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Overhead Masters

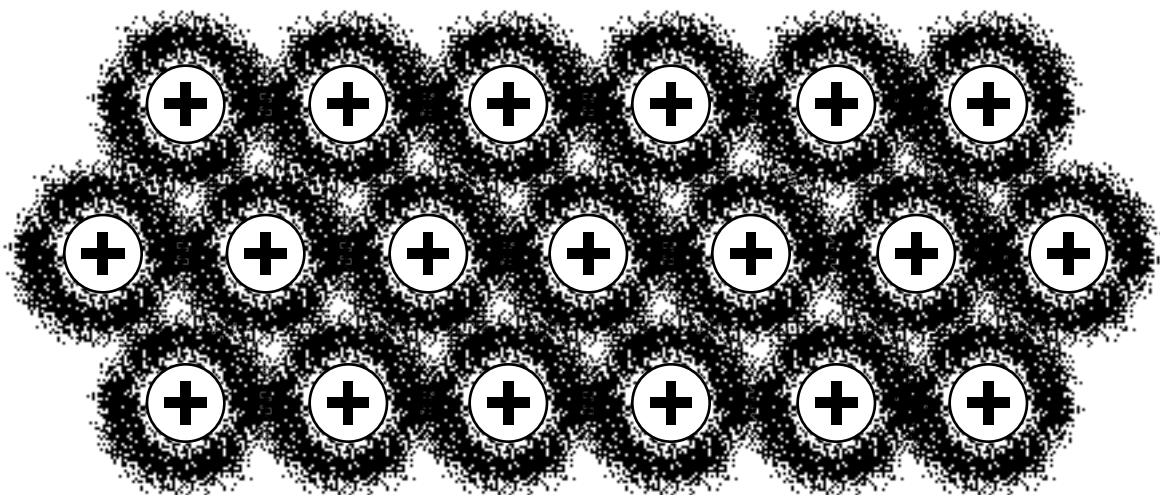
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Laboratory Safety

DISCLAIMER

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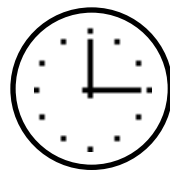
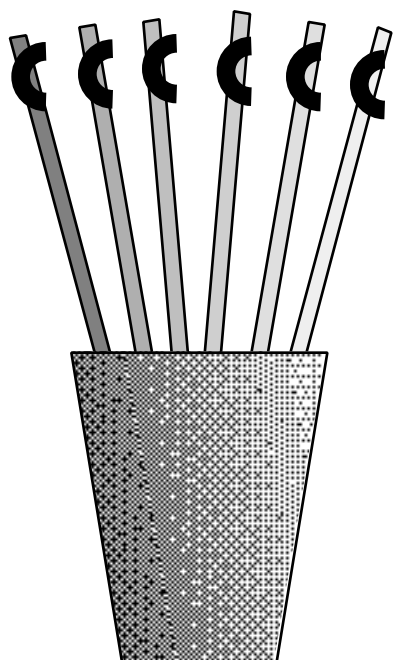
Metallic Sea of Electrons



Electrons are not bonded to any particular atom and are free to move about in the solid.

- ☐ High electrical conductivity
- ☐ High thermal conductivity
- ☐ High reflectivity of visible light

