# 16 – Redox equilibria

Oxidation - e- #o - agents are Reduced to Oxidize other molecules

Reduction - e- #o - agents are Oxidized to Reduce other molecules

Standard conditions - 100kPa, 298K, 1 mol dm-3

## Electrical chemical cell

Standard electrode potential - Potentials measured against standard hydrogen electrode (0.00 V)

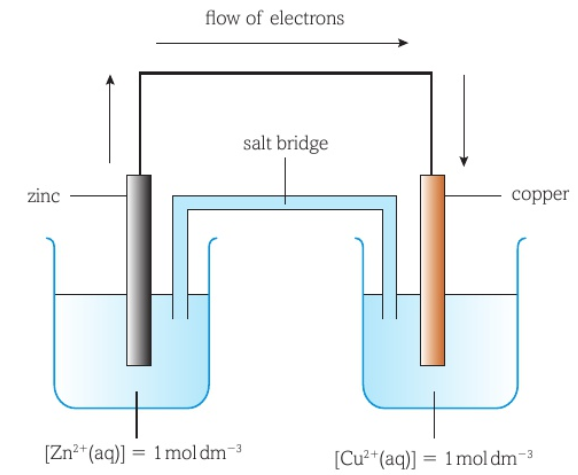
Largerreduced, smaller oxidized

Largerstronger oxidizing / weaker reducing

(Zn oxidized, Cu reduced)

Electrolytes (aqueous substance in beaker) must be **soluble**.

### Electro-cell diagram



e- flows from smaller larger

Left oxidized, right reduced.

Shorthand display: **down-right-up curved arrow** Zn I Zn2+ || Cu2+ I Cu

### Measuring

The standard hydrogen electrode is used to measure:

Half equation:

### Feasibility

reaction is feasible (spontaneous)

## Hydrogen-Oxygen Fuel cells

Both sides overall equations are the same:

The membrane separates H2 and O2 gases

Electrodes are coated in Pt as catalyst

### Acidic electrolyte

Anode (-):

Cathode (+):

### Alkaline electrolyte

Anode:

Cathode:

### Advantages & disadvantages

|  |  |
| --- | --- |
| * Environmentally friendly * No harmful product pollutants * Alternative to use of fossil fuels | * H2(g) is a flammable gas * H2(g) is not renewable * Storage of H2(g) has hazards * Storage of H2(g) is costly |

# 17 – Transitional metals

Transitional metals - Metals that can form > 0 stable ions with partially filled d subshell

Scope of the exam:

## Electronic configuration

If moving 4s e- to 3d, d is d5 / d10, there is more stability so e- would leave 4s.

When forming ions, 4s e- leaves first

## Introduction to complexes

Ligands - Species with lone pair of e- that can form dative bond to t.m. ion

Co-ordinate bonds (c.o. bonds) - Dative covalent bond from ligands

Co-ordination number (c.o. num) - Number of c.o. bonds



### Shapes

Large ligands (Cl-) 4 bonds: Tetrahedral 109.5°

Small ligands (H2O / NH3) forms 6 bonds: Octahedral 90°

*Number of ligands around metal:*

* Ligands repel each other as far as possible
* Giving structure with bond angles of X°

### Naming

H2O aqua | NH3 ammine | X- halo | OH- hydroxo (All negatives end with -o)

### Multidentate ligands

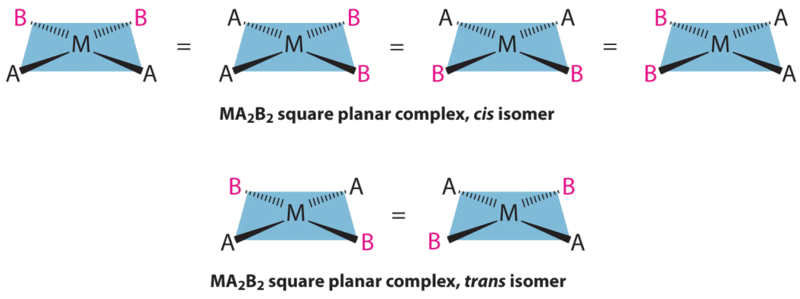
Multidentate ligands - Ligands that has > 1 lone pair of e- that can bond to t.m. ion

Names of multidentate is related to number of c.o. bonds formed.

