Inorganic Chemistry (CY11001)

Chemical Bonding: Part-III covering Metallic Bonding

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Metallic Bonding

Not ionic.........

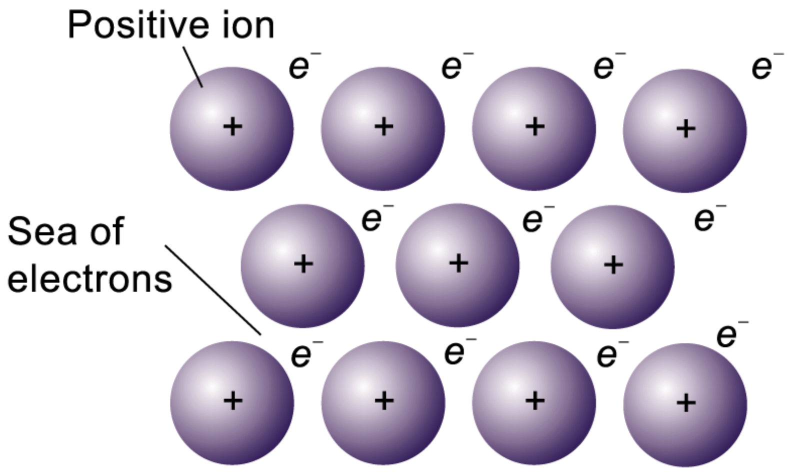
Not covalent.....

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	?	?	?	?	?	?	?

Metals are three-fourth of all the known elements

Metal are found at the left and centre of the periodic table.