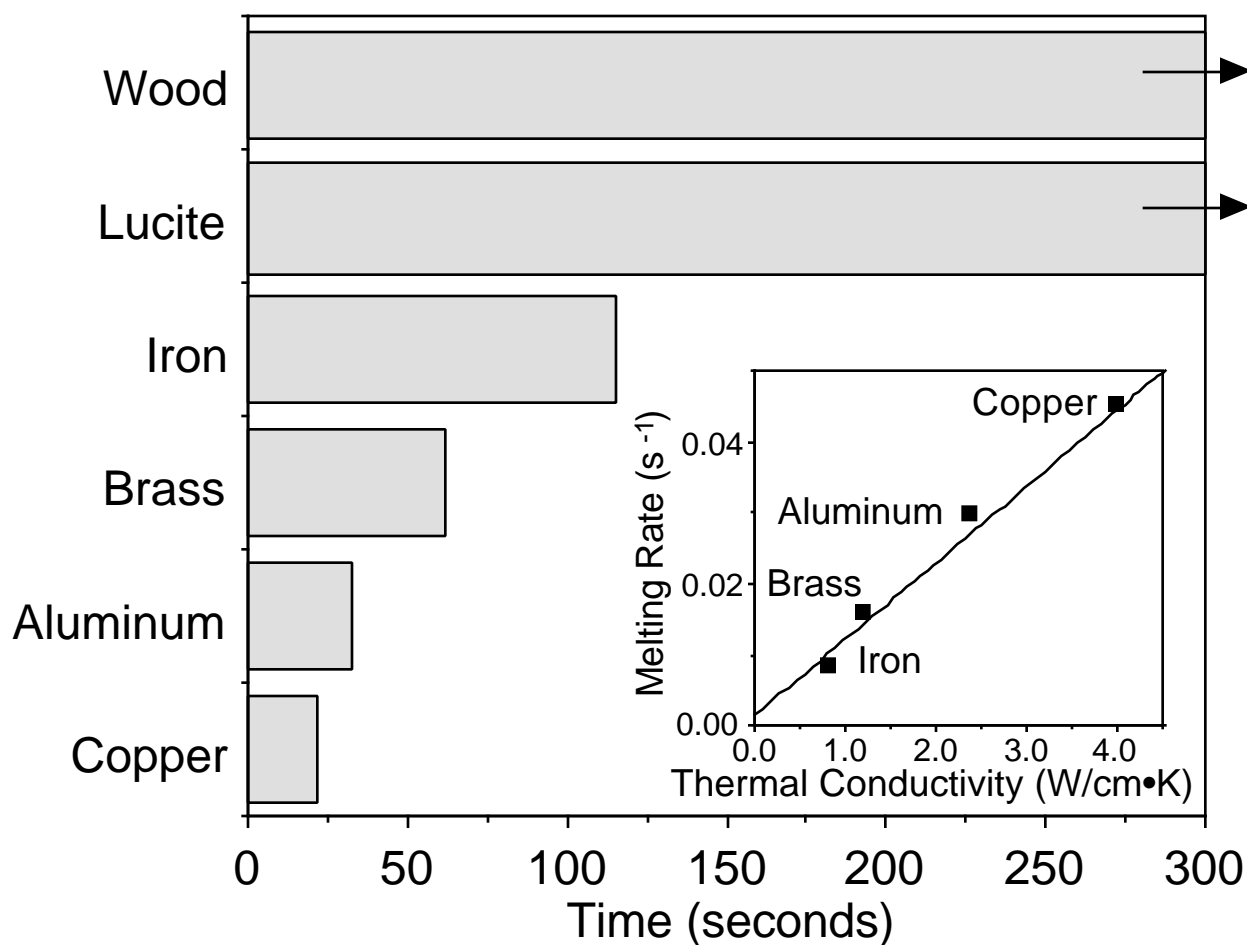
Thermal Conductivity



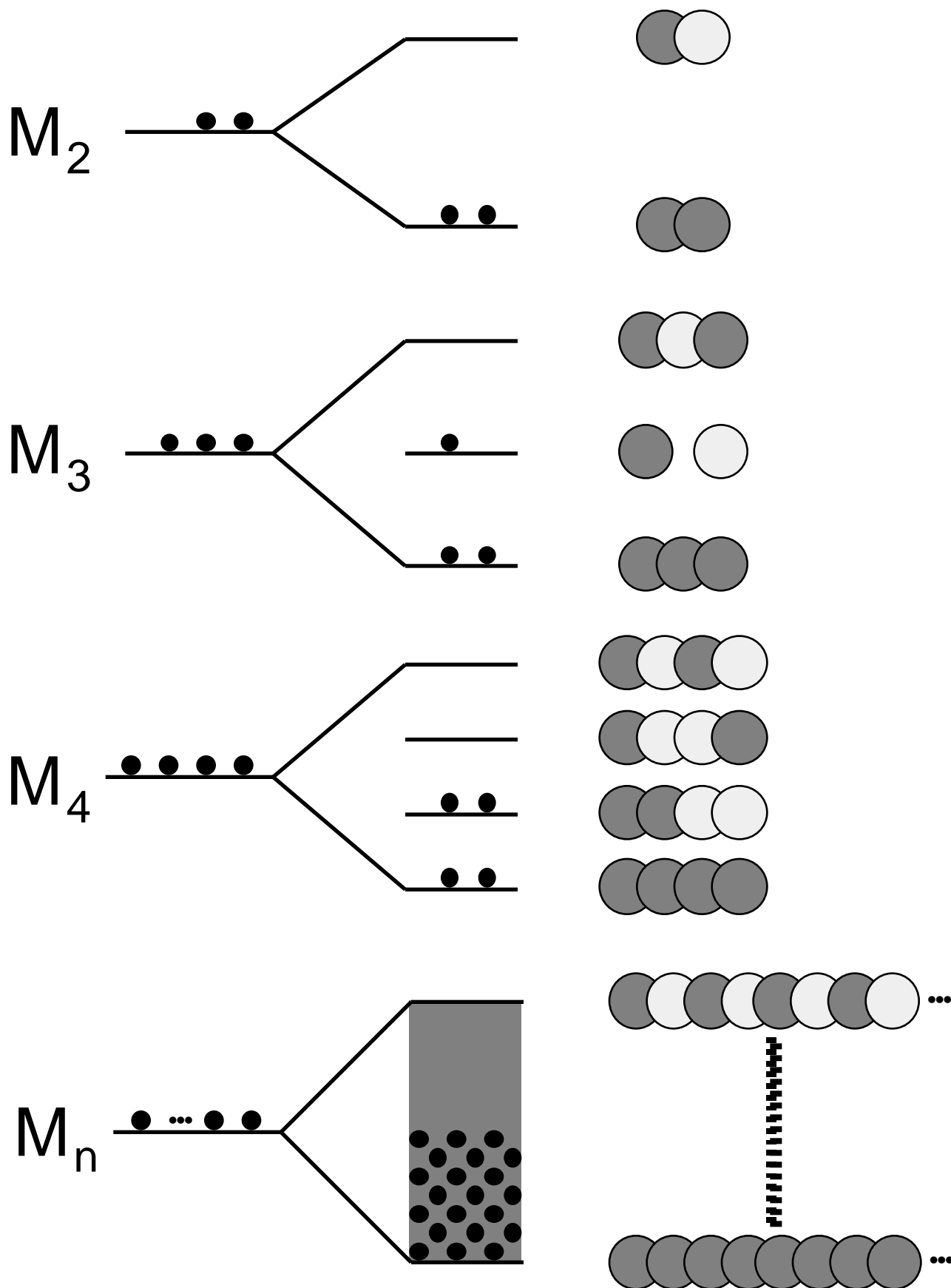
Put equal size rods of material into a foam cup.

Use butter to glue macaroni near end of rod.

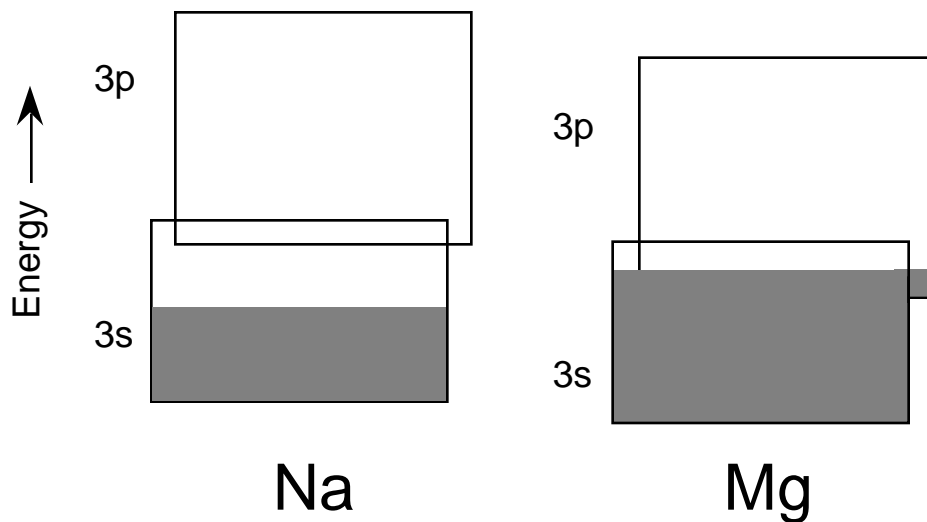
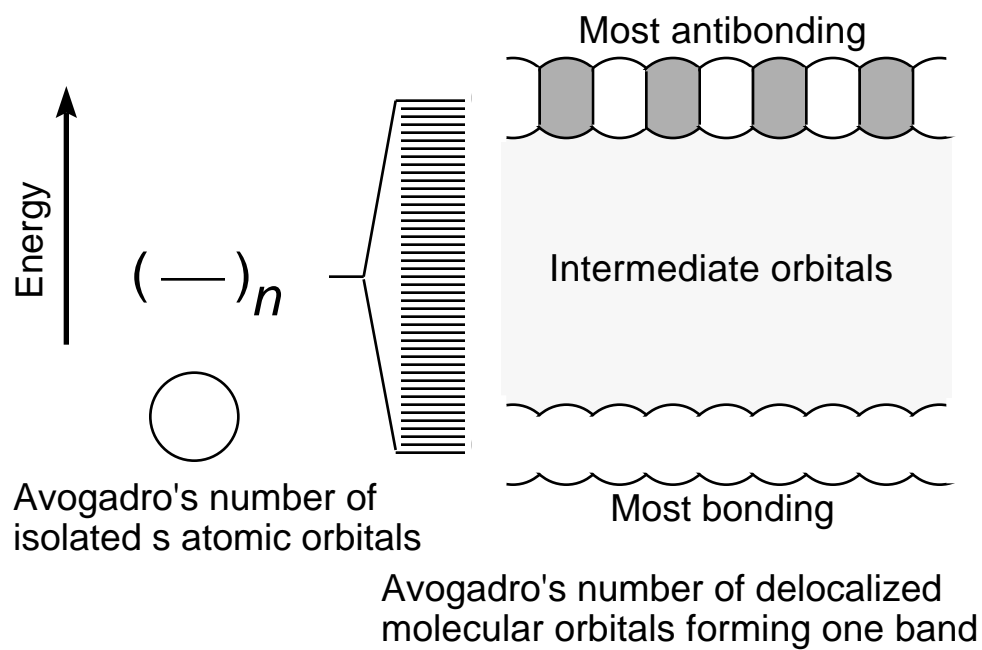
Add hot water and record time for macaroni to fall.



