )



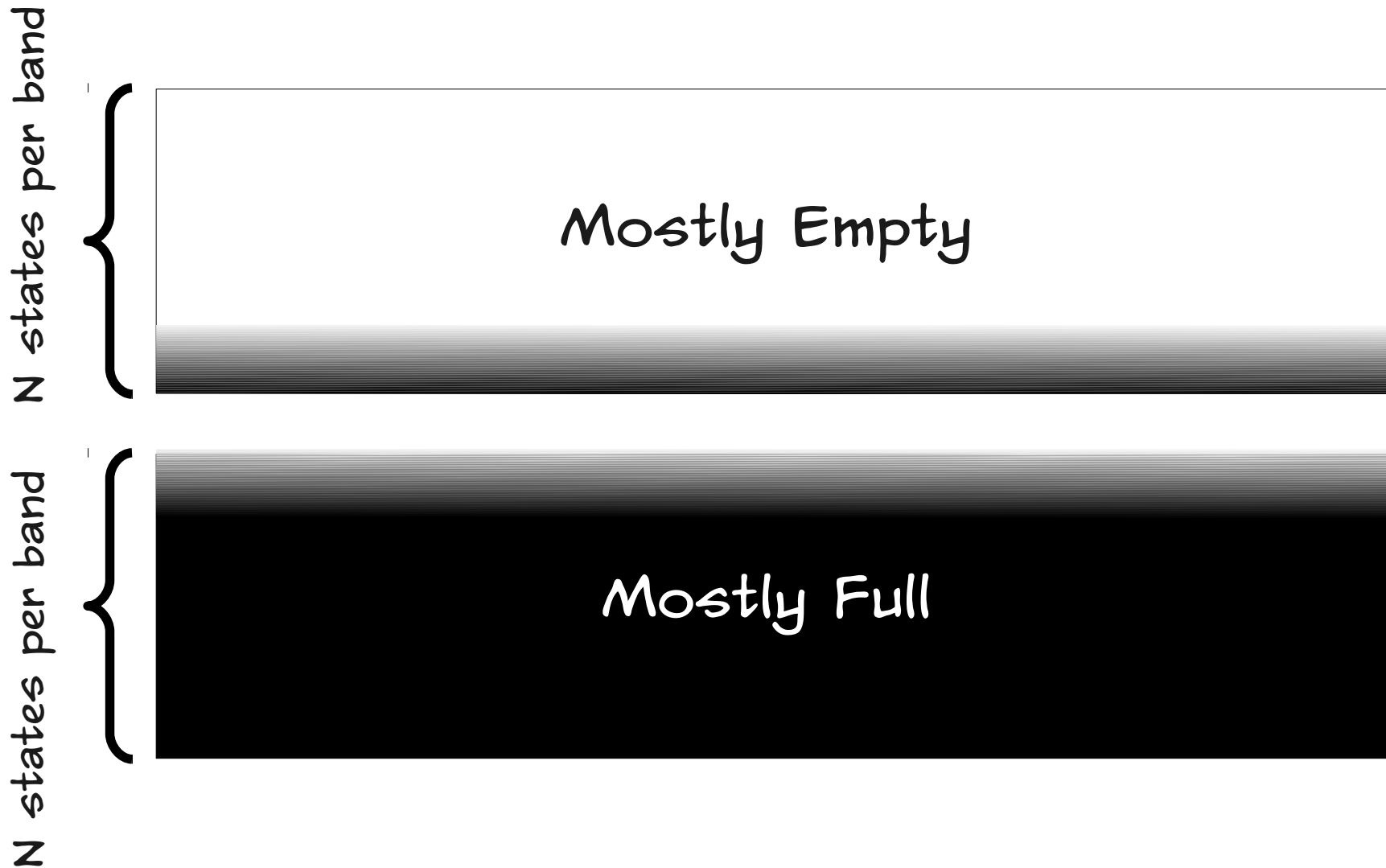
# SEMI-CONDUCTOR ( $T=0$ )



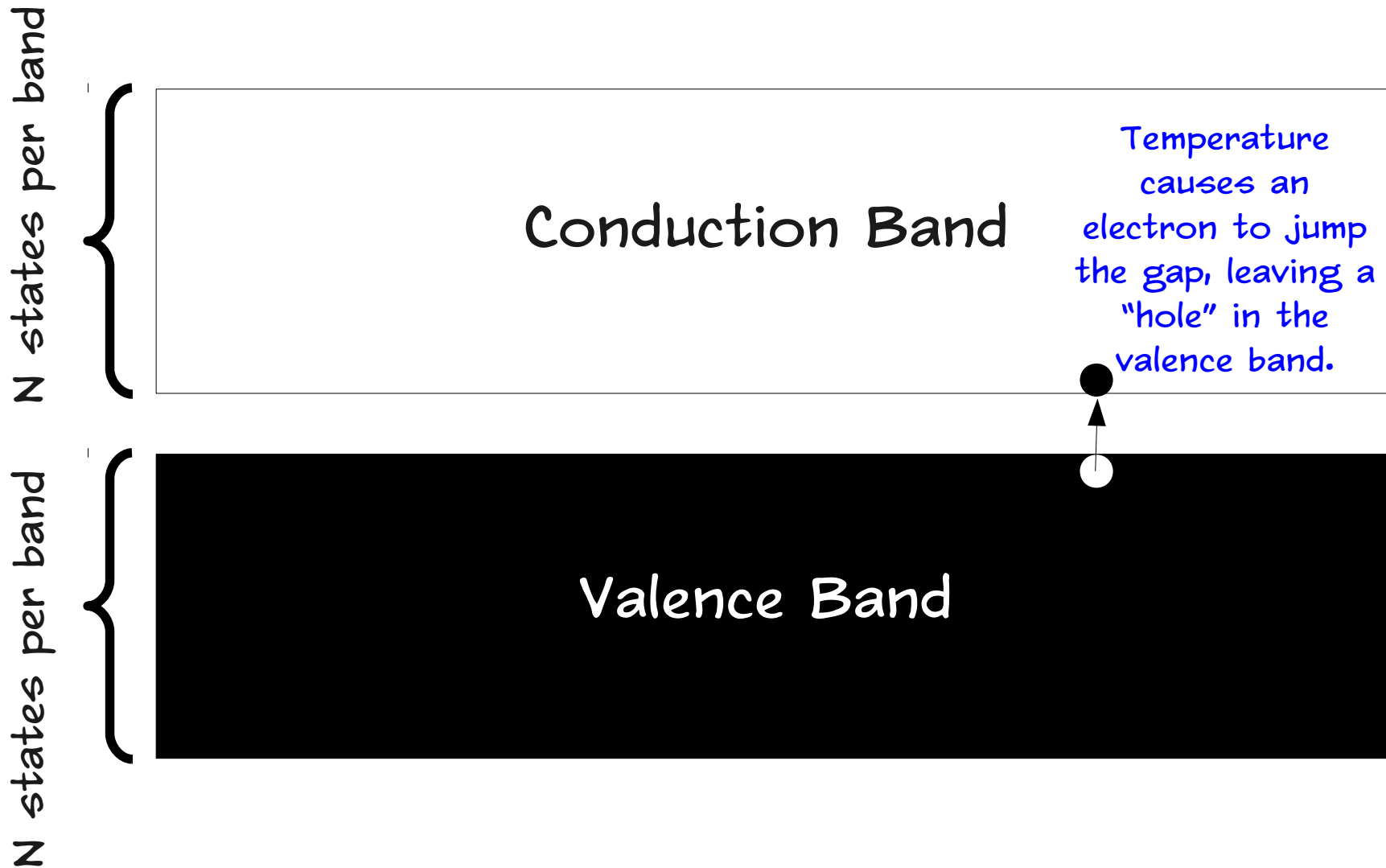
# CONDUCTOR ( $T > 0$ )