The electron-sea model

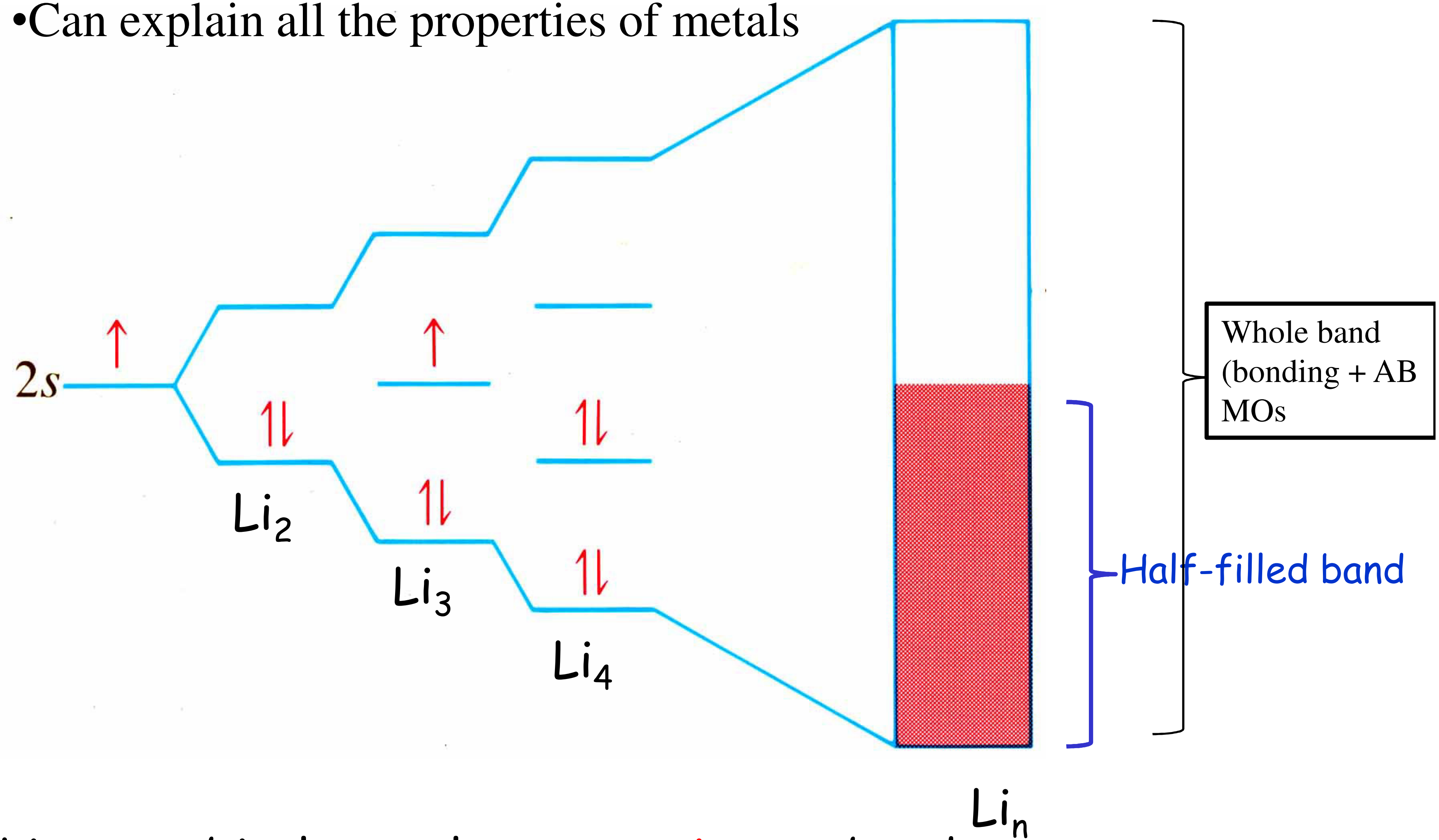


The valence electrons do not belong to any specific atoms (<u>not localized</u>) but <u>delocalize</u> throughout the whole crystal structure.

- Due to smaller ionisation energy, the valence electrons of metal atoms are not held by the nucleus very firmly.
- The metallic bond is the attraction between the Metal positive ions and the delocalised electrons
- The fluid-like movements of the outer-shell electrons make metals good conductors of heat and electricity

