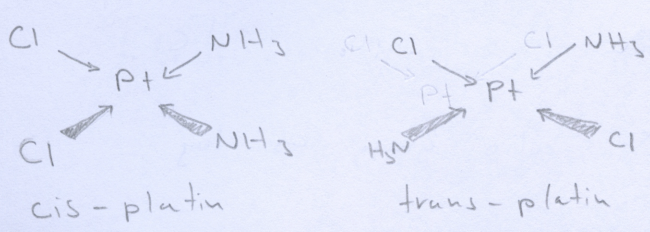
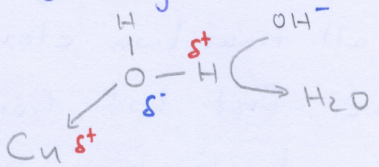
- Transition elements - d block element which forms one or more stable ions with incomplete d subshell
  - ↳ Scandium - not transition - Sc^{3+} (Ar) $3d^0 4s^0$
  - ↳ Zinc - not transition - Zn^{2+} (Ar) $3d^{10} 4s^0$
- Electronic config of atoms
  - ↳ All except Cr and Cu have full $4s^2$ so e^- go to 3d subshell
  - ↳ In Cr and Cu 1 e^- from 4s goes to halve or completly fill d subshell so have $4s^1$
  - ↳ this trend follows down the group
- Electronic config of ions
  - ↳ all transition elements can form more than 1 ion
  - ↳ e^- first lost from 4s subshell than 3d
  - ↳ most common ON +2 since 2e^- from $4s^2$ lost. easily
- Physical properties:
  - ↳ high mp/bp - high density - hard - sonorous good conductors of heat + electricity
  - ↳ strong metallic bonding - small ions packed closely - high charge and many delocalised e^-
  - ↳ $\Delta H_{at}^{\ominus}$, atomic/ionic radius dont vary much across period
  - ↳ higher mp, density, $\Delta H_{at}^{\ominus}$ and conductivity than s block
- Ligand - species with a lone pair of e^- which can form a dative covalent (coordinate) bond with a central transition metal ion.
- Complex - structure of a central transition metal ion surrounded by Ligands to which it bonds coordinately
- Coordination number - no of dative bonds around central ion
- monodentate ligand - can form 1 coordinate bond
  - bidentate, tridentate
- Stereoisomerism
  - ↳ same molecular formula but different 3D geometrical arrangement



- cis - platin acts as anti-cancer drug. binds to DNA in cancer cells to prevent division

- substitution of ligands
  - ligands in a complex can exchange partially or fully
  - occours if new formed complex is more stable than original
  - Co^{2+} and Cu^{2+} usually form tetrahedral complexes with monodentate anionic ligands (Cl^-, SCN^-, OH^-)

- deprotination
  - H_2O strongly polar and e^- density further withdrawn from H^+ by the bonding with central ion so H can be lost as H^+
  - H^+ reacts with approaching OH^- giving H_2O and OH^- is left as the ligand
  - at low conc NH_3 acts as base (deprotinates) at high conc acts as ligand so ligand exchange



$[Cu(H_2O)_6]^{2+} + 2NH_3 \longrightarrow [Cu(OH)_2(H_2O)_4] + 2NH_4^+$

pale blue solution — pale blue ppt

$[Cu(OH)_2(H_2O)_4] + 4NH_3 \longrightarrow [Cu(NH_3)_4(H_2O)_2] + 2H_2O + 2OH^-$

pale blue ppt — deep blue solution

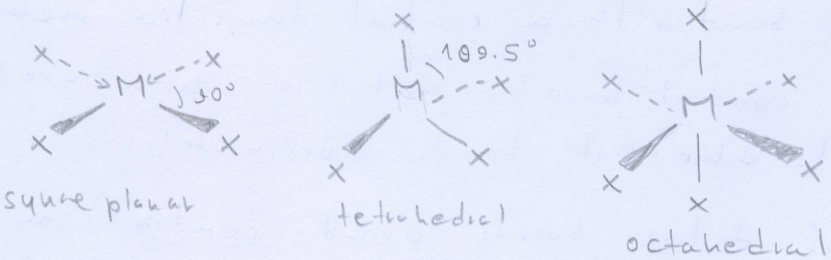
$[CuCl_4]^{2-}$ – yellow $[CuCO_3]_{(s)}$ – blue $Cr_2O_7^{2-}$ – orange bright otherwise Cr – green

$[Fe(H_2O)_6]^{2+}$ – pale green $[Fe(OH)_2(H_2O)_4]_{(s)}$ – green Al – white

$[Co(H_2O)_6]^{2+}$ – pink $[Co(OH)_2(H_2O)_4]_{(s)}$ – blue

$[Co(NH_3)_6]^{2+}$ – orange $[CoCl_4]^{2-}$ – violet $[CoCO_3]_{(s)}$ pale pink

- shapes:



