materials and their properties

macroscopic properties	**microscopic properties**
phase state strength / stiffness electrical conductivity chemical properties color / transparence spectroscopical properties surface properties density heat conductivity (costs of production) (costs of handling) (recycling / disposal)	chemical composition structure of electron orbitals molecular organization intermolecular interactions intramolecular interactions dipolar moment electrical polarization magnetic polarization

materials and their properties

example: portable phone

phase state
electrical conductivity
strength / stiffness
color / transparence
chemical properties
spectroscopical properties
surface properties
density
heat conductivity

(costs of production)
(costs of handling)
(recycling / disposal)

materials and their properties

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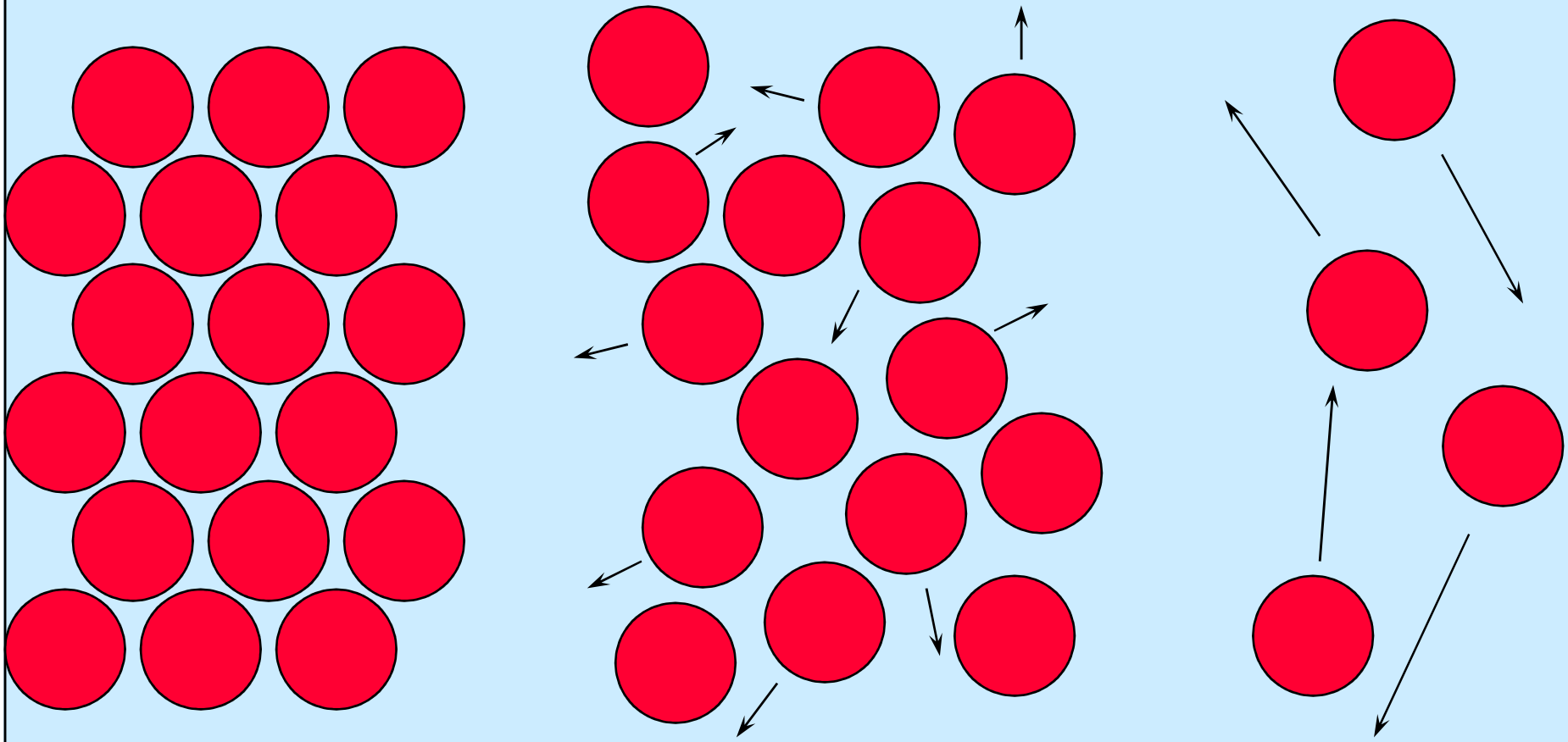
classical phase states