Bonds to Bands

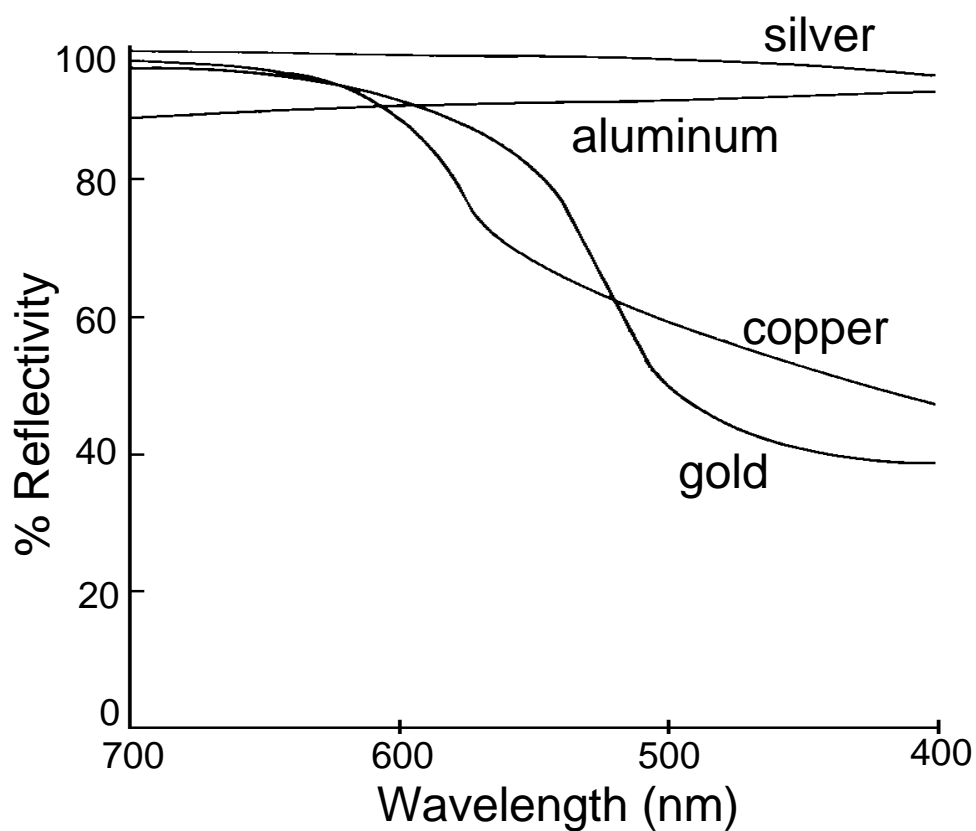
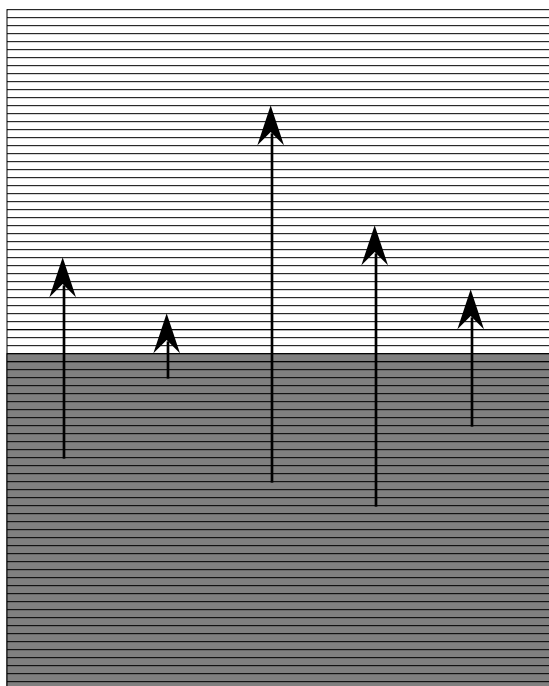


Bands



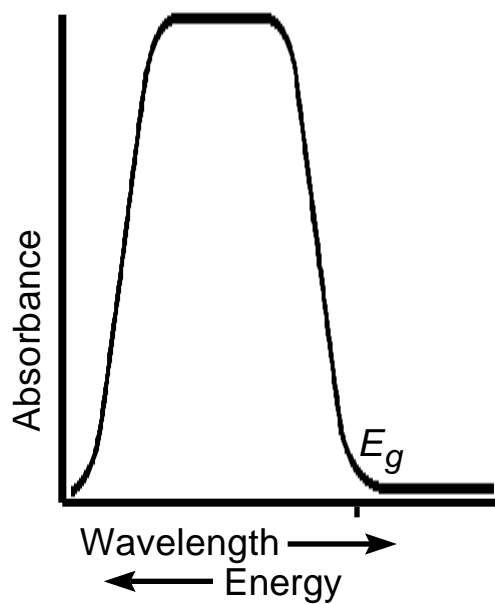
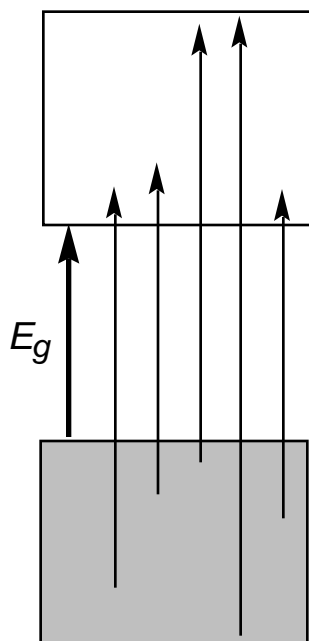
Optical Properties of Metals

Some possible electronic transitions in a half-filled band of a metal.

