

Chapter 15

Extraction of Metals and Corrosion

NCEA Level 1 Chemistry material covered in this chapter includes Achievement Standard 90640 (Chemistry 1.4): 'Describe properties and reactions of metals, acids and bases' by showing understanding of:

- Reactivity of metals related to their extraction from ores.
- Methods of extraction used to obtain metals.
- Corrosion of metals.

Extraction of Metals from their Ores

Metals were discovered in reverse order of their chemical activity:

- The least active metals (ie gold and silver) were discovered first.
- The less active metals (ie iron, zinc, lead, copper) were discovered next.
- The highly active metals (ie sodium, lithium, calcium, magnesium, aluminium) were discovered later.

Extraction of Metals from Metal Oxides

The less active metals either have minerals that are oxides, eg iron, or the oxide can be readily obtained from the mineral (often the metal sulfide), eg zinc, lead and copper. The metal is extracted by thermal reduction of the metal oxide using carbon (in the form of carbon/coke) as the reducing agent.

Iron

Iron oxide, present as the mineral **titanomagnetite** ($\text{Fe}_3\text{O}_4 \cdot \text{TiO}_2$), occurs in abundance in New Zealand in the **iron sand** on the west coast of the North Island.

At the Glenbrook Steel Works, a rotary kiln is used to produce iron from iron sand. (The titanium oxide (TiO_2) in titanomagnetite is not affected by the thermal reduction process that produces iron – titanium is too reactive a metal.)

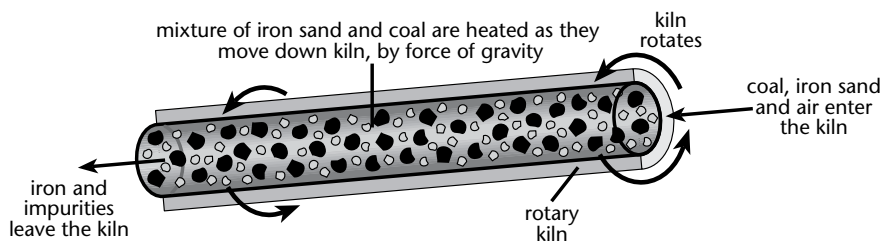
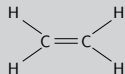


Fig. 15.1: Commercial production of iron by reduction of iron oxide

Activity 24B: Alkenes, polymerisation and hydrocarbon solubility in water

- Write the general formula for an alkene.
- Explain the difference between the two formulae for the ethene molecule, C_2H_4 and



- Suggest a name for a compound with molecular formula C_4H_8 .
 - Draw a structural formula for the molecule C_4H_8 . *Note:* There are three possible structures depending upon where the double bond is placed – any one structure is sufficient.
- Match the following terms with their explanations:

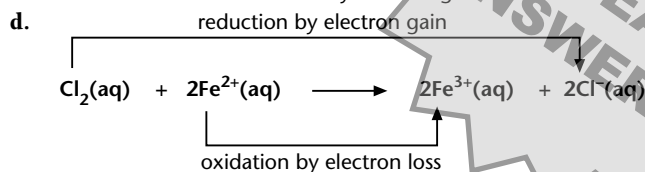
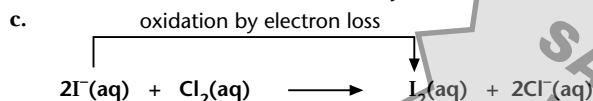
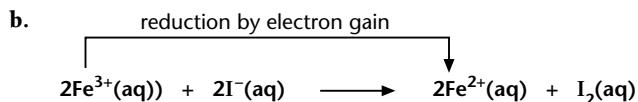
<ol style="list-style-type: none"> Polymer Alkene Monomer Polymerisation Double bond Plastic 	<ol style="list-style-type: none"> Two atoms joined together in a molecule using four electrons. A simple molecule that can be polymerised. A material that can be easily shaped. A hydrocarbon that contains one double bond. The process of making a polymer from a monomer. The product of a polymerisation process.
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- State one use for:
 - Polythene.
 - Polypropylene.
 - State what material is used for:
 - Yoghurt cups.
 - Rainwear.
 - Non-stick frying pans.
- State what is meant by the term 'unsaturated' in connection with carbon compounds.
 - Describe a simple test you could apply to some cooking oil to see if it contained unsaturated compounds.
 - Complete the following equation by placing a symbol for an atom or group of atoms in each box, and adding a letter or number for each dash.



- Diesel oil spilt into a river will float on top of the water. Explain why the oil and water do not mix. *Hint:* Diesel oil is composed of hydrocarbon molecules and, although these molecules are comparatively large, the boiling point of diesel oil is comparatively low.

Combustion

All hydrocarbons are fuels that undergo combustion, ie they combine with oxygen when heated and release more heat, and also light.



(A – two equations correct for both oxidation and reduction; M – four equations correct for both oxidation and reduction)

Activity 10A: Soluble and insoluble substances, preparation of an insoluble compound

- Insoluble. (A)
 - Soluble. (A)
 - Sparingly soluble. (A)
- Any three of: sodium nitrate, magnesium nitrate, calcium nitrate, aluminium nitrate, zinc nitrate, iron(III) nitrate, lead nitrate, copper nitrate, silver nitrate. (A)
 - Lead chloride or silver chloride. (A)
 - Any two of: magnesium carbonate, calcium carbonate, zinc carbonate, iron(II) carbonate, lead carbonate, copper carbonate. (A)
 - Sodium hydroxide, potassium hydroxide. (A)
- A precipitate is an insoluble solid formed when two solutions are mixed. (A)
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Solution A	Solution B	Precipitate		
		Name and formula	Appearance	Equation in word form
silver nitrate	sodium chloride	silver chloride AgCl	a. white solid	b. silver nitrate + sodium chloride → silver chloride + sodium nitrate
barium nitrate	sodium sulfate	c. barium sulfate BaSO ₄	white solid	d. barium nitrate + sodium sulfate → barium sulfate + sodium nitrate
e. iron(III) nitrate	f. sodium hydroxide	iron(III) hydroxide Fe(OH) ₃	g. red-brown solid	h. iron(III) nitrate + sodium hydroxide → iron(III) hydroxide + sodium nitrate