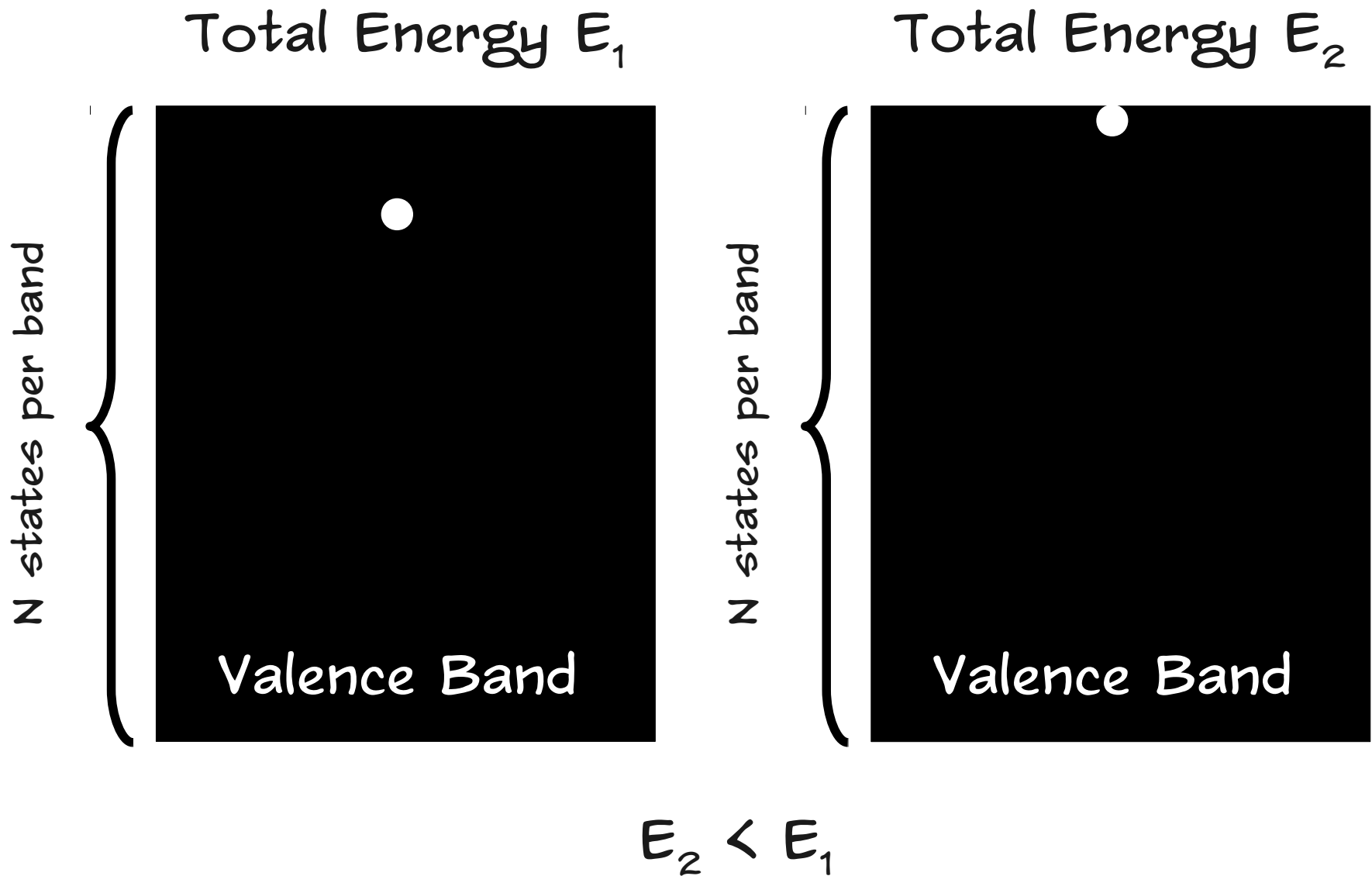
# SEMI-CONDUCTOR ( $T > 0$ )