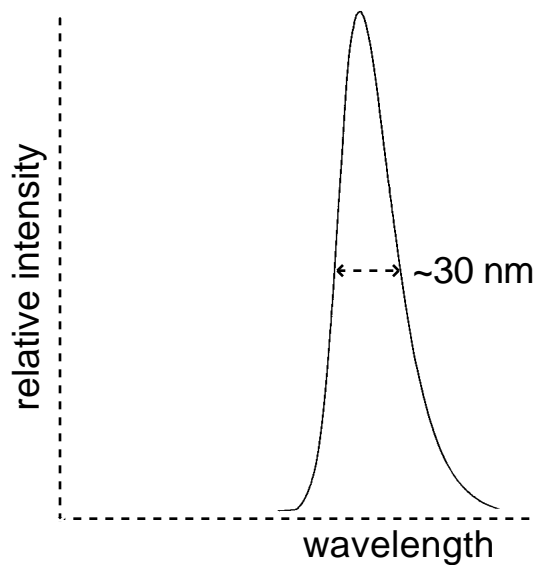
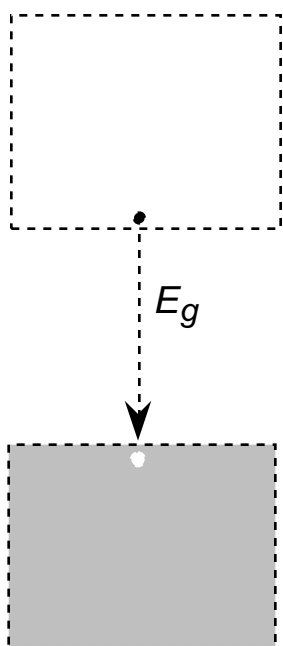


Optical Properties of Semiconductors

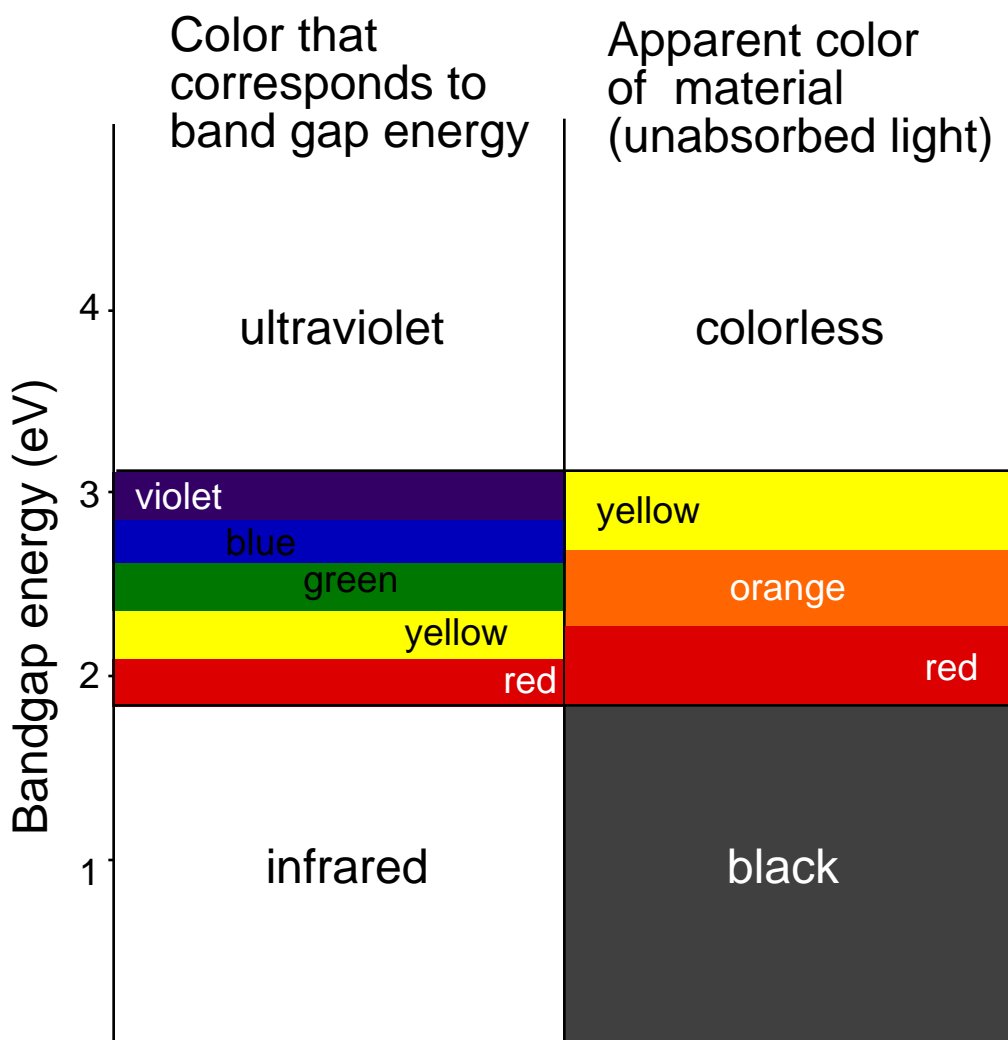
Absorption



Emission



Band Gap Energy and Color

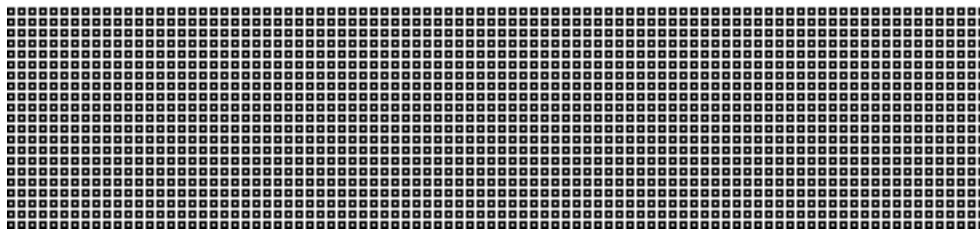
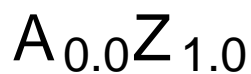
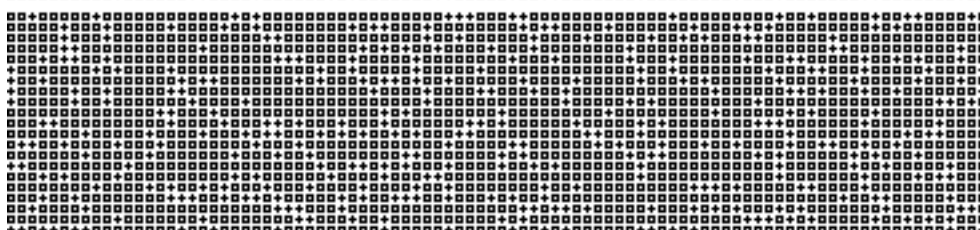
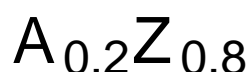
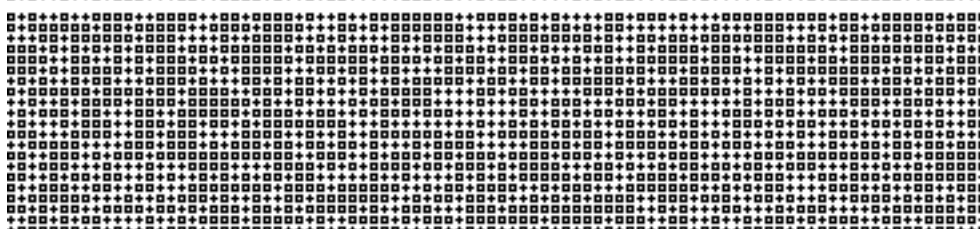
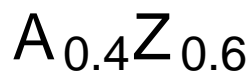
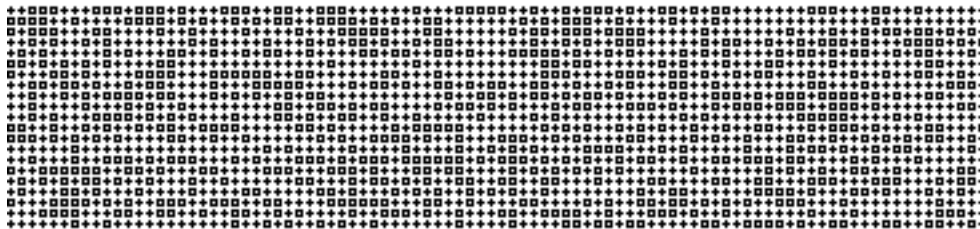
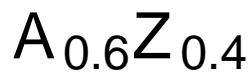
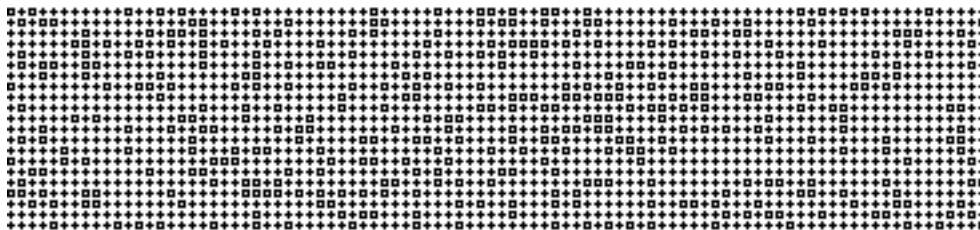
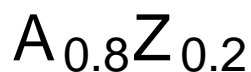
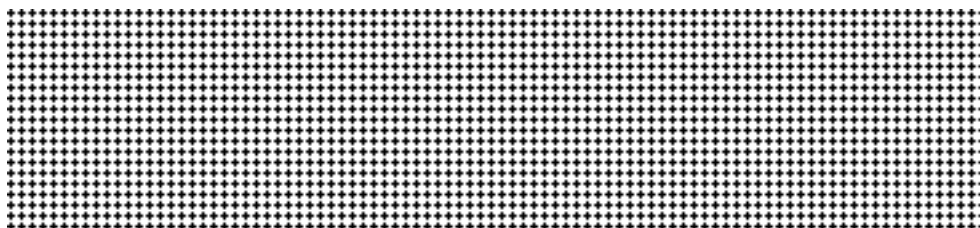
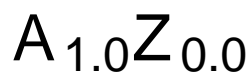
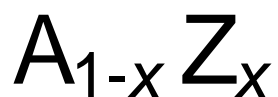