solid

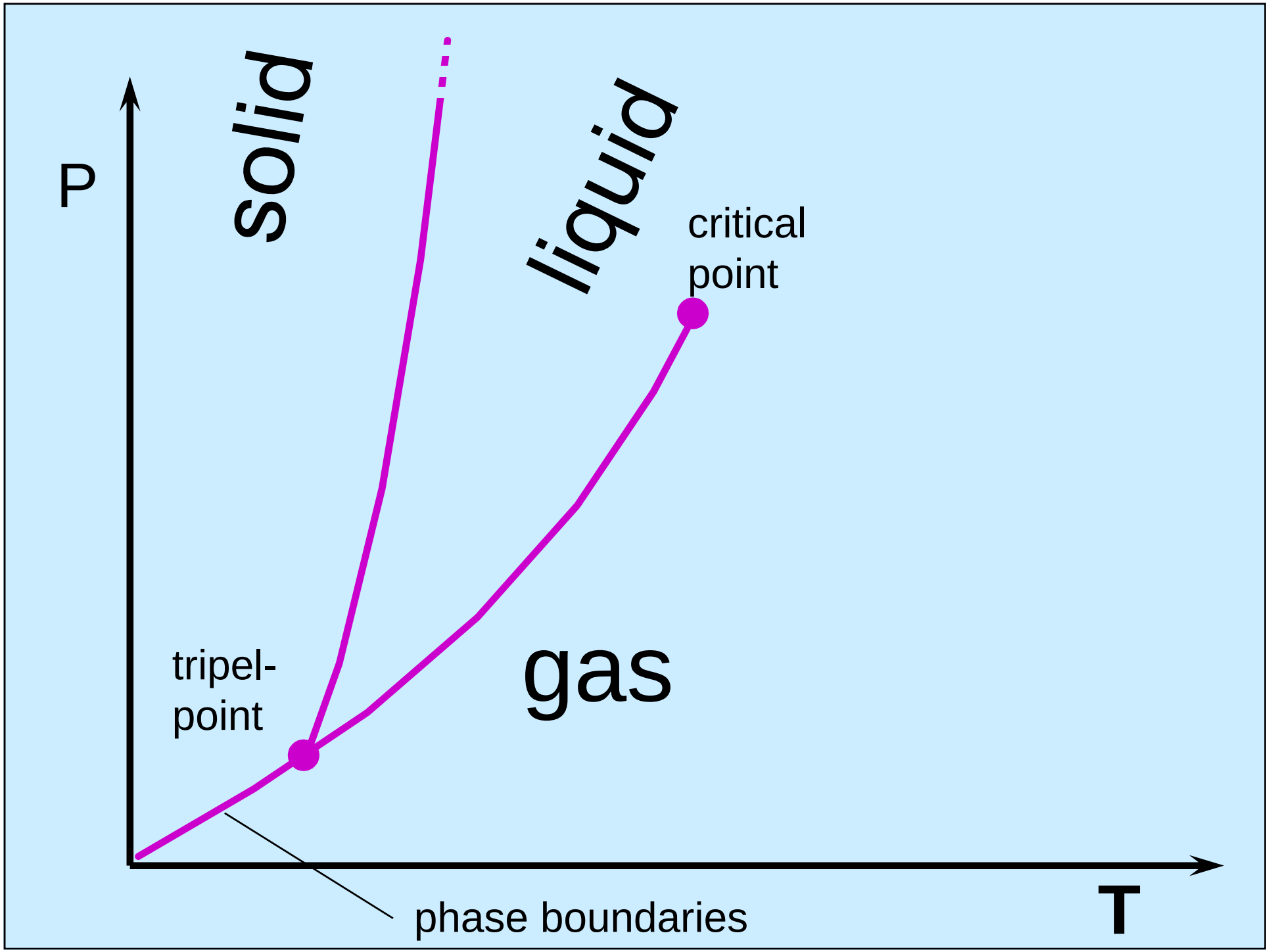
- hardly compressible
- elastic response to deformation