# HOLES ( $T > 0$ )

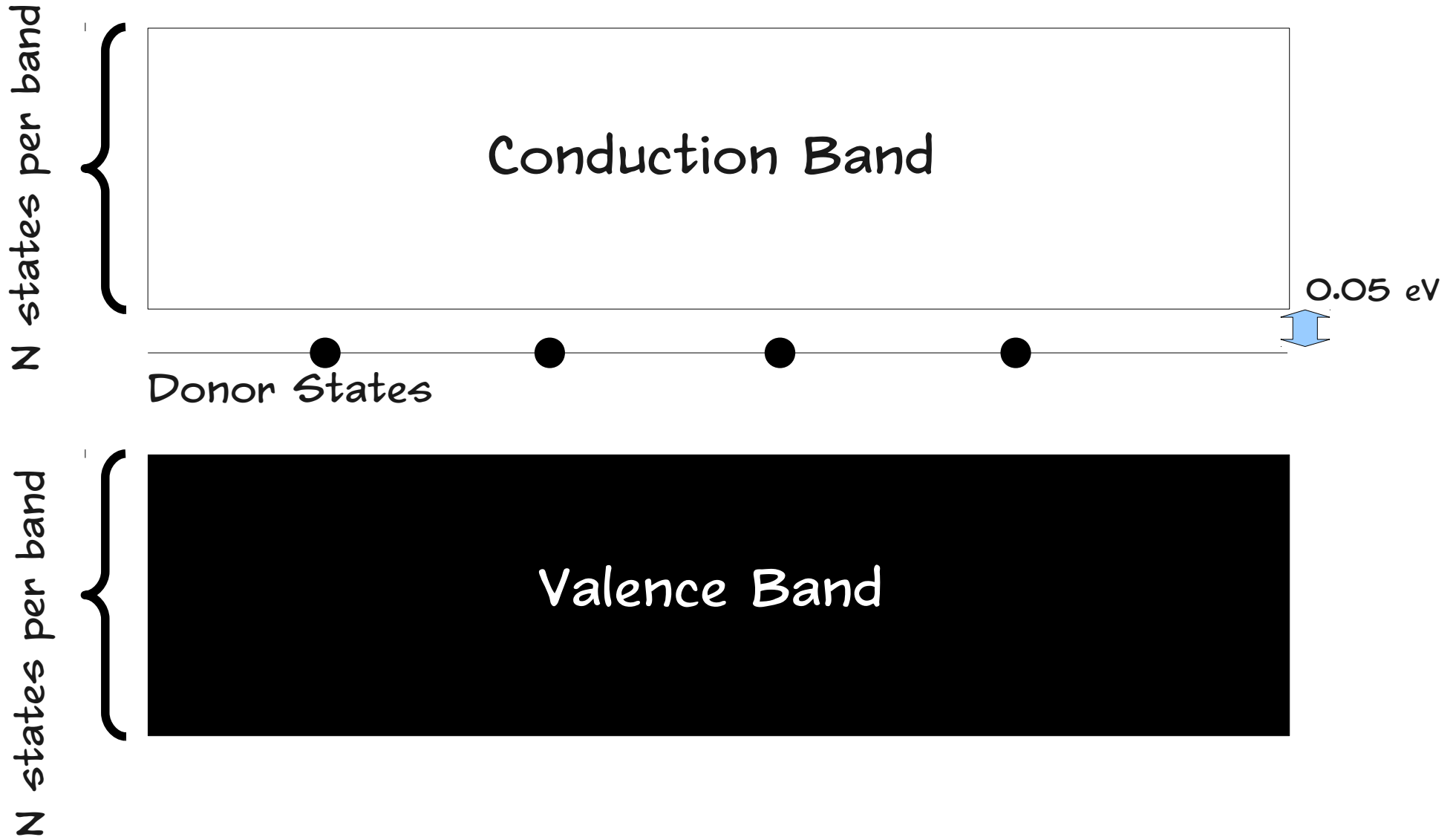


# HOLES FLOAT

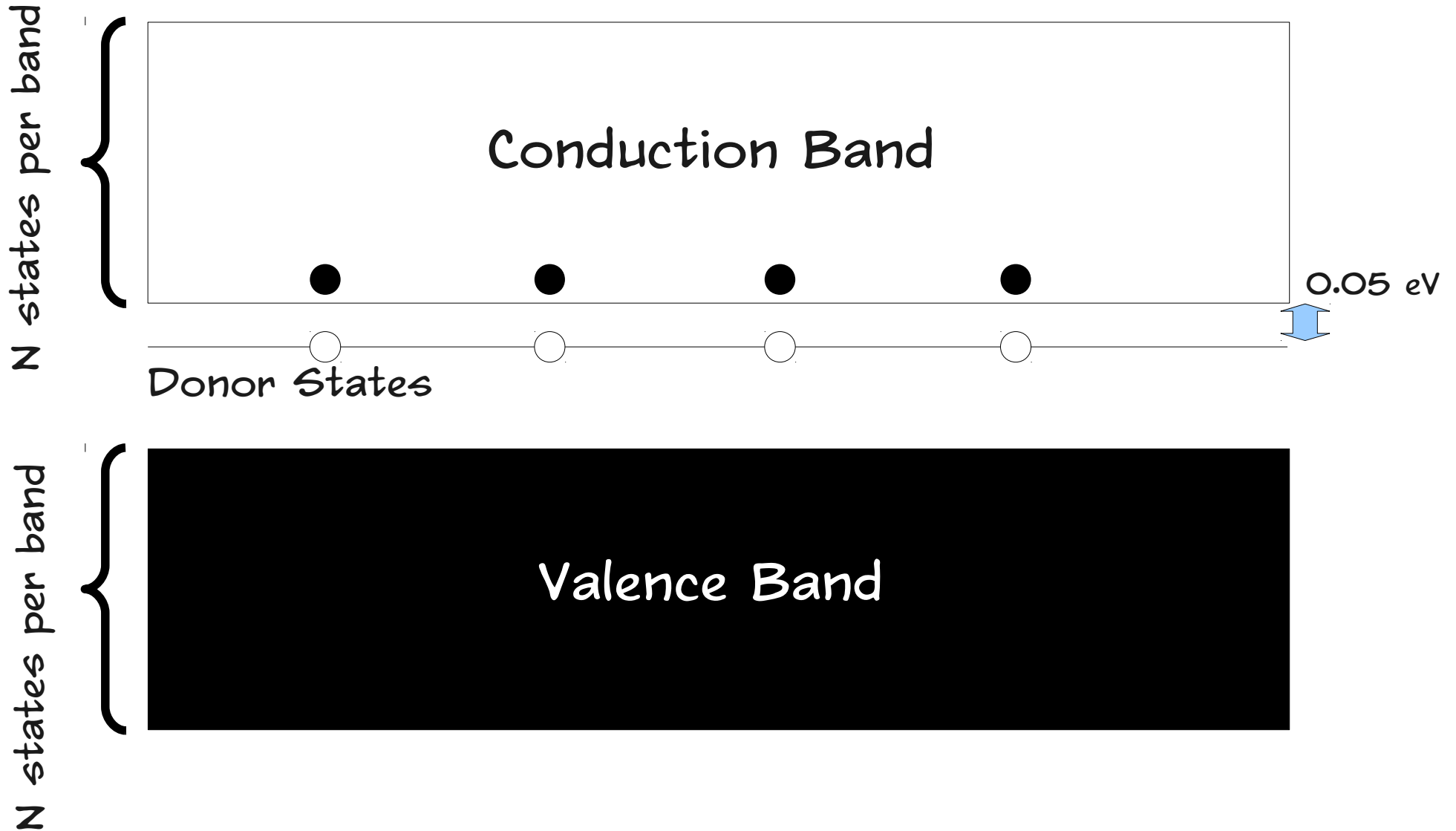