Band Gap and Periodic Properties

Element	Unit Cell, Å	D_0 , kJ/mol	E_g , eV (, nm)
C	3.57	346	5.5 (230)
Si	5.43	222	1.1 (1100)
Ge	5.66	188	0.66 (1900)
-Sn	6.49	146	< 0.1 (12,000)

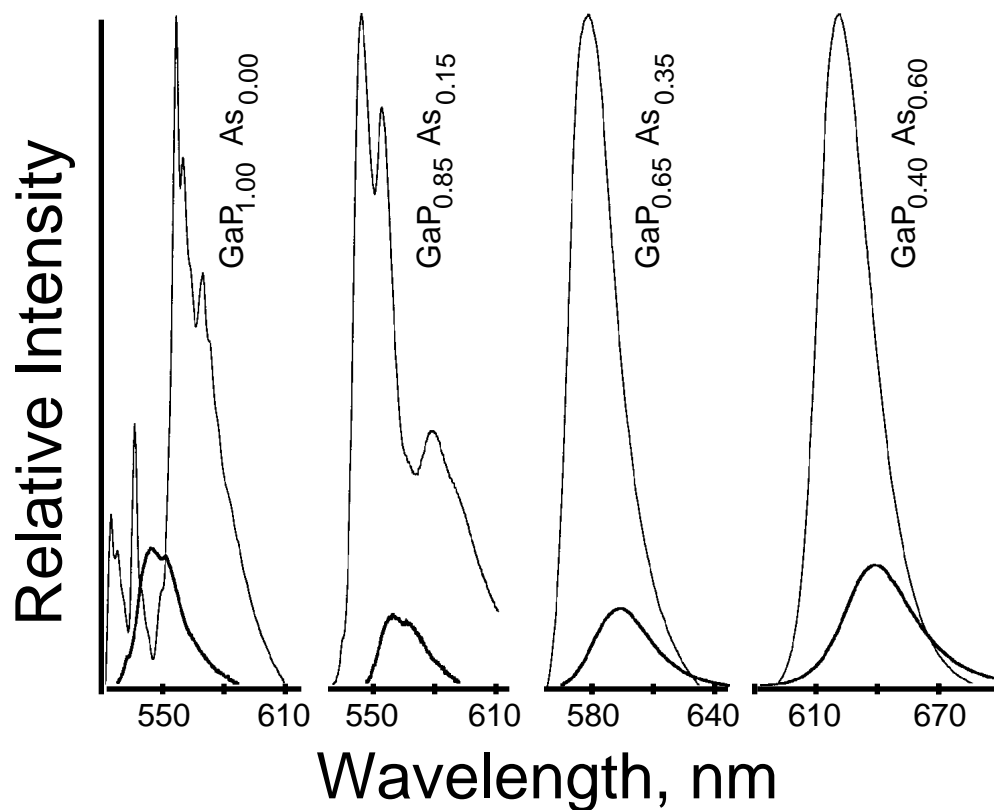
Material	Unit Cell, Å		E_g , eV (, nm)
Ge	5.66	0.0	0.66 (1900)
GaAs	5.65	0.4	1.42 (890)
ZnSe	5.67	0.8	2.70 (460)
CuBr	5.69	0.9	2.91 (430)