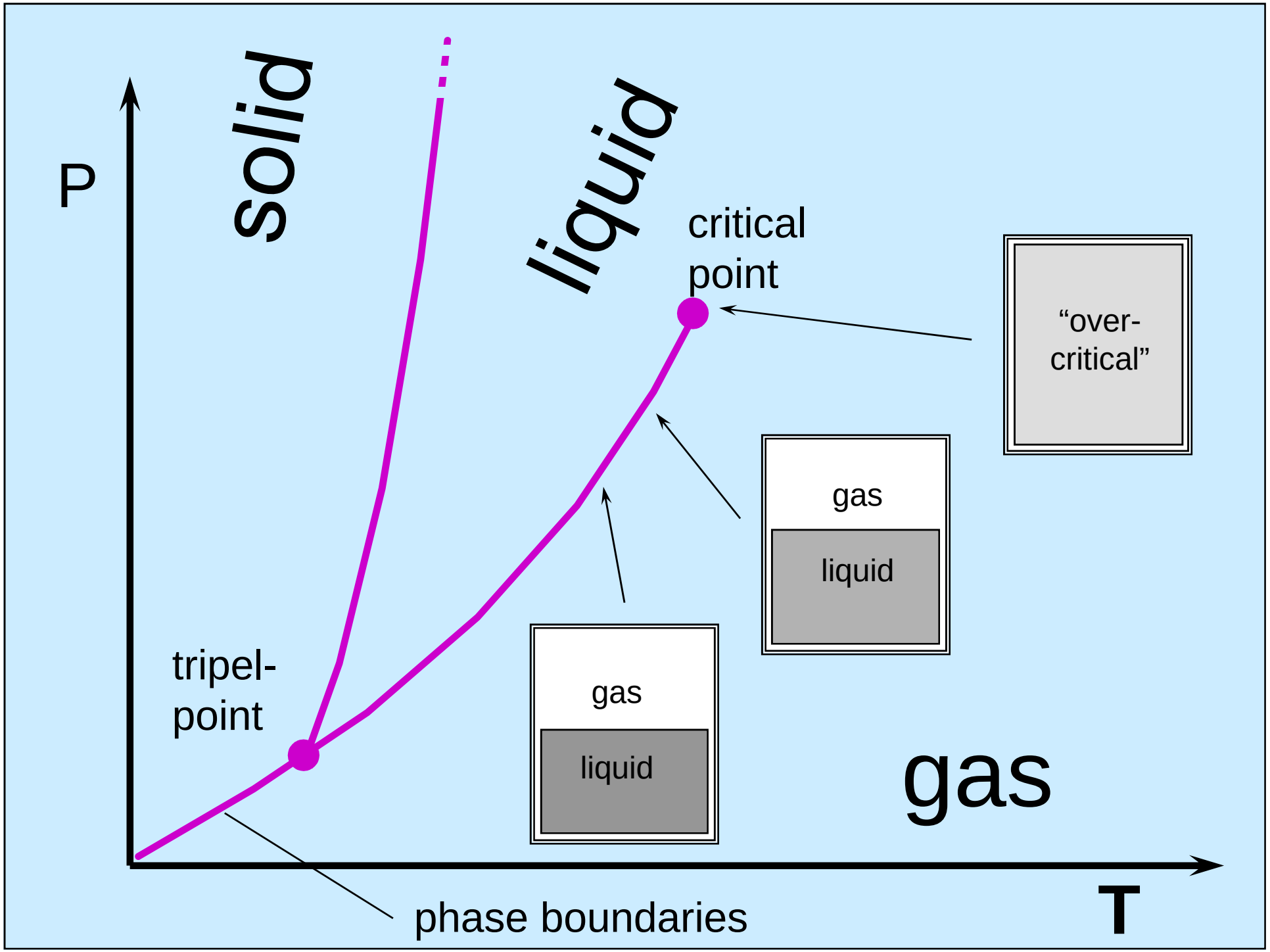
liquid

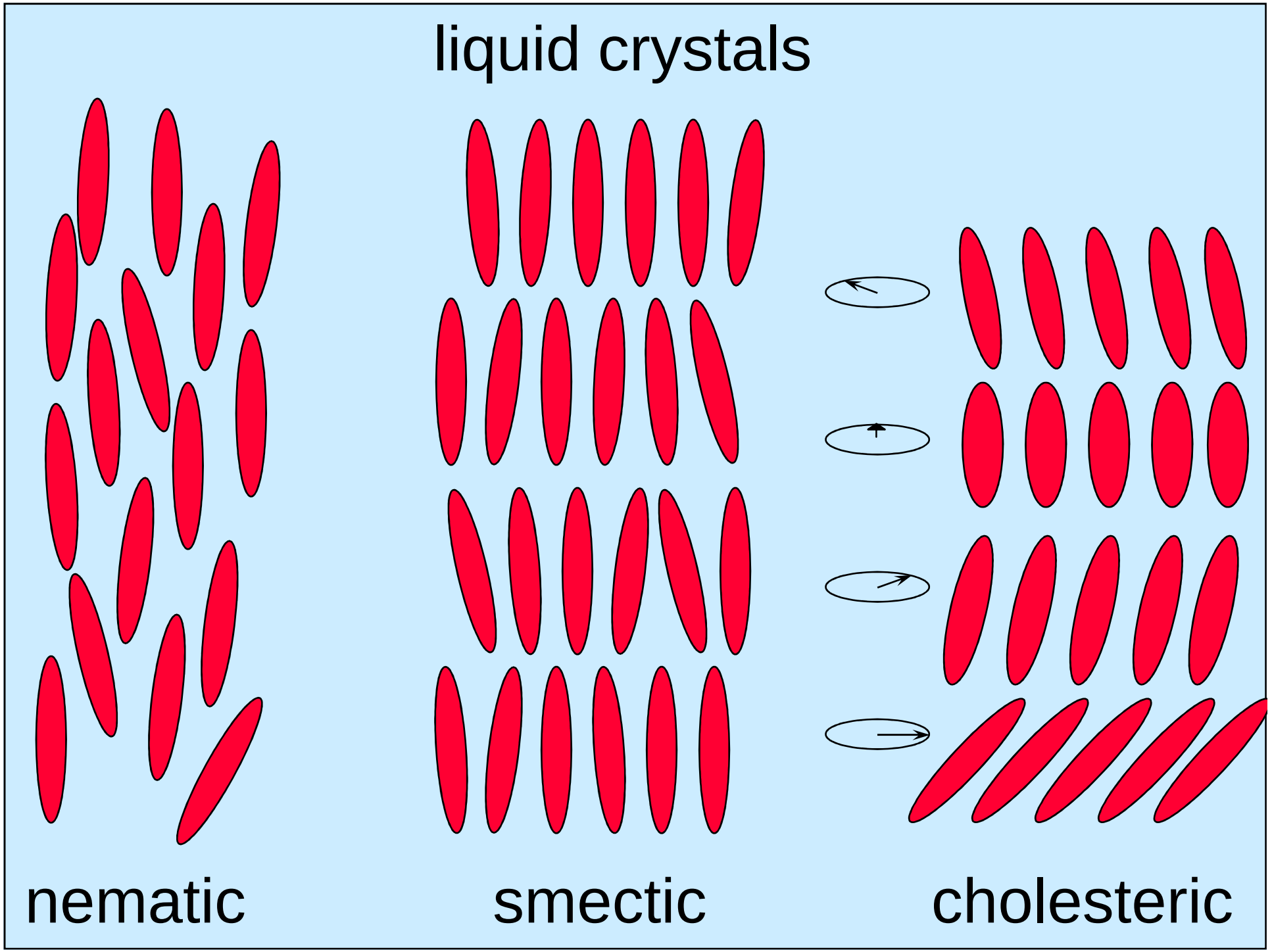
- hardly compressible
- viscous response to deformation

gas

- easily compressible
- viscous response to deformation


P
solid
liquid
critical
point
tripel-
point
gas
phase boundaries
T


P
solid
liquid
critical
point
“over-
critical”
gas
liquid
gas
liquid
tripel-
point
gas
phase boundaries
T


liquid crystals
nematic
smectic
cholesteric

materials and their properties

macroscopic properties	microscopic properties
phase state **strength / stiffness**	**1) molecular mass:** increasing molecular mass ↓ gas ... liquid ... solid **2) intermolecular interactions:** increasing strength ↓ gas liquid solid examples: a) London forces b) dipolar interactions c) hydrogen bonds d) covalent, metallic or ionic bonds

1) molecular mass

example: alkanes (molecular mass):

methane (16)

ethane (30)