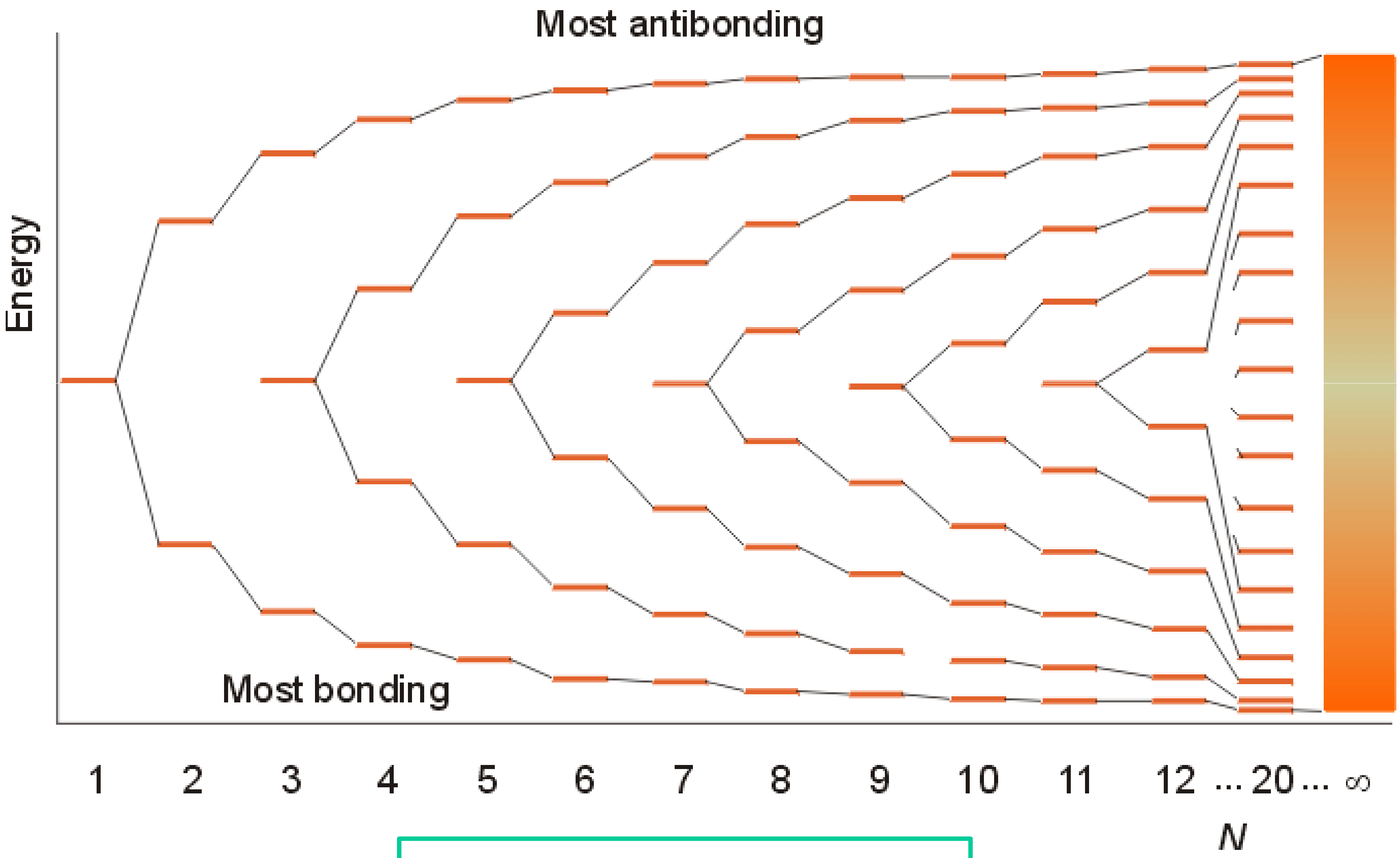
MO approach: Band theory

- Electron sea model could be well explained by MO approach
- Can explain all the properties of metals



Li_n : n orbitals overlap → continuous band

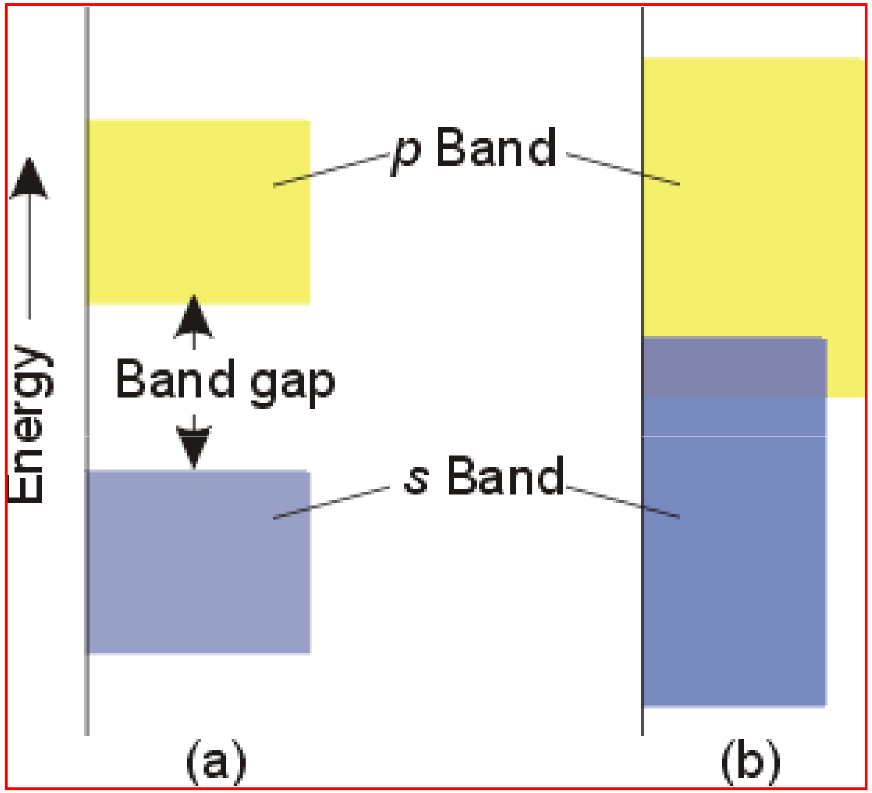
Overlap of Orbitals: *2, 3, 4, ... infinity*



N AOs gives rise N MOs

Molecular Orbital Theory (MOT) of Metals/Solids

- **Aggregations of virtually infinite number of atoms.**
- **Individual atoms contribute electrons to a common sea, therefore High mobility of electrons.**



When metals have both s & p electrons...