Solid Solutions



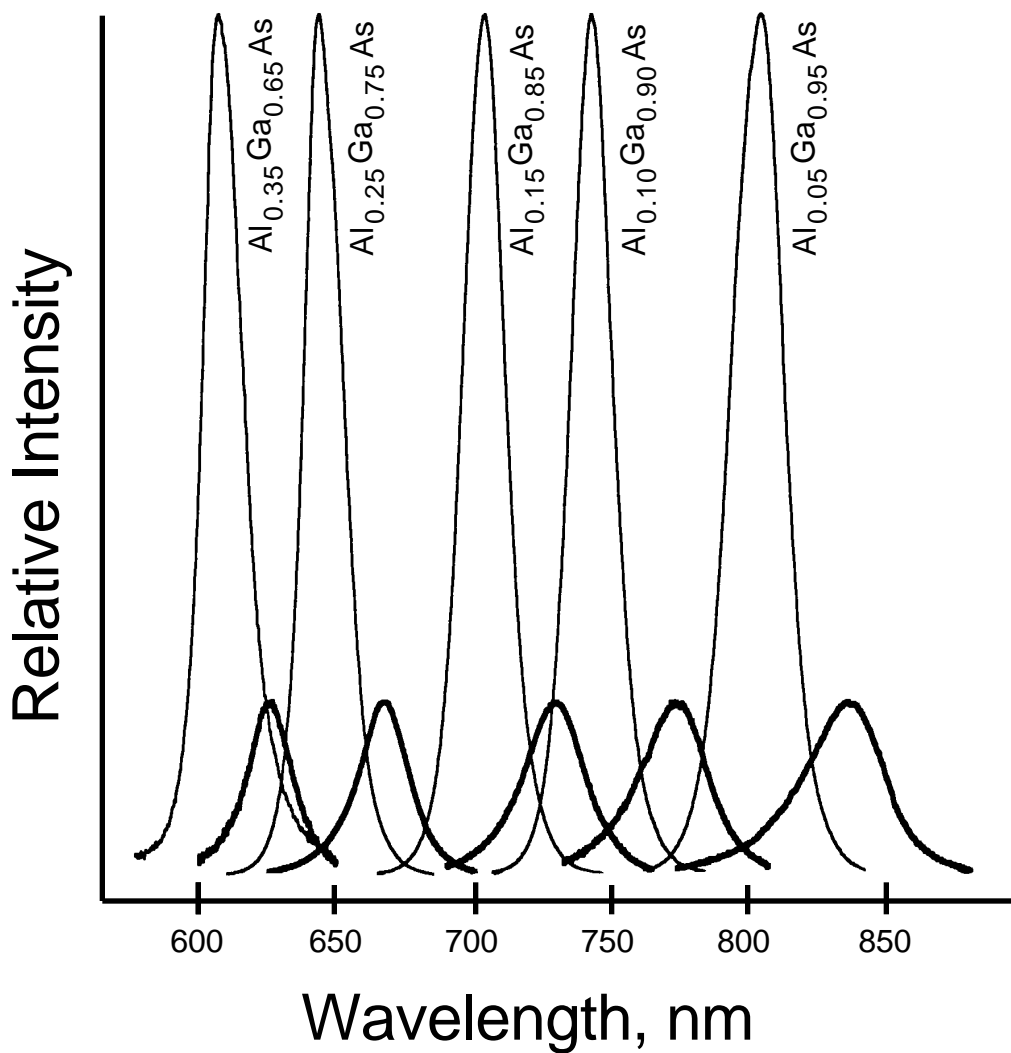
GaP_xAs_{1-x} LED Spectra

Recorded at 300 K and at 77 K (brighter)

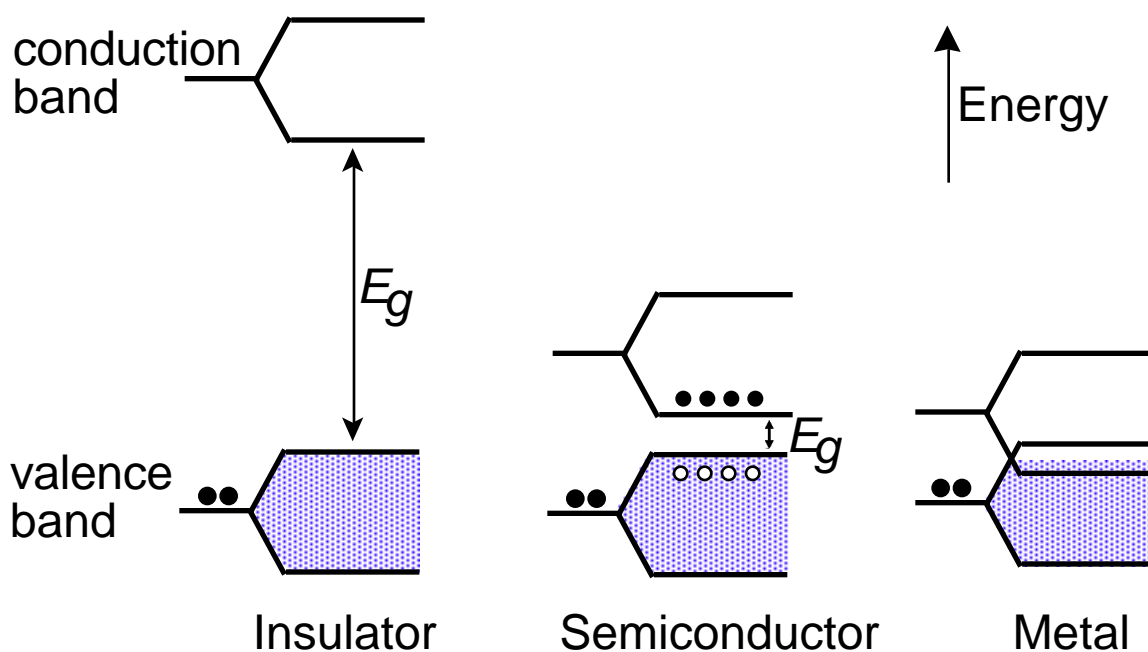
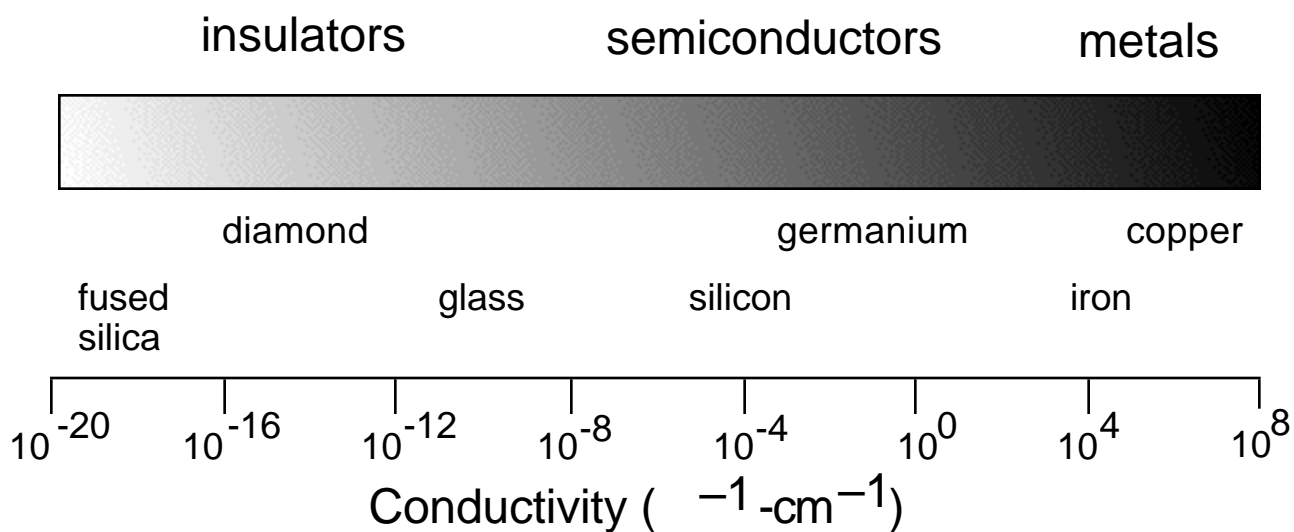


$\text{Al}_x\text{Ga}_{1-x}\text{As}$ LED Spectra

Recorded at 300 K and at 77 K (brighter)