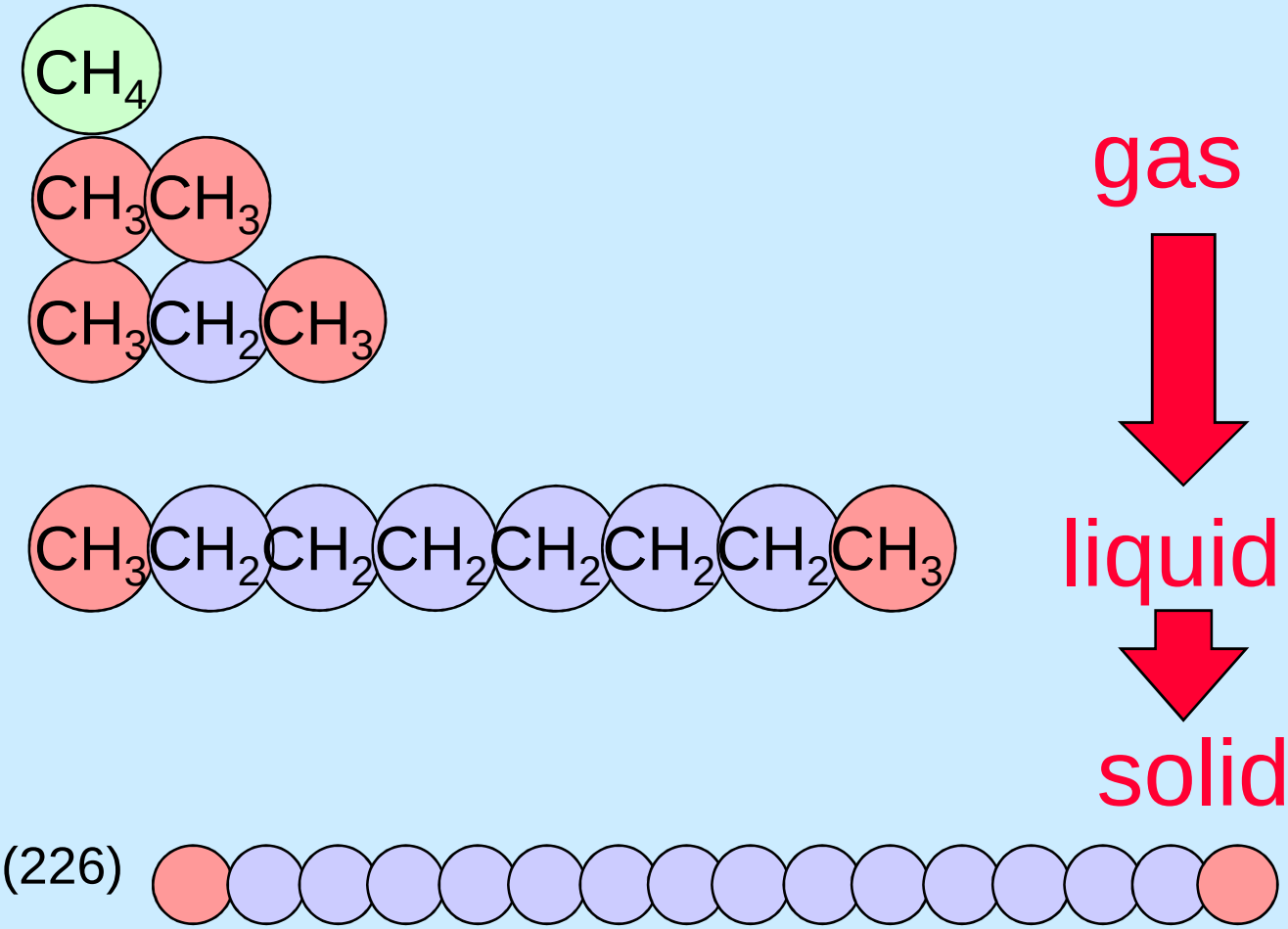
propane (44)

...

octane (114)

...

hexadecane (226)



materials and their properties

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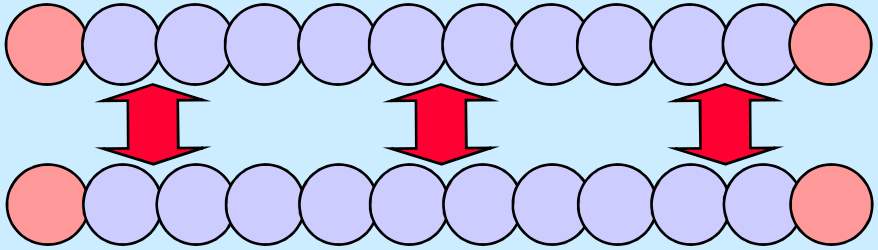
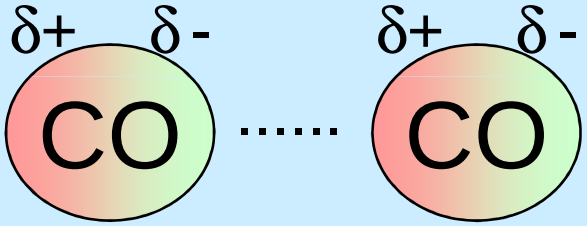
2) intermolecular interactions

a) London forces



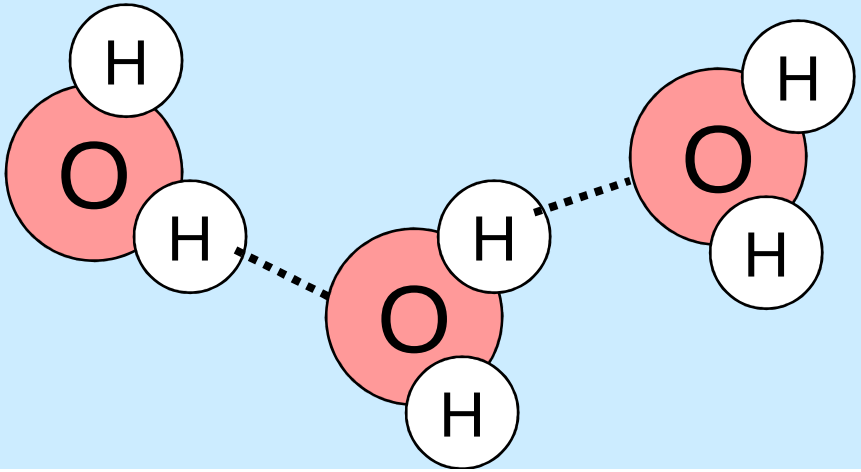
a very general interaction acting between uncharged molecules (e.g. alkanes)

b) dipolar interactions



act between all permanent electrical dipoles (e.g. CO)

c) hydrogen bonds



found in all compounds with polar X-H-bonds (e.g. water)