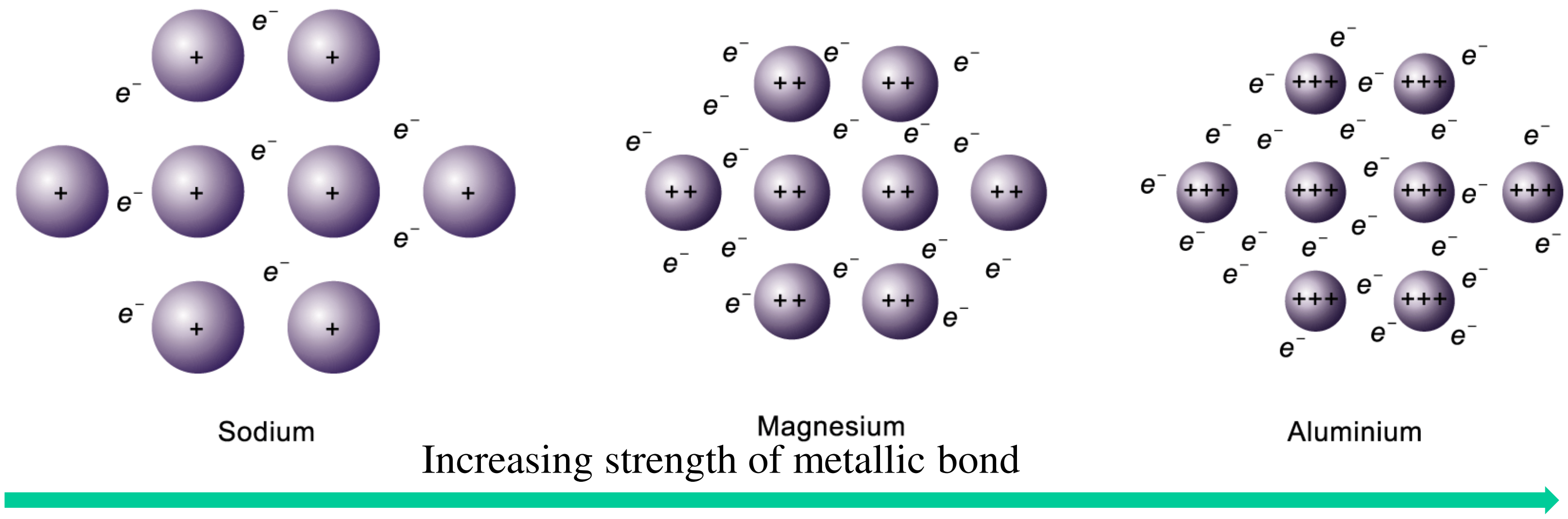
Factors Affecting the Strength of Metallic Bond

The strength of metallic bond can be estimated by
melting point,
boiling point,
enthalpy of vapourization/heat of atomization.

Higher m.p./b.p./Hvap
$\Rightarrow$ stronger metallic bond

The cohasive force/energy may be measured as the heat of atomization

Factors affecting the strength of metallic bond



The metallic bond strength increases with:

1. decreasing size of the metal atom
   i.e. the metallic radius;

2. increasing number of valence electrons
   of the metal atom.

Metal	Number of valence electrons(s)	Melting point (°C)
Na	1	98
Mg	2	650
Al	3	660

Factors affecting the strength of metallic bond

Effect of metallic radius on metallic bond strength of Group IA metals

Metal	Metallic radius (mm)	Melting point (°C)
Lithium	0.152	180
Sodium	0.186	98
Potassium	0.231	64
Rubidium	0.244	39
Caesium	0.262	29

Typical properties of metals

1. High density

Reason: close packing of atoms in metallic crystal (h.c.p./f.c.c (ccp). co-ordination number = 12)

Metal	Ni	Cu	Ag	Pb	Hg	Au
Density (g cm^{-3})	8.91	8.94	10.49	10.66	13.53	19.30

Exception : Alkali metals have low densities
(< 1 for Li, Na and K)

(a) they have more open structures
(b.c.c. /co-ordination number = 8)

(b) their atomic radii are the highest in their own Periods.