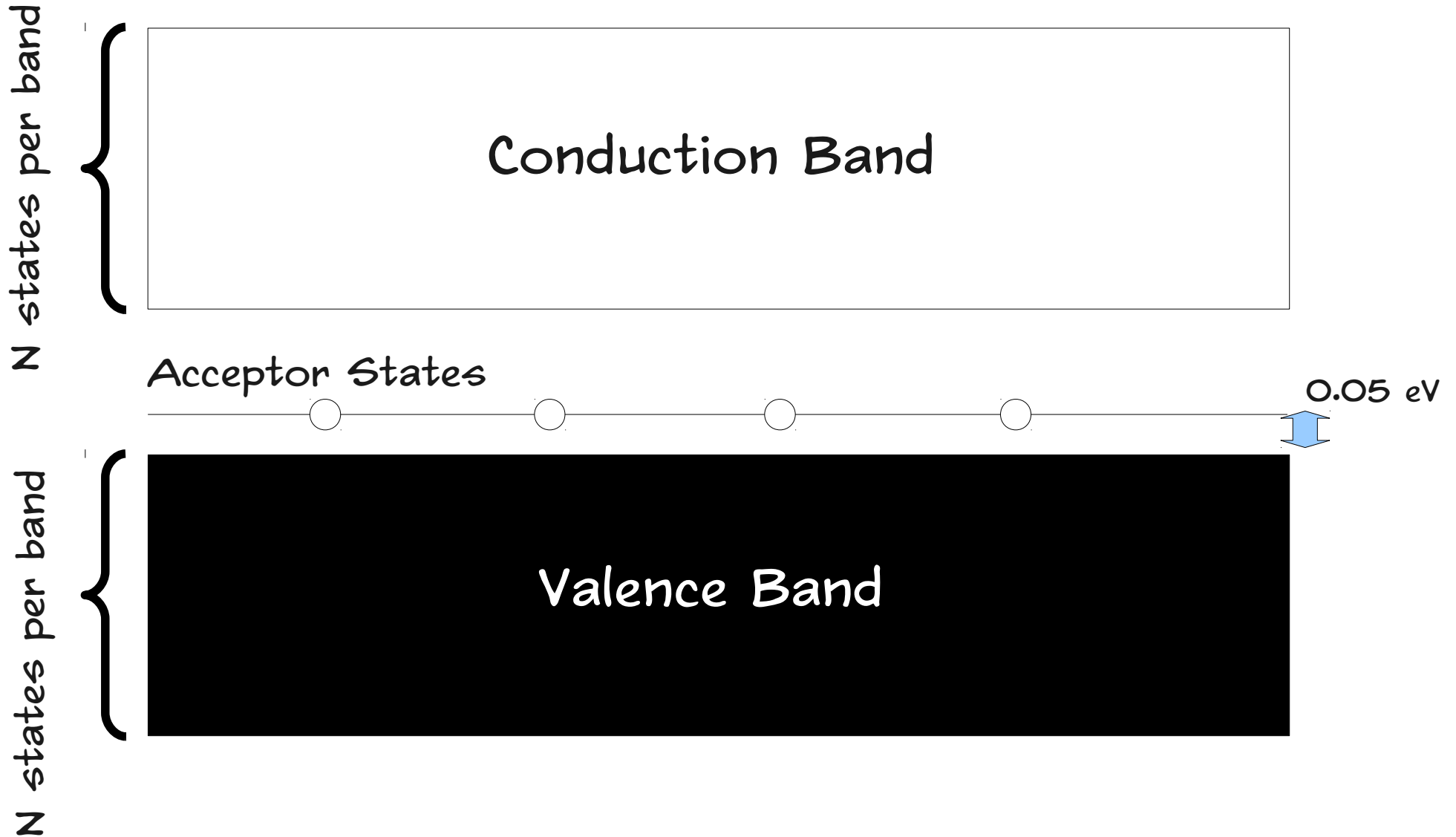
# N-TYPE EXTRINSIC SEMICONDUCTOR (T=0)



