**The Transition Metals**

IUPAC – "An element whose atom has an incomplete d sub-shell, or which can give rise to cations with an incomplete d sub-shell." Group 12 elements are excluded by this definition.

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<th>Early</th>
<th>Middle</th>
<th>Late</th>
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**Characteristic properties**

- formation of compounds whose color is due to \(d - d\) electronic transitions
- formation of compounds in many oxidation states, due to relatively low reactivity of unpaired \(d\) electrons
- formation of many paramagnetic compounds due to unpaired \(d\) electrons

The Early Transition Metals

Early Transition Metals

- Strongly electrophilic and oxophilic
- Few redox reactions (except Ti)
- Nearly always < 18 electrons
- Few \(d\)-electrons
- Polar and very reactive M–C bonds
- Preference for "hard" \(\sigma\)-donors (N/O/F)
- Weak complexation of \(\pi\)-acceptors (olefins)

Highly useful in polymerizations, we will probably not discuss much
The Middle Transition Metals

- Many accessible oxidation states
- Mostly 18 electrons
- Ligands strongly bound
- Strong, not very reactive M–C bonds
- Preference $\sigma$-donor/$\pi$-acceptor combinations (e.g., CO)
The Late Transition Metals

- Many accessible oxidation states
- Mostly 18 or 16 electrons
  - 16 common for square-planar complexes
- Easy ligand association/dissociation
- Weak, not very reactive M–C bonds
- Weaker, reactive M–O/M–N bonds
- Preference $\sigma$-donor/weak $\pi$-acceptor combinations (e.g., phosphines)