E.g. Size : Na > Mg > Al

2. High melting point and boiling point

Extensive delocalization of valence electrons $\Rightarrow$ stronger bonds

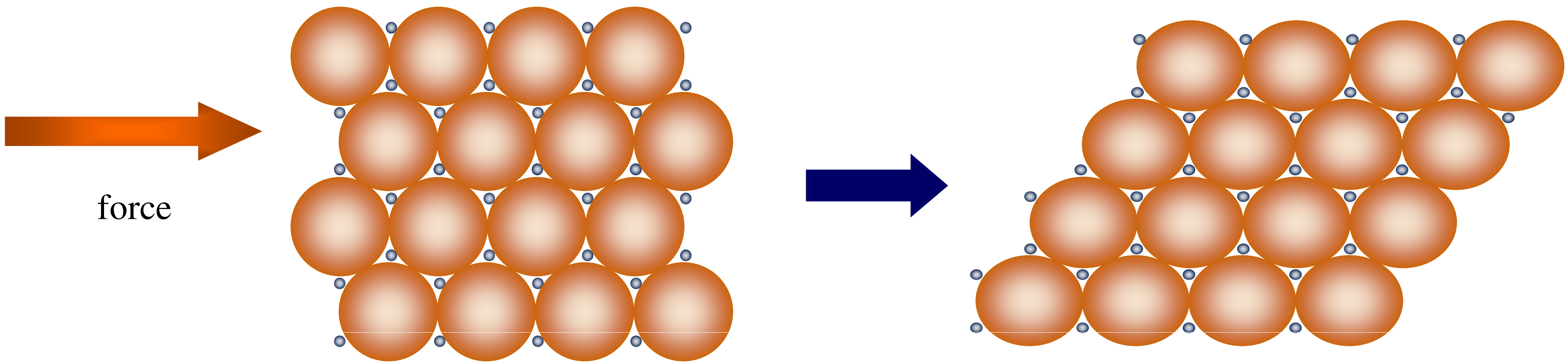
•Since metallic bonds are **non-directional**, they exist in significant extent even in molten state. Thus, boiling points of metals are much higher than the corresponding melting points. e.g.Na: m.p. = 97.8oC ; b.p. = 903.8^{o}C

Bond strength : -

ionic bond ≈ covalent bond ≈ metallic bond

3. High flexibility

Metals are usually tough, not brittle.



This means that metals are:

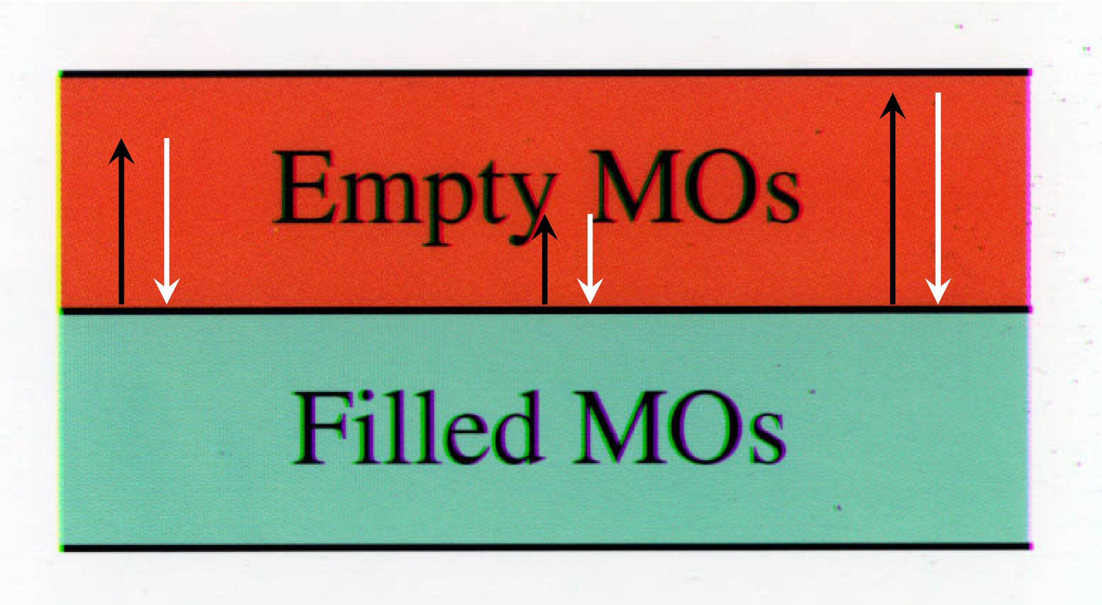
- malleable – they can be bent and pressed into shape;
- ductile – they can be drawn out into wires.