2) intermolecular interactions

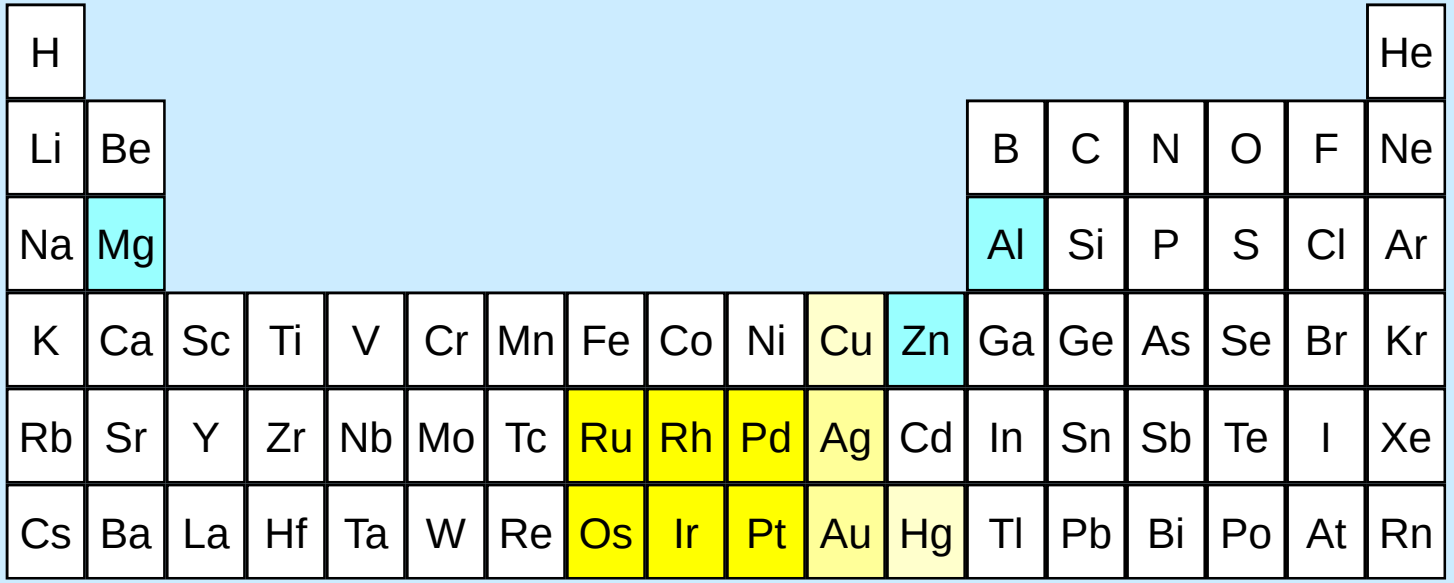
Comparison of materials with similar molecular masses:

compound	molecular mass	interaction	melting point	boiling point
a) Ne neon	18 g/Mol	London forces	-249℃	-246℃
b) CO carbon monoxide	28 g/Mol	+ dipolar forces	-204℃	-191℃
c) NH_3 ammonia	17 g/Mol	+ hydrogen bonds	-40℃	-33℃
d) H_2O water	18 g/Mol	+ strong hydrogen bonds	0℃	100℃

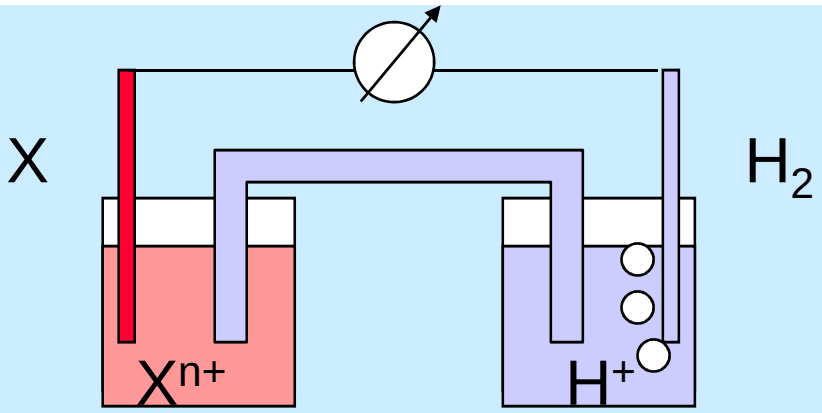
materials and their properties

macroscopic properties	microscopic properties
chemical properties important material property: resistance against corrosion	**1) low chemical reactivity** **- noble metals (Ag, Au, Pt)** **- filled electron orbitals (Ar)** **2) passivation** **- formation of a thin, passive oxidized layer (Al)** **3) use of additives that prevent corrosion** **- paint** **- anti-oxidants in plastics**

inert, corrosion-resistant metals



electrical potentials of metals against hydrogen:



(all values in V against H_2)

Li	lithium	- 2.96
K	potassium	- 2.92
Ca	calcium	- 2.76
Na	sodium	- 2.71
Mg	magnesium	- 2.34
Al	aluminum	- 1.33
Mn	manganese	- 1.10
Zn	zinc	- 0.76
Cr	cromium	- 0.51
Fe	iron	- 0.44
Cd	cadmium	- 0.40
Co	cobalt	- 0.28
Ni	nickel	- 0.23
Sn	tin	- 0.16
Pb	lead	- 0.12
H_2	hydrogen	0
Cu	copper	0.34
Ag	silver	0.79
Hg	mercury	0.85
Au	gold	1.36
Pt	platinum	1.60