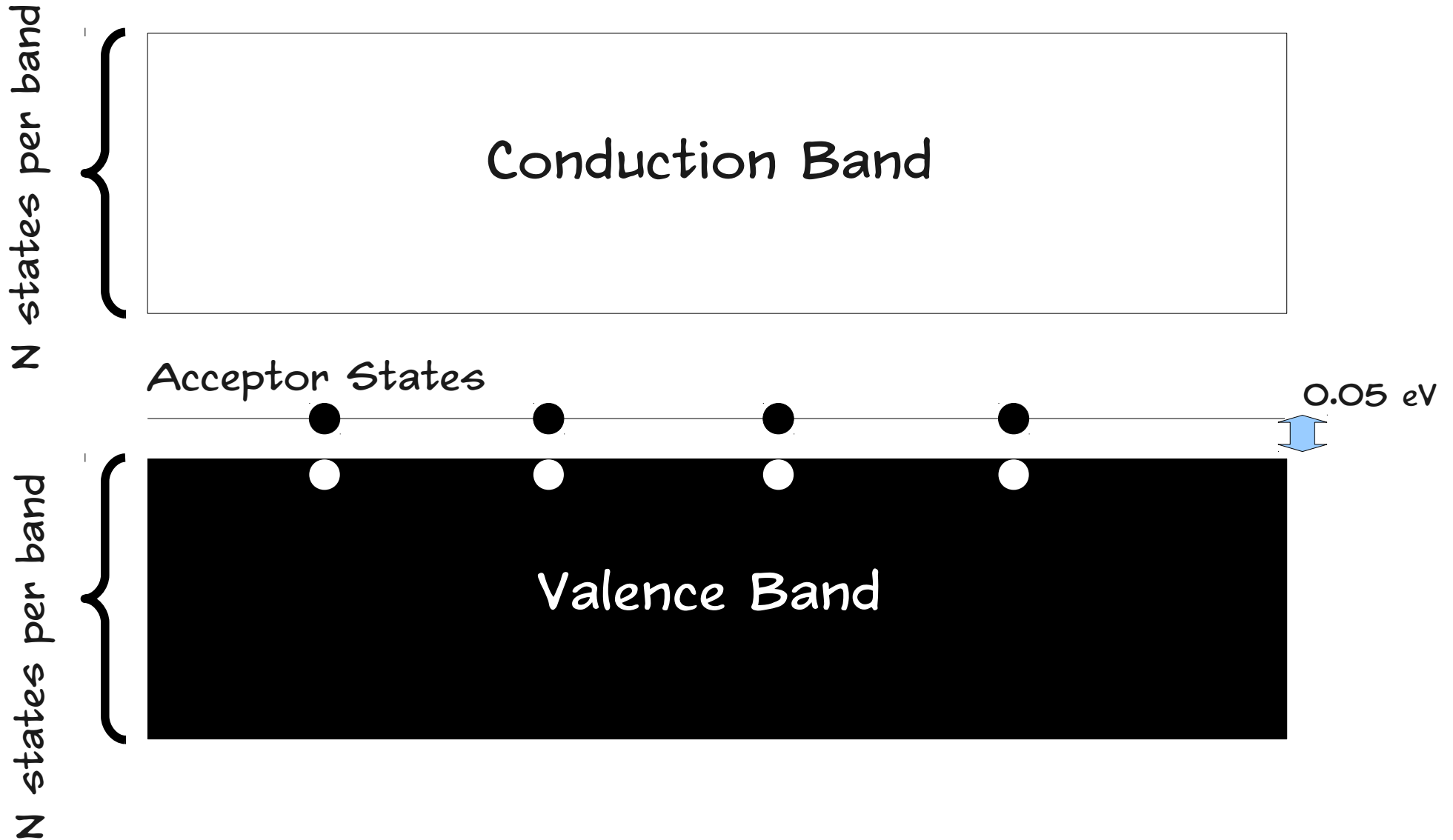
# N-TYPE EXTRINSIC SEMICONDUCTOR ( $T > 0$ )



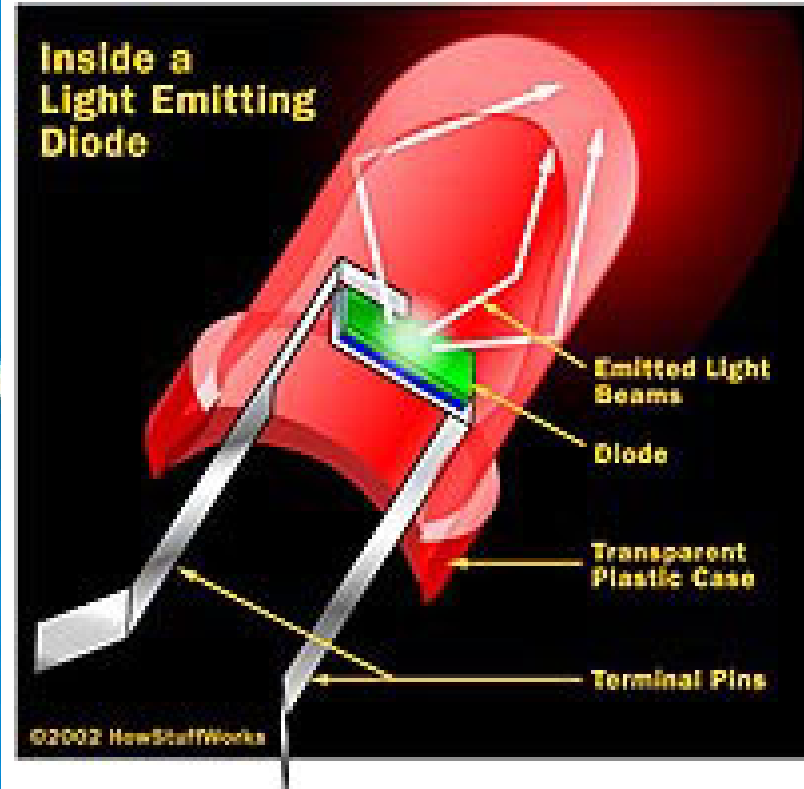
# P-TYPE EXTRINSIC SEMICONDUCTOR (T=0)