(a) The presence of layers in the crystal lattice i.e. the layers can slide over one another under strain (when a metal is hit)

(b) Metallic bonds are non-directional. i.e. electrons can take up new positions and reform metallic bond after the deformation

4. Surface lustre

⇒ Silvery and shiny

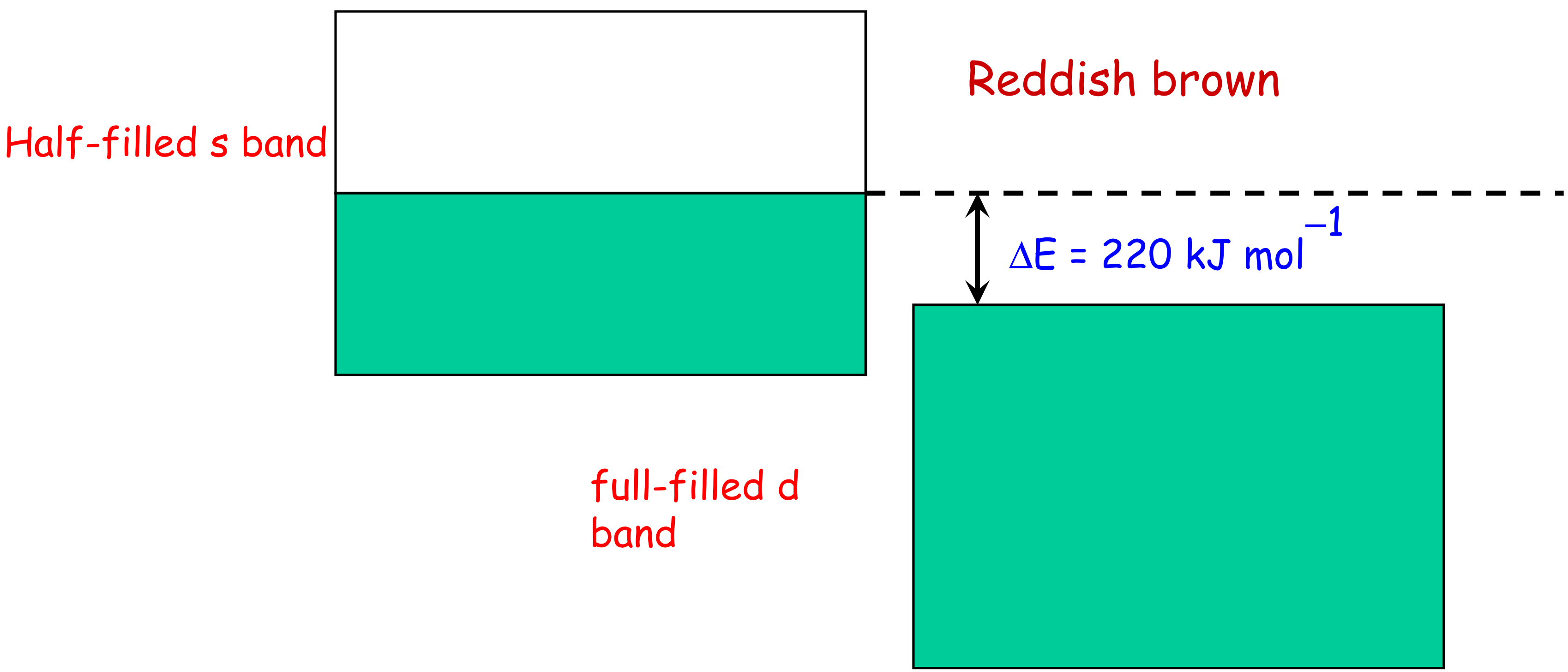


Since the gap between energy levels are extremely small, radiation of any frequency (colors) in visible region can be absorbed by free e and immediately reemitted, practically all the light is reflected back-hence the lusture.