### Ligand isomerism

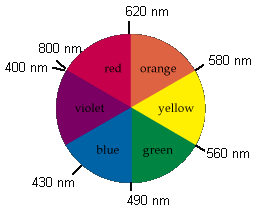
Optical isomerism: only 3 bidentate ligands

Cis-trans geometric isomerism: quad-bi octahedral ligands / bi-bi square planar ligands

Cis - same side | Trans - opposite side

## Complex reactions & color

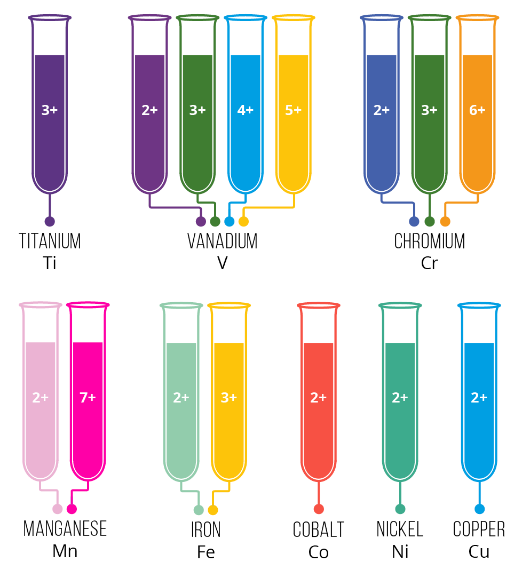
### Cause of colors – 3d Energy levels

1. Partially filled d-orbital
2. Ligands cause d-d splitting
3. Visible spectrum radiation absorbed
4. Light causes d-d transitions
5. Complementary color observed

### Reactions

1. Deprotonation Ligands ± H+
2. Ligand exchange Ligands replaced
3. Redox Oxidation number
4. C.o. number change Number of ligands in complex

## Summary of reactions



https://www.docbrown.info/page07/SSquestions/transppt.gif

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reagent | NaOH  *Deprotonation* | e. NaOH | NH3  *Deprotonation* | e. NH3  *Ligand exchange* |
| Cr3+ ⬤ | Cr(OH)3 ▲ | [Cr(OH)6]3- ⬤ | Cr(OH)3 ▲ | [Cr(NH3)6]3+ ⬤ |
| Mn2+ ⬤ | MnO2 △ |  | MnO2 △ |  |
| Fe2+ ⬤ | Fe(OH)2 ▲  Fe(OH)3 ▲ |  | Fe(OH)2 ▲  Fe(OH)3 ▲ |  |
| Fe3+ ⬤ | Fe(OH)3 ▲ |  | Fe(OH)3 ▲ |  |
| Co2+ ⬤ | Co(OH)2 ▲ |  | Co(OH)2 ▲ | [Co(NH3)6]2+⬤ |
| Ni2+ ⬤ | Ni(OH)2 ▲ |  | Ni(OH)2 ▲ | [Ni(NH3)6]2+ ⬤ |
| Cu2+ ⬤ | Cu(OH)2 ▲ |  | Cu(OH)2 ▲ | [Cu(NH3)4(H2O)2]2+⬤ |
| Zn2+ ⊚ | Zn(OH)2 △ | [Zn(OH)4]2-⊚ | Zn(OH)2 △ | [Zn(NH3)4]2+ ⊚ |

# References

## Solubility rules

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Soluble** | | | | | **Exceptions** |
| Nitrate | Ammonium | Potassium | Sodium |  | - |
| Chlorine | Iodine |  |  |  | Pb2+ Hg22+ Ag+ (PHAg) |
| Sulphate |  |  |  |  | Pb2+ Hg22+ Ag+ Ca2+ Ba2+ Sr2+ (Castro bear) |
| **Insoluble** | | | | |  |
| Carbonate | Phosphate |  |  |  | Group 1, NH4+ |
| Hydroxide |  |  |  |  | Group 1, NH4+ Ca2+ Ba2+ Sr2+ (Castro bear) |