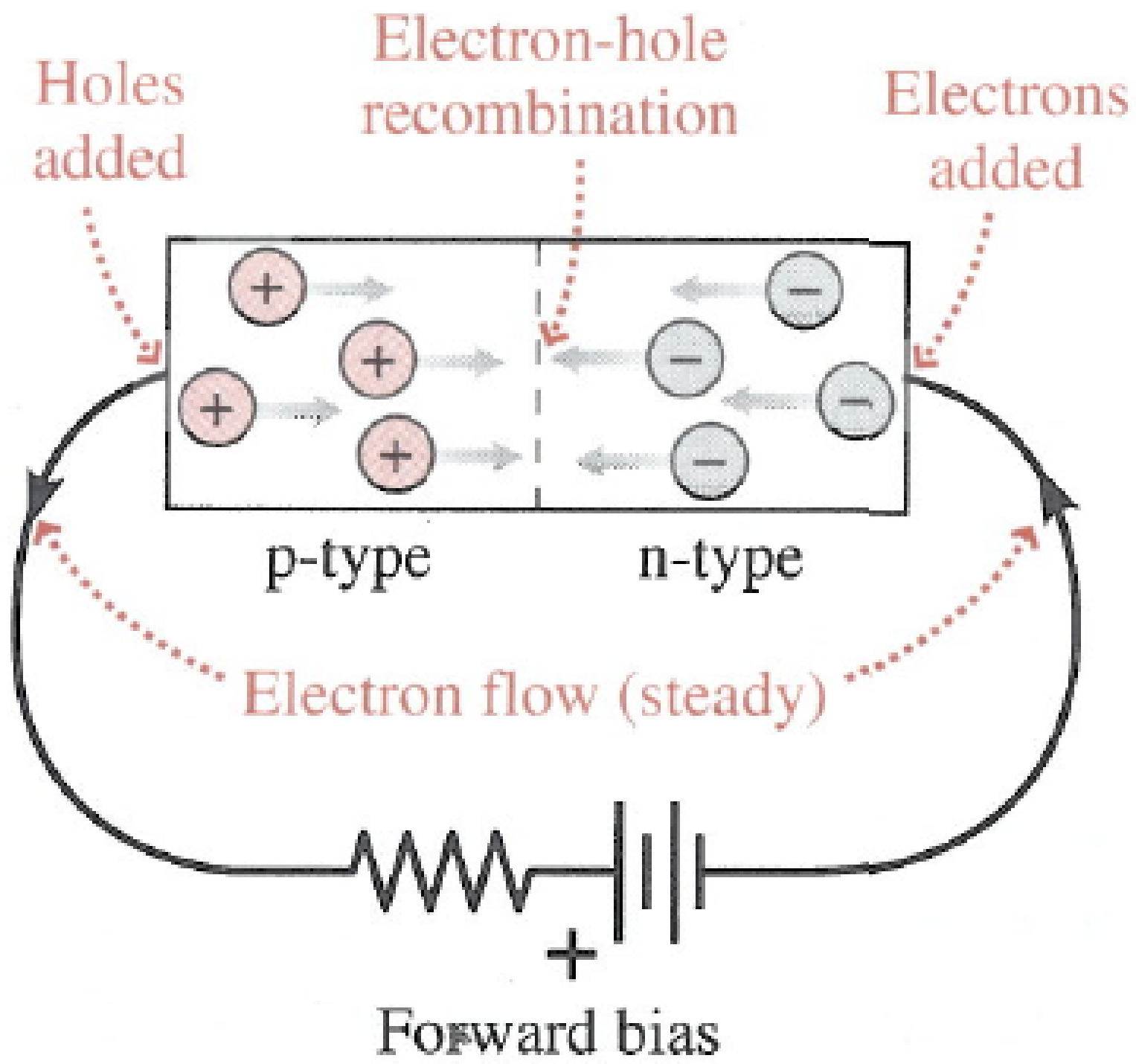


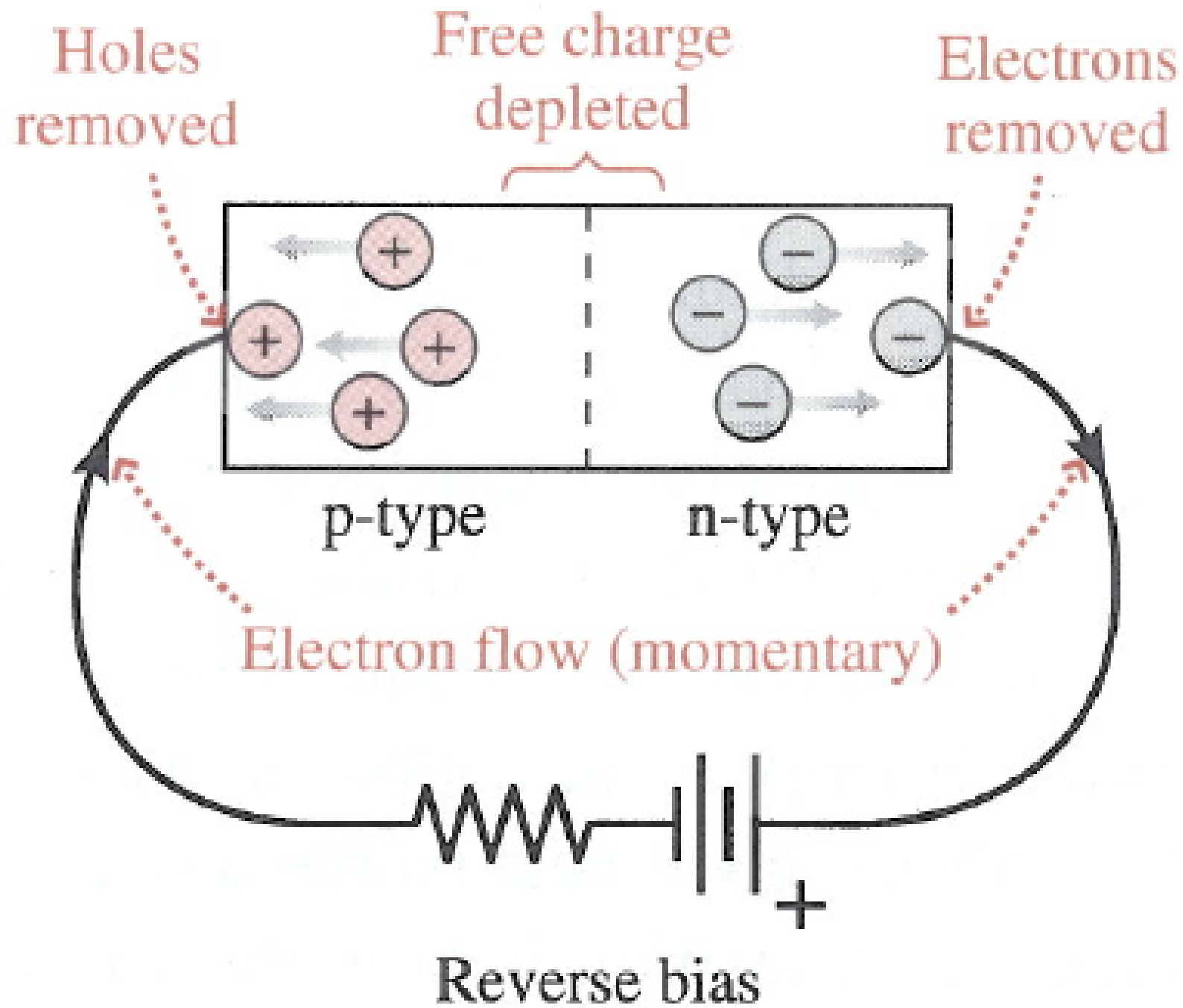
# P-TYPE EXTRINSIC SEMICONDUCTOR ( $T > 0$ )



# THE DIODE

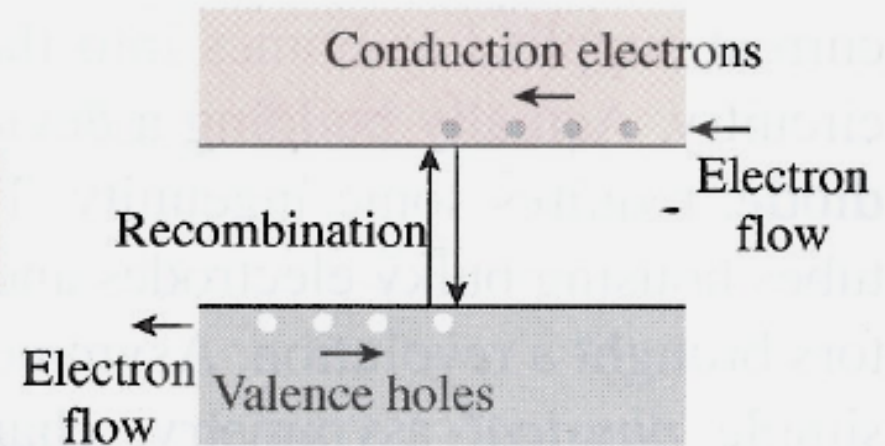