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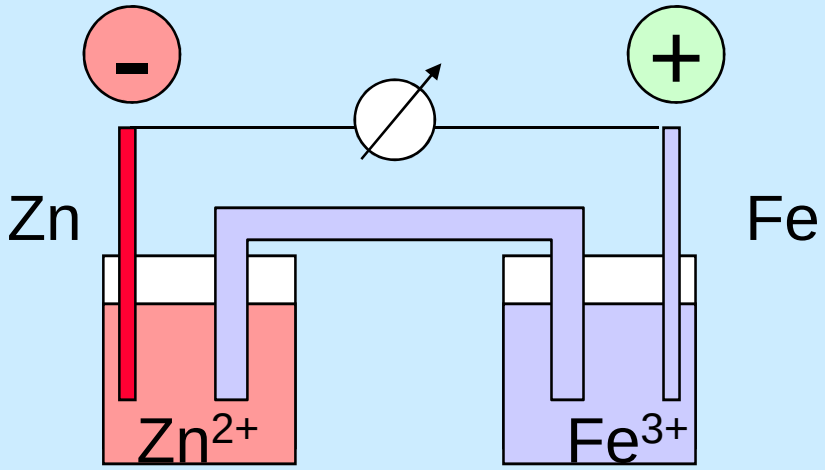
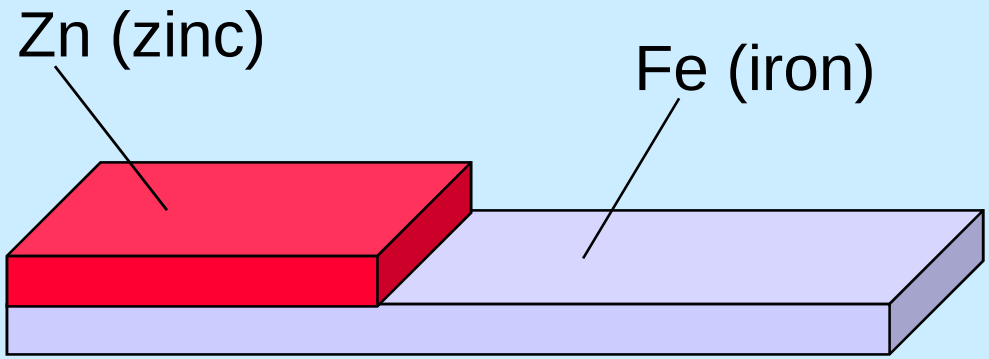
galvanic cell:



galvanic cell under short-circuit:



In direct contact with zinc, iron becomes more inert against oxidation, while zinc is more easily oxidized. Zinc, however, forms a passivation layer.