Metals r used as mirrors: reflect light at all angles

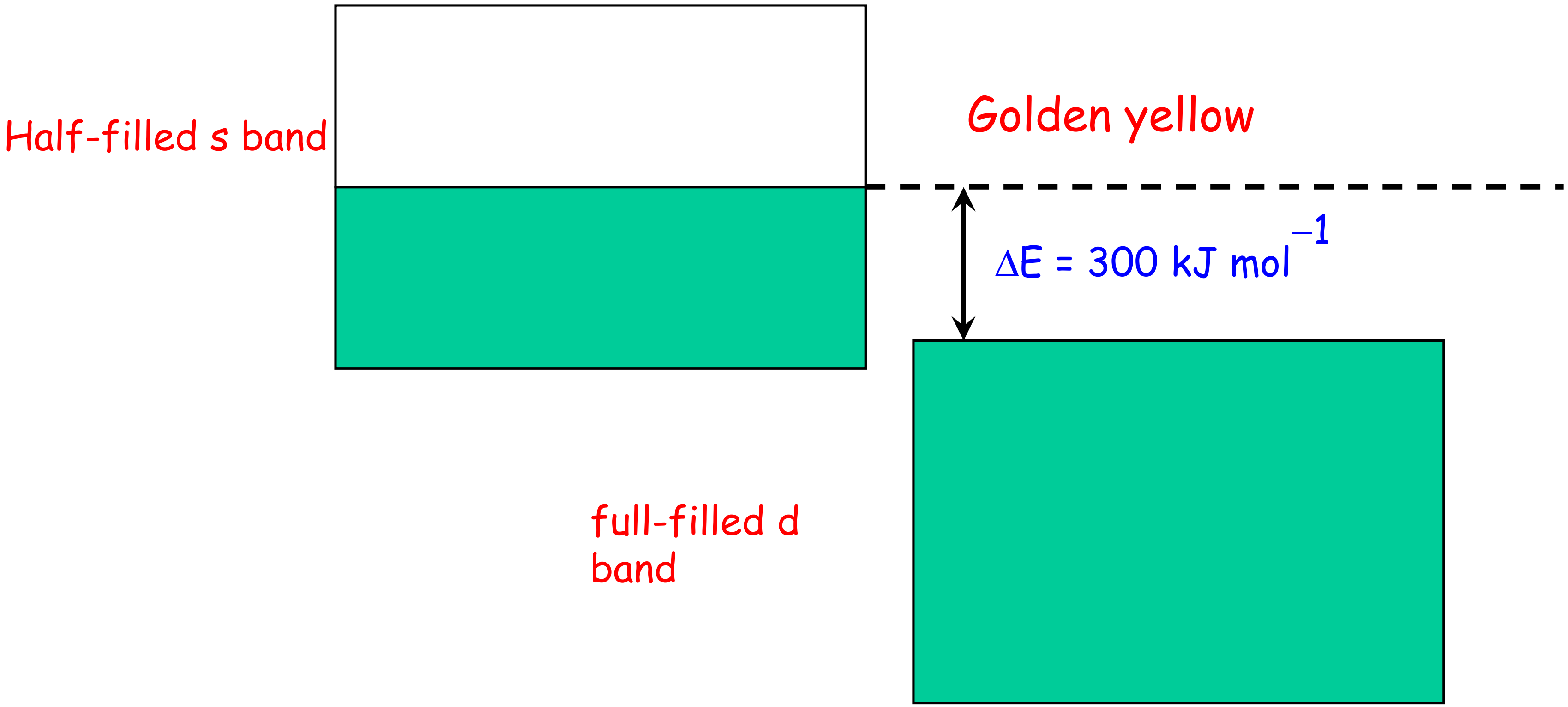
Metallic lusture: bright, shiny and highly reflective