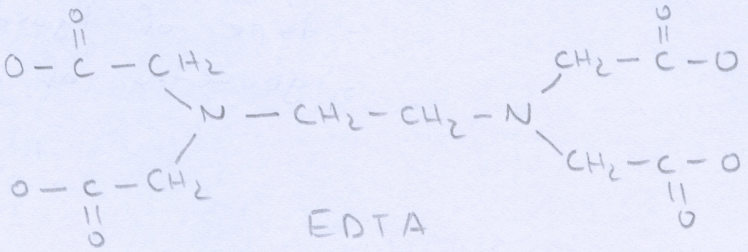
- Stability constant – k_{stab}
  - equilibrium constant for ligand exchange
  - conc of H_2O not included since it is in massive excess
  - ↑ k_{stab} is more stable so will form
  - given relative to hydrated complex so has all H_2O as ligands

$[Cu(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-} + 6H_2O$

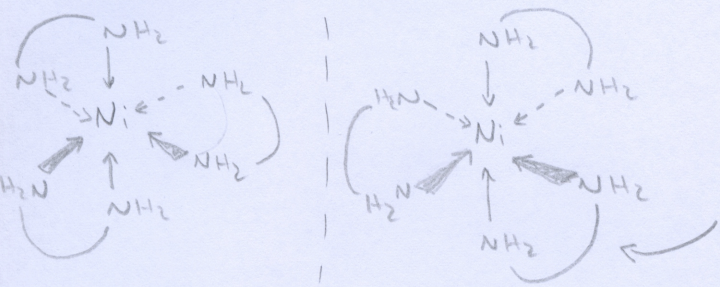
$$k_{stab} = \frac{[[CuCl_4]^{2-}]}{[[Cu(H_2O_6)]^{2+}][Cl^-]^4}$$

also given as log

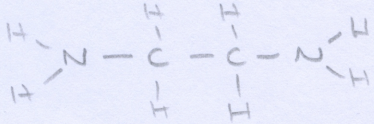
- generally complexes with bidentate or multidentate ligands are more stable than monodentate
  - ↳ explained by ΔS_{sys} since 1 ligand displaces multiple waters so great increase in entropy
  - ↳ eg EDTA - hexadentate



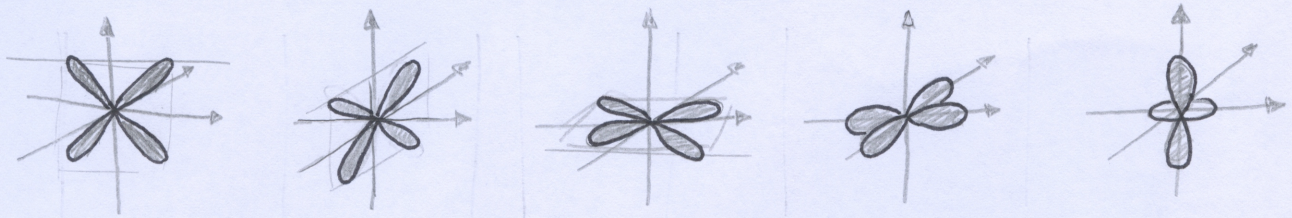
- optical isomers:



ethylene diamine



- d orbitals:



d_{yz} d_{xz} d_{xy} $d_{x^2-y^2}$ d_{z^2}

- degenerate orbitals - all at the same energy level
- Colour of complexes
  - ↳ coordinate bonding with ligands cause 3d orbitals to split into two sets of non-degenerate orbitals at slightly different energy levels
  - ↳ certain orbitals line up with bonds so the e^- in them are repelled ∴ ↑ e^-

  splitting pattern depends on geometry of ~~bon~~ coordinate bonds

octahedral ⟶ $\underline{d_{x^2-y^2}}$ $\underline{d_{z^2}}$ / d_{yz} d_{xz} d_{xy}

tetrahedral ⟶ d_{z^2} d_{yz} d_{xz} / $d_{x^2-y^2}$ d_{xy}

  - ↳ difference in energy of orbitals ΔE
  - ↳ e^- absorb photons to excite into higher energy level

    $\Delta E = hf$ f corresponds to visible light
  - ↳ talk about absorption - the light we see is transmitted

Cu^{2+} : ↑↓ ↑↓ ↑↓ ↑↓ ↑ ⟶ ↑↓ ↑ / ↑↓ ↑↓ ↑↓ ; ΔE ⟶ ↑↓ ↑↓ / ↑↓ ↑↓ ↑ ← light

- different complexes split orbitals to different extent so diff ΔE and colour of light absorbed ∴ transmitted
- ΔE depends on
  - type of central metal ion
  - type of ligand
  - geometry of complex