Structure 2.4

IB CHEMISTRY SL

Structure 2.4.1

Understandings:

- Bonding is best described as a continuum between the ionic, covalent and metallic models, and can be represented by a bonding triangle.

Learning outcomes:

- Use bonding models to explain the properties of a material.

Additional notes:

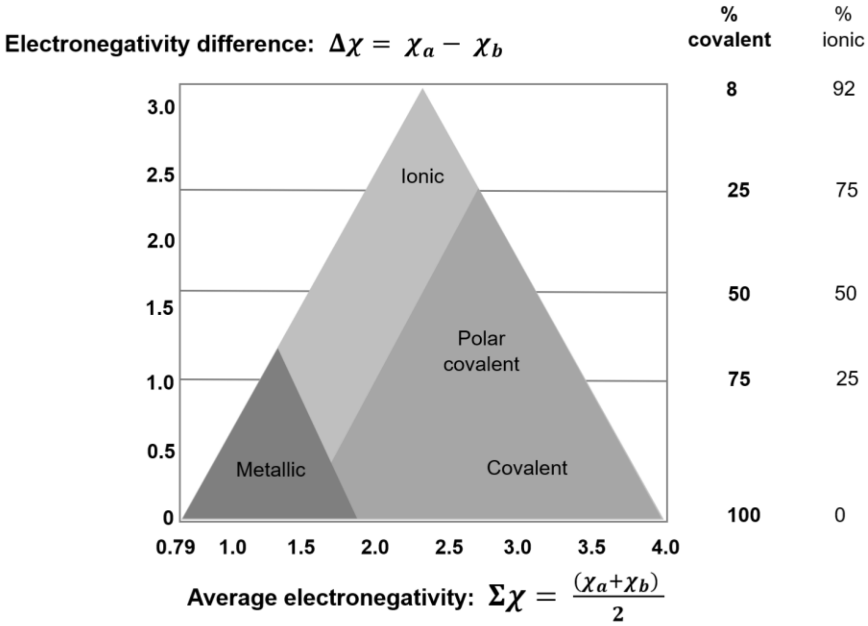
- A triangular bonding diagram is provided in the data booklet.

Linking questions:

- Structure 3.1 How do the trends in properties of period 3 oxides reflect the trend in their bonding?
- Structures 2.1, 2.2 What are the limitations of discrete bonding categories?

Bonding triangle

- A bonding triangle can be used to determine the type of bonding that occurs between atoms in a solid as well as the properties of the substance.



On the *y*-axis:

$$\text{Electronegativity difference}$$
$$\Delta\chi = \chi_a - \chi_b$$

On the *x*-axis:

$$\text{Average electronegativity}$$
$$\Sigma\chi = \frac{(\chi_a + \chi_b)}{2}$$

Bonding types and their properties

Type of bonding	State at room temperature	Boiling and melting points	Electrical conductivity	Solubility in water
Covalent	Mainly gases and liquids	Mainly low	Low	Low
Ionic	Solids	Mainly high	Depends on state	Most are soluble
Metallic	Solid	Mainly high	Good	Insoluble

Structure 2.4.2

Understandings:

- The position of a compound in the bonding triangle is determined by the relative contributions of the three bonding types to the overall bond.

Learning outcomes:

- Determine the position of a compound in the bonding triangle from electronegativity data.
- Predict the properties of a compound based on its position in the bonding triangle.

Additional notes:

- To illustrate the relationship between bonding type and properties, include example materials of varying percentage bonding character. Only binary compounds need to be considered.
- Calculations of percentage ionic character are not required.
- Electronegativity data are given in the data booklet.

Linking questions:

- Structure 2.1, 2.2, 2.3 Why do composites like reinforced concretes, which are made from ionic and covalently bonded components and steel bars, have unique properties?