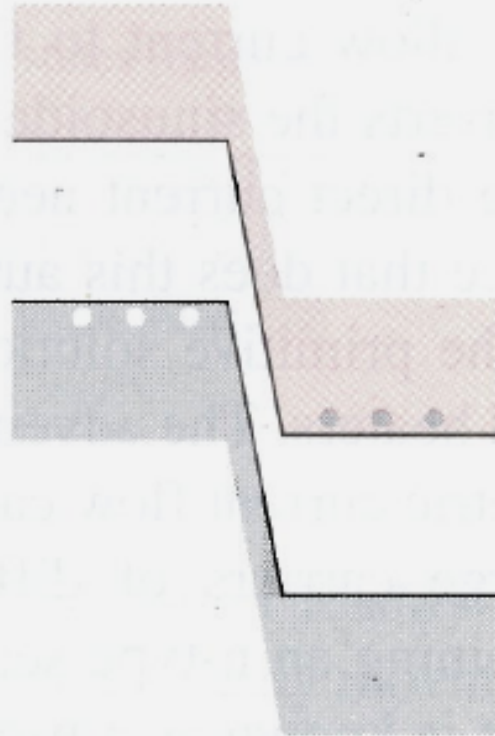
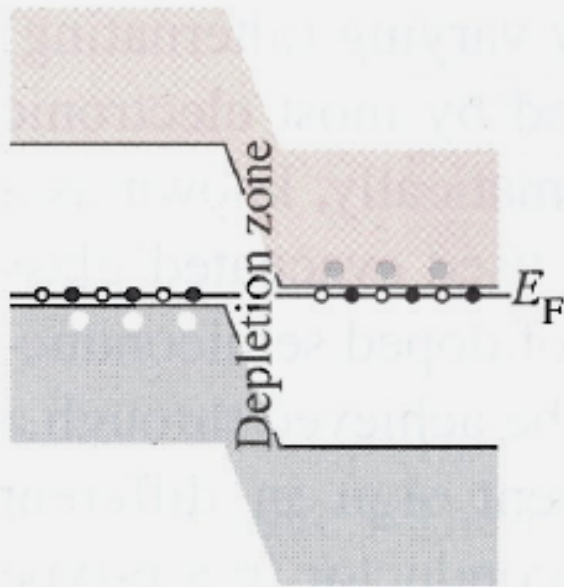
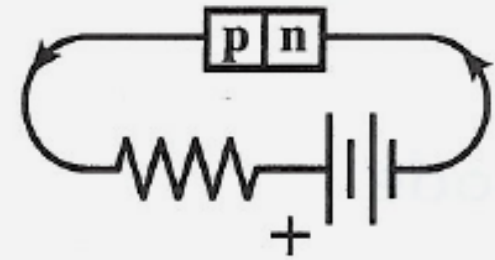
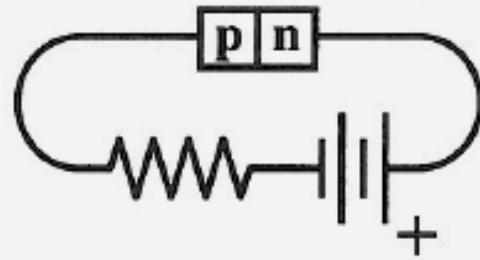