Electrical Conductivity



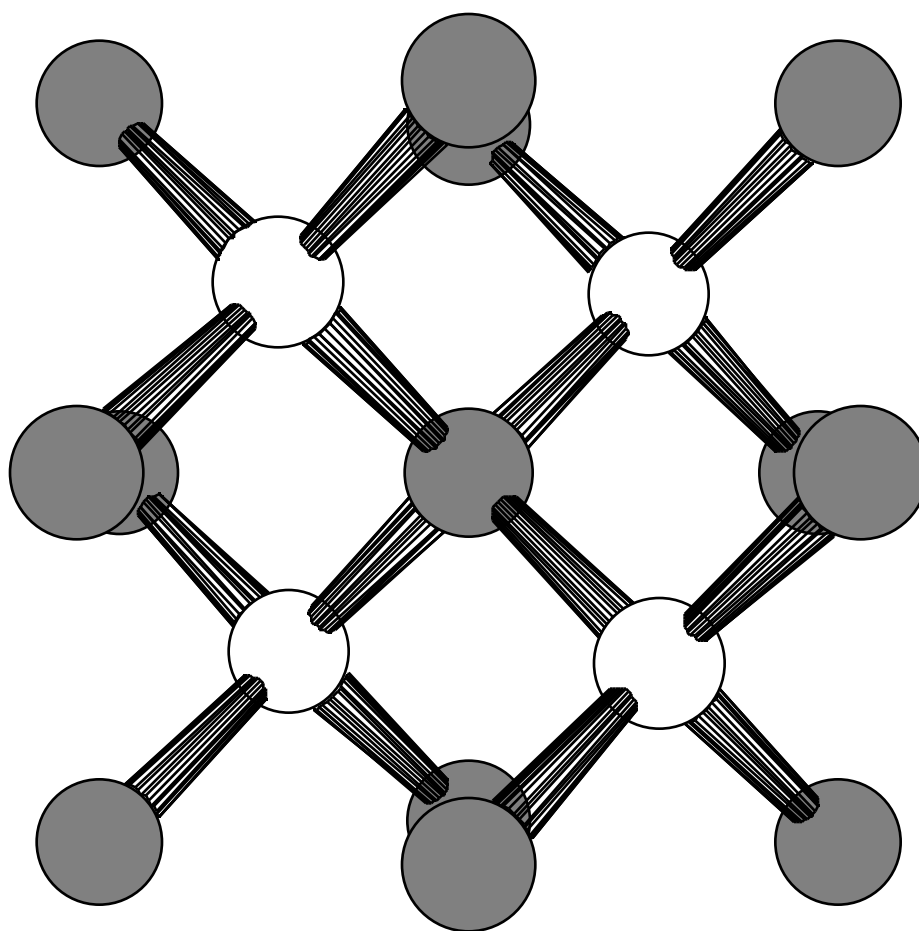
Conductivity of metals decreases with temperature as atomic vibrations scatter free electrons.

Conductivity of semiconductors increases with temperature as the number of carriers increase.

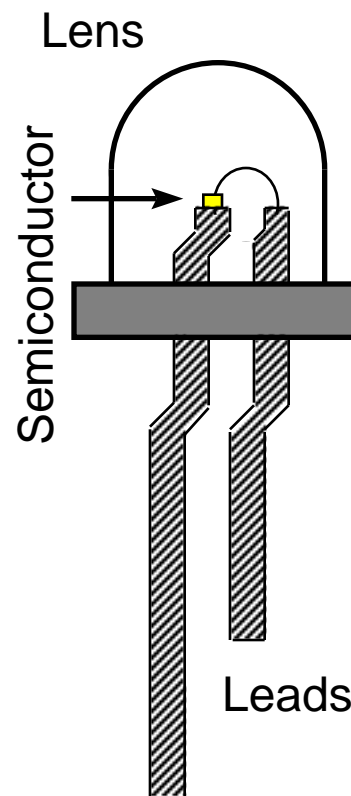
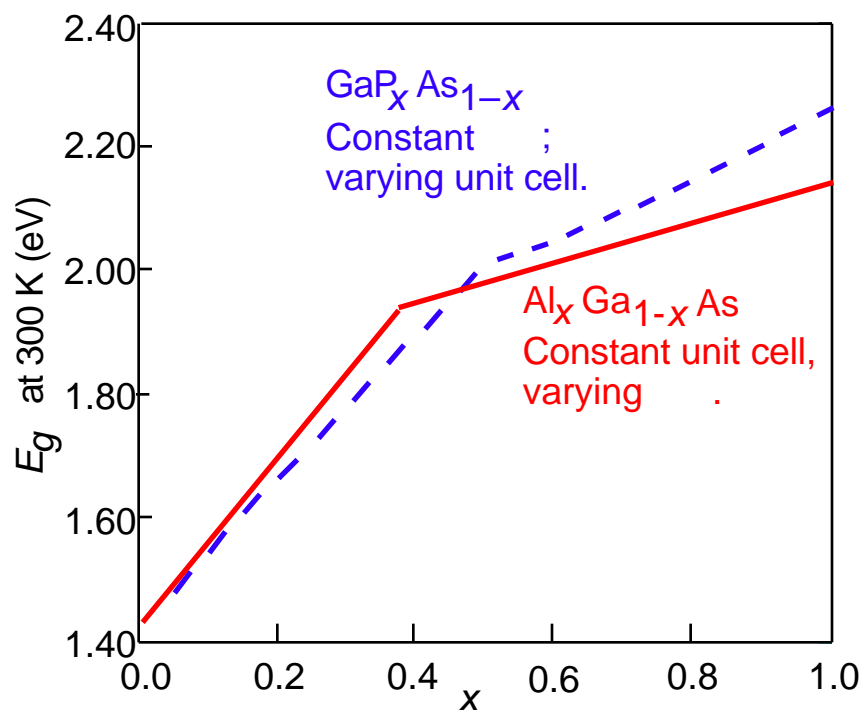
Semiconductors

		13	14	15	16	17
		B	C	N	O	F
		Al	Si	P	S	Cl
11	12	Ga	Ge	As	Se	Br
Cu	Zn	In	Sn	Sb	Te	I
Ag	Cd	Tl	Pb	Bi	Po	At
Au	Hg					