materials and their properties

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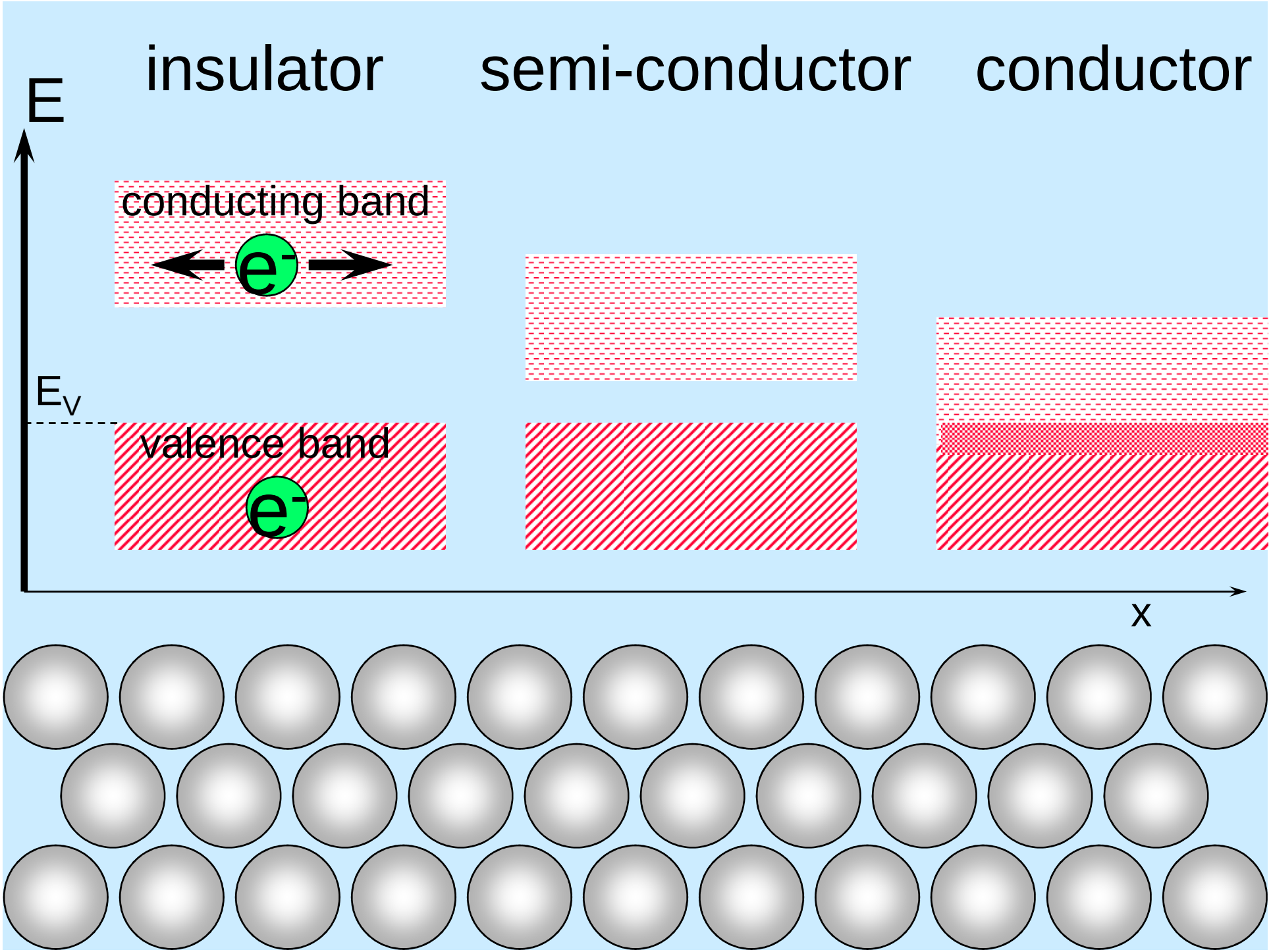
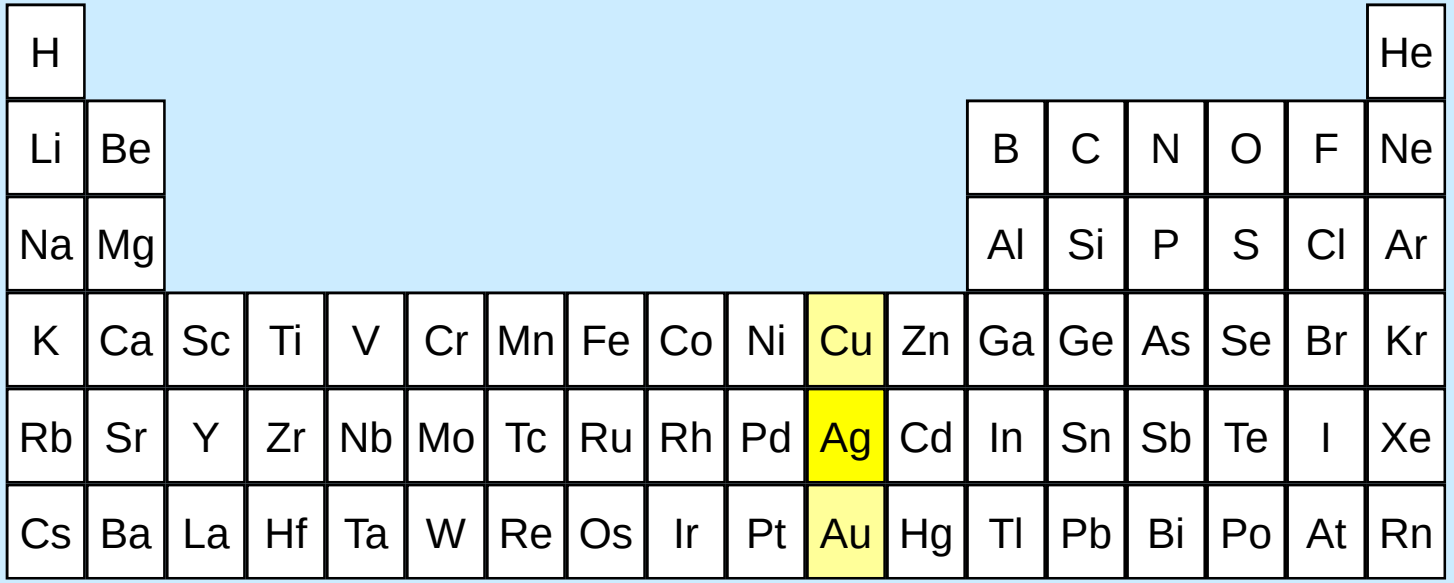
materials and their properties

macroscopic properties	microscopic properties
electrical conductivity	**1) metallic conductors** - highly delocalized electrons - increasing resistance with increasing temperature **2) semi-conductors** - electrons may be delocalized under certain conditions - decreasing resistance with increasing temperature **3) electrolytes** - conductance under chemical decomposition


insulator
semi-conductor
conductor
E
conducting band
e-
E_V
valence band
e-
x

best electric conductors



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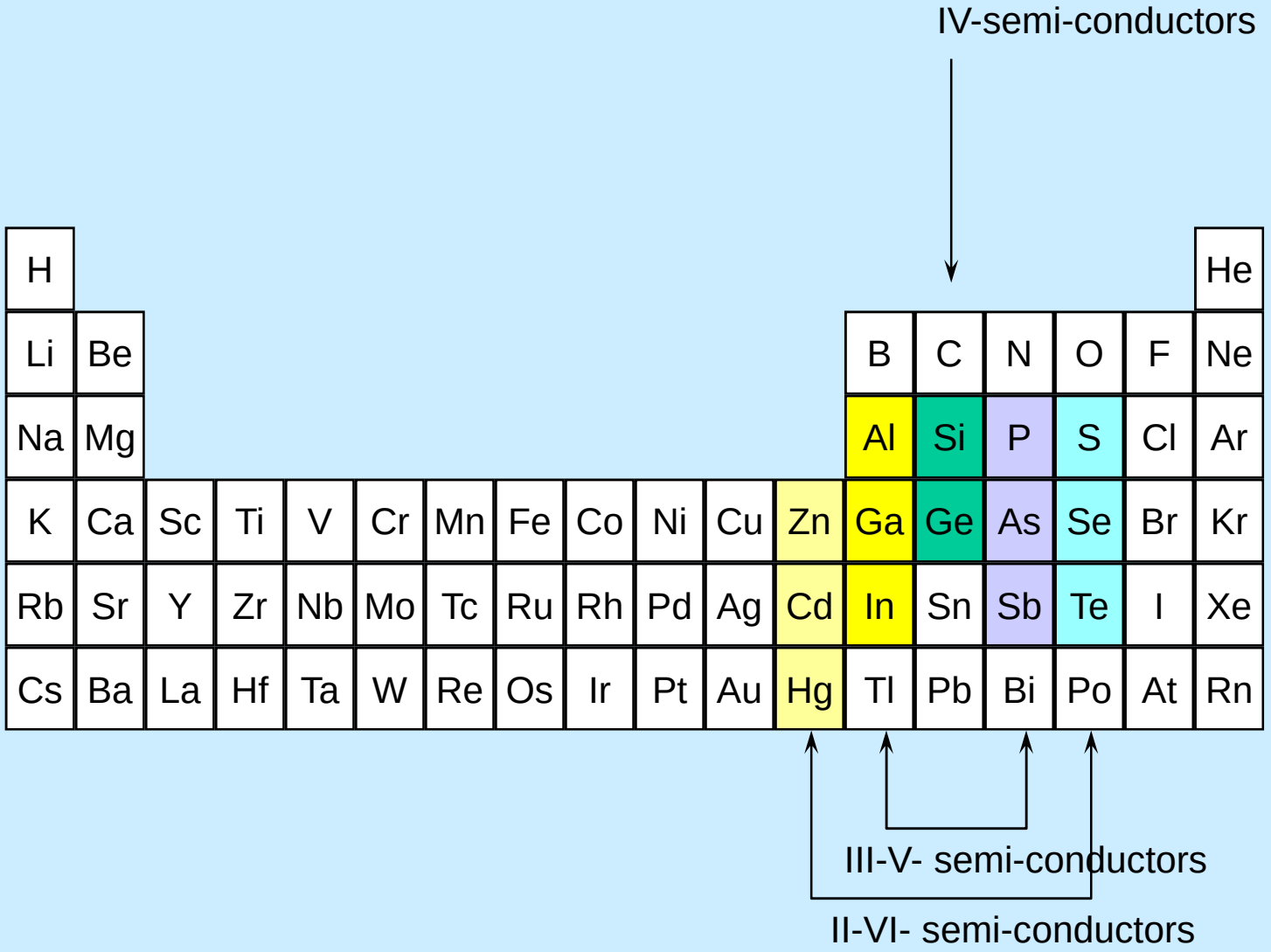
semi-conductors