(A – each correct answer)

5. a. Copper(II) nitrate + sodium hydroxide \rightarrow copper(II) hydroxide + sodium nitrate. (A)
 b. Calcium nitrate + sodium hydroxide \rightarrow calcium hydroxide + sodium nitrate. (A)
 c. Zinc nitrate + sodium carbonate \rightarrow zinc carbonate + sodium nitrate. (A)
 d. $\text{Mg}(\text{NO}_3)_2(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Mg}(\text{OH})_2(\text{s}) + 2\text{NaNO}_3(\text{aq})$. (A)
 e. $\text{FeSO}_4(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{FeCO}_3(\text{s}) + \text{Na}_2\text{SO}_4(\text{aq})$. (A)
 f. $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$. (A)
 g. $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$. (A)
6. *Word description:*
- Prepare lead nitrate solution and sodium chloride solution.
 - Mix equal volumes of the two solutions.
 - Lead nitrate + sodium chloride \rightarrow lead chloride + sodium nitrate, or
 $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{NaCl}(\text{aq}) \rightarrow \text{PbCl}_2(\text{s}) + 2\text{NaNO}_3(\text{aq})$, or
 $\text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \rightarrow \text{PbCl}_2(\text{s})$.
 - Filter off the white precipitate of lead chloride, retaining the solid on a filter paper held in a funnel.
 - Wash the precipitate with distilled water.
 - Open up the filter paper and allow the lead chloride to dry by the water evaporating from the solid.

Alternative answer using diagram:

I Mix solutions to form a precipitate

$\text{NaCl}(\text{aq})$
 Na^+
 Cl^-
 Pb^{2+}
 NO_3^-
 $\text{Pb}(\text{NO}_3)_2(\text{aq})$
 solutions mixed \rightarrow precipitation occurs
 $\text{PbCl}_2(\text{s})$

II Filter precipitate to obtain lead chloride as a residue in the filter paper, and sodium nitrate solution.
 Spectator ions of Na^+ and NO_3^-

III Wash precipitate to remove spectator ions clinging to the lead chloride.
 Spectator ions of Na^+ and NO_3^-

IV precipitate of lead chloride drying in air

Follow sequence I to IV

For clarity, the lead chloride precipitate has been drawn showing the Pb^{2+} and Cl^- ions. If this experiment were to be performed, the pure, dry sample of lead chloride would be present as a white solid.

Either word description or diagram acceptable. (A – reagents correct, purification process mentioned, word equation; M – filtration, washing and drying of ppt, molecular equation; E – complete description/diagram, ionic equation)

Glossary/Index

Note: Numbers in brackets refer to pages on which term is defined or discussed.

- acid** (131): a substance in solution that will turn blue litmus paper red and has a pH of less than 7.
- acid radical** (80): a group of atoms in a molecule that, when joined to hydrogen atom(s), form an acid.
- acid rain** (163, 181): rain that is more acidic than normal due to the presence of sulfur dioxide, nitrogen dioxide and other acidic gases formed in industrial areas.
- activity series** (91, 111, 171): an order for the arrangement of metals, with the most active metal at the top of the series; for Level 1 NCEA Chemistry, the metals listed are, in order of activity: sodium > lithium > calcium > magnesium > aluminium > zinc > iron > lead > copper > silver > gold.
- aerosol** (181): a dispersion of very small drops of liquid in a gas, eg air; forming part of what is commonly referred to as 'smog'.
- alcohol** (219): a compound of carbon formed by replacement of a hydrogen atom by a hydroxyl group in the molecule of an alkane; general formula $C_nH_{2n+1}OH$.
- alkali** (131): a soluble base that will turn red litmus paper blue and has a pH greater than 7.
- alkane** (101, 207): a compound of hydrogen and carbon, in a series with the general formula, C_nH_{2n+2} .
- alkene** (211): a compound of hydrogen and carbon, in a series with the general formula, C_nH_{2n} .
- alkyne**: a compound of hydrogen and carbon, in a series with the general formula, C_nH_{2n-2} .
- allotrope** (151, 191): the existence of an element in two or more different forms in the same physical state.
- alloy** (108): two or more metals dissolved in each other; (*Note:* carbon, a non-metal, can form an alloy with iron (called steel)).
- alumina** (125): aluminium oxide, obtained from the mineral bauxite and used to produce aluminium metal.
- amalgam**: an alloy formed between a metal and mercury.
- amu** (97): **atomic mass unit**; the unit is $\frac{1}{12}$ of the mass of a carbon-12 atom and is the standard against which all atomic and molecular masses are compared.
- anhydride** (179): a compound that reacts with water to produce an acid.
- anhydrous** (141): without water – used to describe crystals that have lost their water of crystallisation.
- anion** (49): a negative ion that is attracted to the anode during electrolysis.
- anode**: the positive terminal in an electrolysis process to which anions are attracted.
- antioxidant** (163, 189): another name for a reducing agent, or reductant; in terms of food preservation, the antioxidant removes oxygen, and thus prevents bacteria surviving to cause food to decay.
- aqueous solution**: a solution formed by dissolving a substance in water.
- A_r** (97): symbol used to indicate relative atomic mass; relative atomic mass of an atom is the mass of an atom in amu.