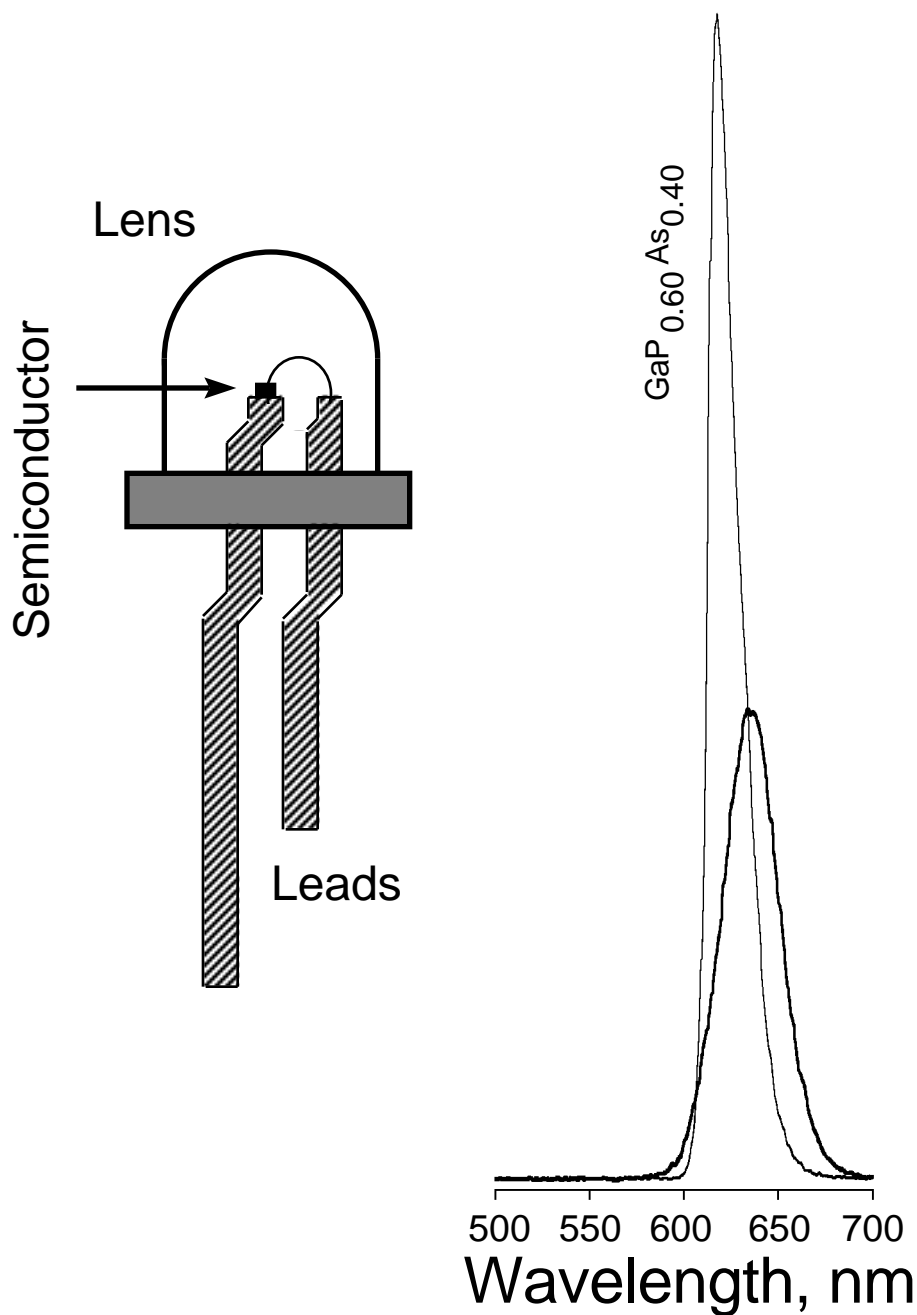
Similar shading indicates complementary pairs that preserve the total valence electron count for AZ stoichiometry. In the zinc blende structure each AZ atom is four coordinate.



Light-Emitting Diodes (LEDs)



$\text{GaP}_{0.60}\text{As}_{0.40}$ LED



Decreasing temperature moves atoms closer together and holds bonding electrons tighter. Replacing such an electron releases more energy.

When the LED is cooled, emission of light becomes more efficient (less energy is lost to vibrations).

Composition	Predicted Relative E_g	Color Emitted	Wavelength (relative spacing)	Energy (relative voltage)
GaP _{0.40} As _{0.60}				
GaP _{0.65} As _{0.35}				
GaP _{0.85} As _{0.15}				
GaP _{1.00} As _{0.00}				

Composition	Predicted Relative E_g	Color Emitted	Wavelength (relative spacing)	Energy (relative voltage)
GaP _{0.40} As _{0.60}	4	red	1	4
GaP _{0.65} As _{0.35}	3	orange	2	3
GaP _{0.85} As _{0.15}	2	yellow	3	2
GaP _{1.00} As _{0.00}	1	green	4	1

Thermal Conductivity of Diamond



Diamond

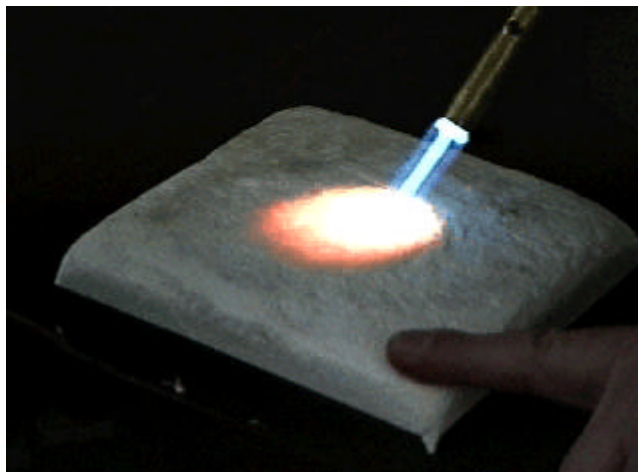


Aluminum



Diamond (left) and Aluminum (right)

Poor Heat Conductivity of Shuttle Tile



Resistance of 150 Meters of Fine Copper Wire

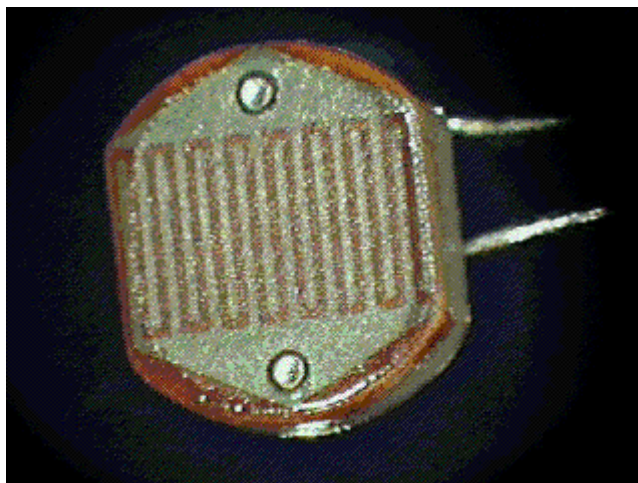


Room temperature

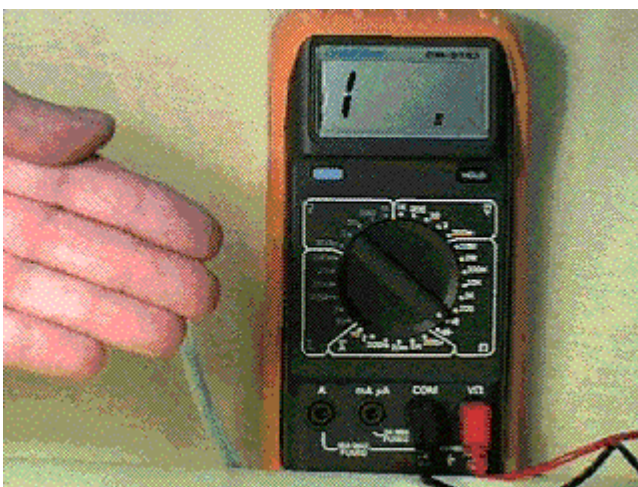


Cool in liquid nitrogen

Resistance of CdS Semiconductor



illuminated



shaded

Light Emitting Diode (LED)