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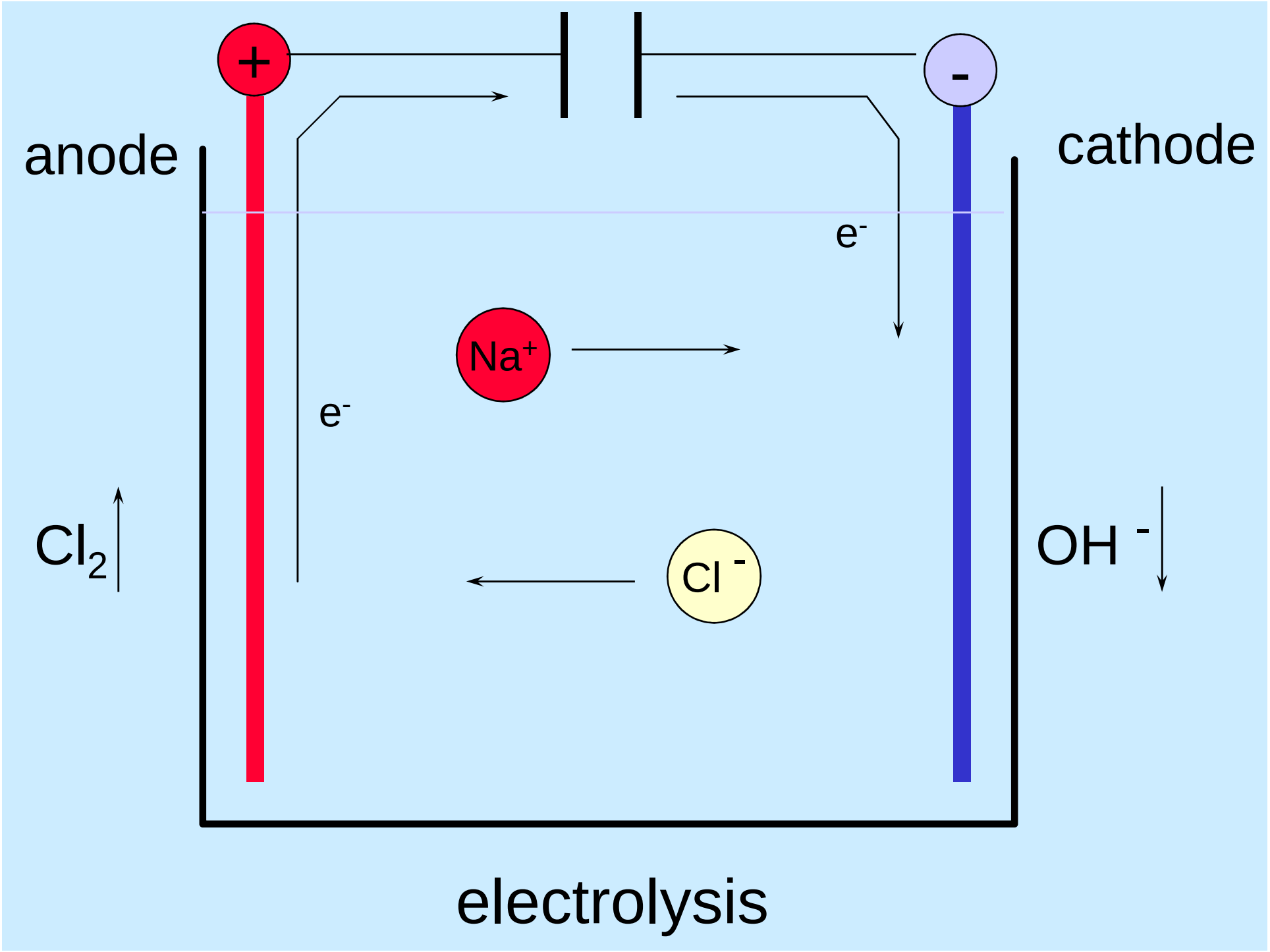
+
-
anode
cathode
e-
Na+
e-
Cl2
Cl -
OH -
electrolysis