$Cu : 3d^{10}, 4s^{1}$

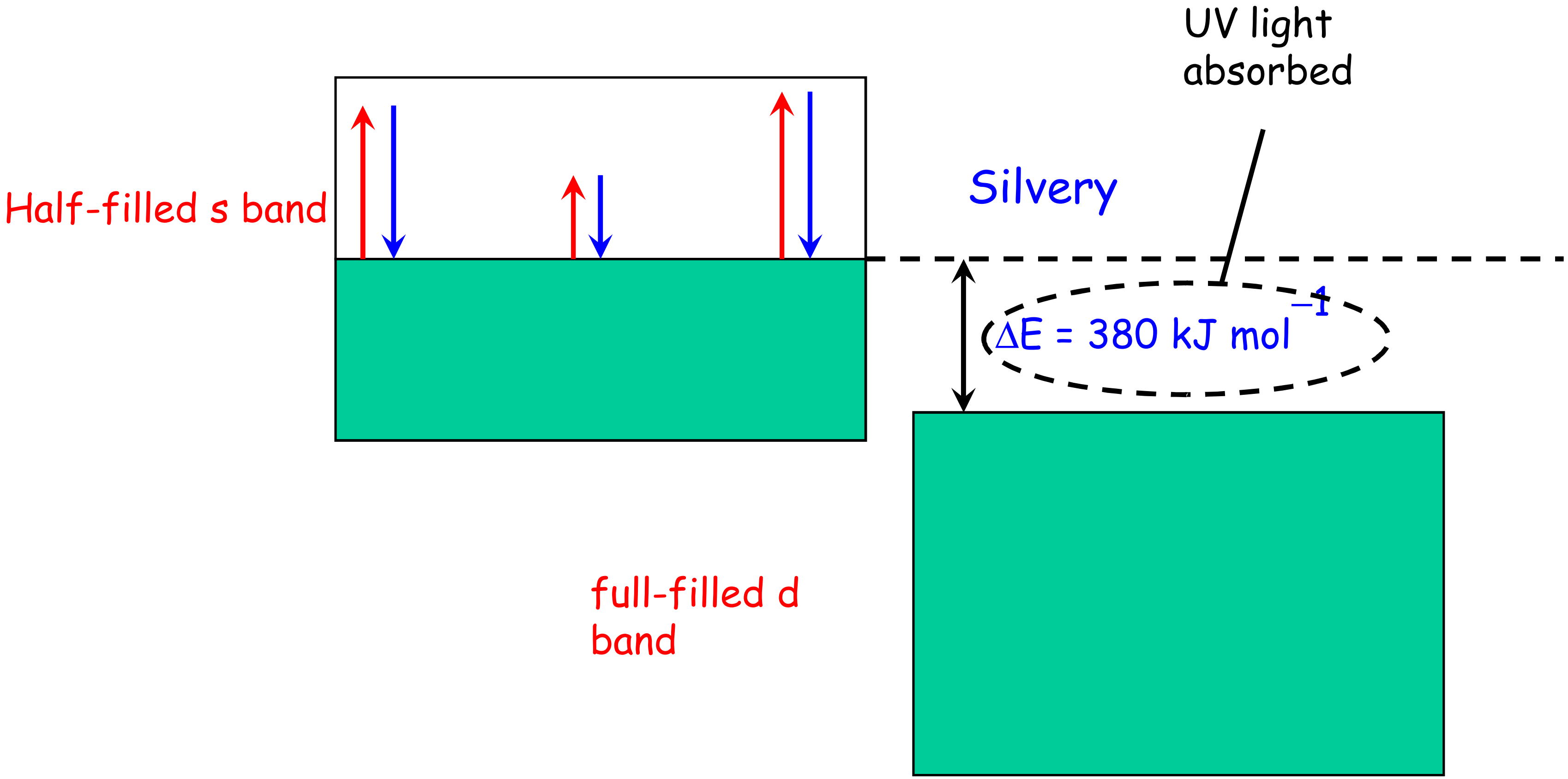


Reddish brown
Half-filled s band
ΔE = 220 kJ mol–1
full-filled d band

Au : $5d^{10}, 6s^{1}$


Half-filled s band
Golden yellow
ΔE = 300 kJ mol^{-1}
full-filled d band

$Ag : 4d^{10}, 5s^{1}$



UV light absorbed
Half-filled s band
Silvery
ΔE = 380 kJ mol⁻¹
full-filled d band

5. High Thermal and Electrical Conductivity

Due to the free movement of delocalized electrons

Silver is the best conductor of electricity and copper is the second best.

Why is copper used instead of silver for electrical wires?