# ENERGY BAND PICTURE

p n



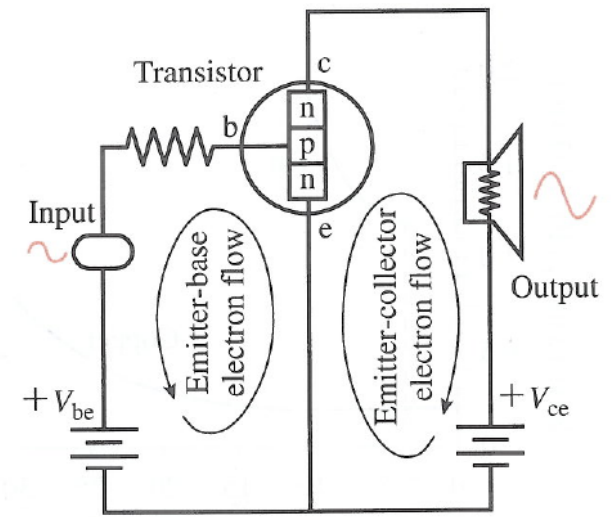
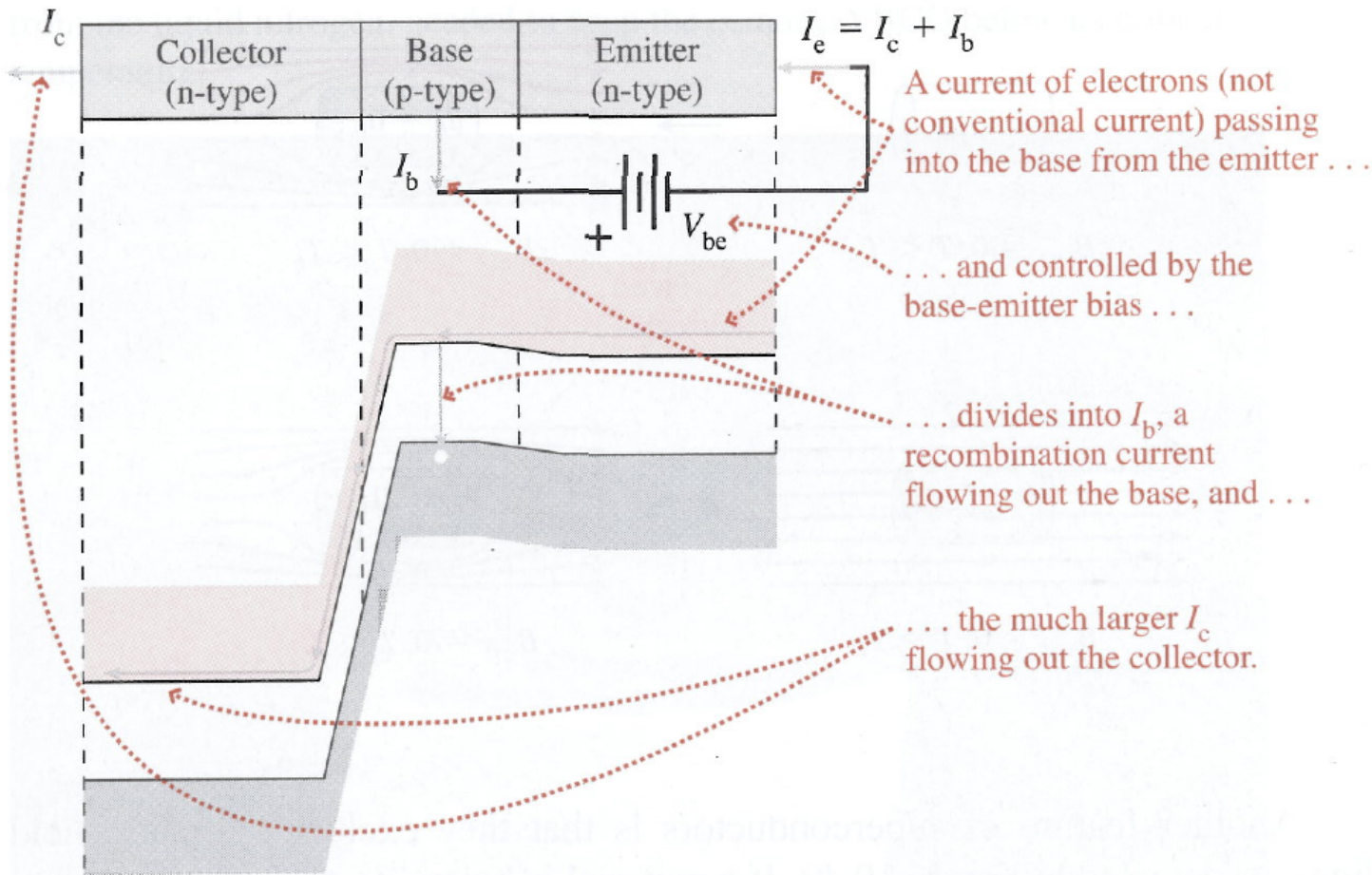
(a) Unbiased

(b) Reverse bias

(c) Forward bias



# TRANSISTOR



# NEXT TIME

- Superconductivity
- Nuclear Physics
- Good presentation style
- Reading for next time: Harris Ch. 10.9, 11.1-11.2