

13.1 First row d-block elements

Complex ions
 Transition metal ions combine with high charge density and often water molecules which form coordinate bonds with the positive ions to form a complex ion.

What is a coordinate bond (dative covalent bond)?
 Is a covalent bond in which a pair of electrons is donated by a molecule or ion to form a covalent bond.

Examples of complex ions and ligands

Ligand	Charge	Number of donor atoms	Coordination number of complex ion	Example
H_2O	0	1	4	Aqua
NH_3	0	1	4	Amine
Cl^-	-1	1	4	Chloride
OH^-	-1	1	4	Hydroxide
SCN^-	-1	1	4	Thiocyanate
F^-	-1	1	4	Fluoride
$\text{C}_2\text{O}_4^{2-}$	-2	2	4	Oxalate
$\text{C}_2\text{O}_4^{2-}$	-2	2	4	Oxalate
EDTA^{4-}	-4	6	6	Ethylenediaminetetraacetate
$\text{C}_2\text{O}_4^{2-}$	-2	2	4	Oxalate

Types of ligands:
 - **Polydentate ligands (chelate ligands):** Ligands that can form more than one coordinate bond to a central metal ion.
 - **Monodentate ligands:** Ligands that form only one coordinate bond to a central metal ion.
 - **Bidentate ligands:** Ligands that form two coordinate bonds to a central metal ion.
 - **Hexadentate ligand:** Ligands that form six coordinate bonds to a central metal ion.

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Transition metals as catalysts

What is a catalyst?
 A substance that alters the speed of a chemical reaction. (It does not get used up itself.)

Heterogeneous catalysts → Catalyst is in a different state of matter to the reactants.

Examples of transition metals as heterogeneous catalysts include the following:

Nickel (Ni) in the Haber process:
 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 Ammonia (NH_3) is the raw material for a large number of other useful chemical products such as fertilizers, plastics, drugs, and explosives.

Palladium (Pd) in the combustion of carbon monoxide:
 $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g})$
 This reaction allows contaminated vegetable oils with a carbon-carbon double bond to be converted to margarine.

Pt and Rh in the catalytic converter:
 $2\text{CO}(\text{g}) + 2\text{NO}(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{N}_2(\text{g})$
 This reaction removes harmful primary pollutants from a car's exhaust gases.

Pt and Rh in the decomposition of hydrogen peroxide:
 $2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$

Pt and Rh in the Contact process:
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
 Sulfur trioxide (SO_3) is used in the production of sulfuric acid, the manufacturing world's most important chemical.

Why do industrial processes prefer to use heterogeneous catalysts to homogeneous ones?
 It is easier to remove the catalyst after use.

Homogeneous catalysts?
 The catalyst is in the same state as reactants.

***Fe²⁺ in heme:** oxygen is transported through the bloodstream by forming a weak bond with the heme group of hemoglobin. This group contains a central Fe²⁺ ion surrounded by four nitrogen atoms. The O₂-Fe²⁺ bond is easily broken when the oxygen needs to be released.

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The magnetic properties of the transition metals and their compounds

Every spinning electron in an atom or molecule can behave as a tiny magnet. Electrons with opposite spins behave like minute bar magnets with opposing orientation and so have no net magnetic effect. Most substances have paired electrons that pair up and so are non-magnetic. Some transition metals and their compounds are unusual in having some electrons that remain unpaired, which when aligned lead to magnetic properties.

When placed in an external magnetic field we use three terms to describe magnetic behaviour:

- Diamagnetism** is a property of all materials and produces a very weak opposition to an applied magnetic field.
- Paramagnetism**, which only occurs with substances which have unpaired electrons, is stronger than diamagnetism. It produces magnetization proportional to the applied field and in the same direction.
- Ferromagnetism** is the largest effect, producing magnetizations sometimes orders of magnitude greater than the applied field.

<https://www.youtube.com/watch?v=CkSP-QwIDAO>

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