Chlorine, Cl_2
Difference in electronegativity
$\Delta\chi = 3.2 - 3.2$
$\Delta\chi = 0$

Average electronegativity
$\Sigma\chi = \frac{(3.2 + 3.2)}{2}$
$\Sigma\chi = 3.2$
Type of bonding: covalent

Hydrogen chloride, HCl
Difference in electronegativity
$\Delta\chi = 3.2 - 2.2$
$\Delta\chi = 1.0$

Average electronegativity
$\Sigma\chi = \frac{(3.2 + 2.2)}{2}$
$\Sigma\chi = 2.7$
Type of bonding: Polar covalent

Cesium fluoride, CsF
Difference in electronegativity
$\Delta\chi = 4.0 - 0.8$
$\Delta\chi = 3.2$

Average electronegativity
$\Sigma\chi = \frac{(4.0 + 0.8)}{2}$
$\Sigma\chi = 2.4$
Type of bonding: Ionic

Magnesium, Mg
Difference in electronegativity
$\Delta\chi = 1.3 - 1.3$
$\Delta\chi = 0$

Average electronegativity
$\Sigma\chi = \frac{(1.3 + 1.3)}{2}$
$\Sigma\chi = 1.3$
Type of bonding: metallic

Structure 2.4.3

Understandings:

- Alloys are mixtures of a metal and other metals or non-metals. They have enhanced properties.

Learning outcomes:

- Explain the properties of alloys in terms of non-directional bonding.

Additional notes:

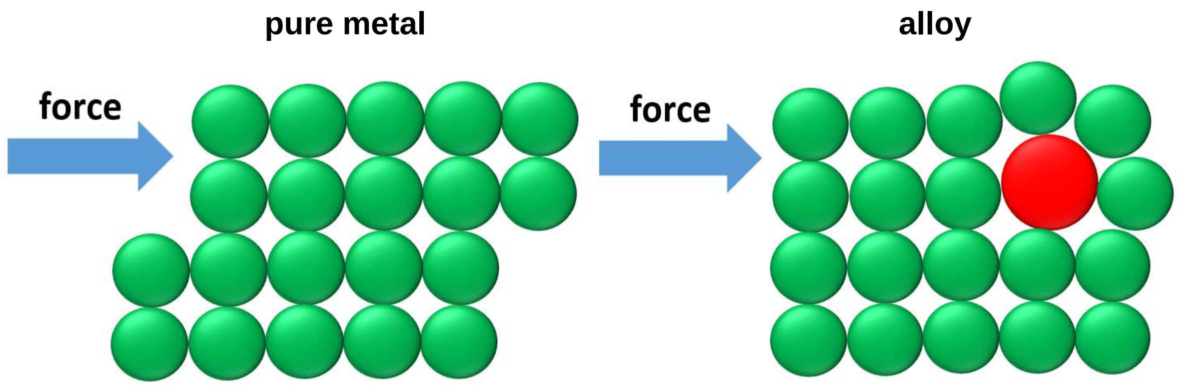
- Illustrate with common examples such as bronze, brass and stainless steel. Specific examples of alloys do not have to be learned.

Linking questions:

- Structure 1.1 Why are alloys more correctly described as mixtures rather than as compounds?

Alloys

- Alloys are materials that are composed of two or more metals or a metal and a non-metal.
- The bonding in metals is non-directional; the force of attraction between the positive metal ions and the delocalised electrons acts in all directions around the fixed metal ions.
- Alloys have enhanced properties (increased tensile strength and increased resistance to corrosion); they have different properties to the metals that they are made from.
- They tend to be harder (less malleable) and have greater tensile strength (stronger).
- The added metal atoms can distort the lattice structure.
- The distortion of the lattice structure makes it more difficult for the layers to slide over each other.



- In a pure metal the layers can slide over each other.
- The presence of different sized metal atoms (ions) means the layers cannot slide over each other as easily as in a pure metal.

Exercise: Explain why alloys are harder than pure metals.

Uses of alloys

Alloy	Component metals	Properties and uses
Steel	iron, carbon	high tensile strength; used in construction
Stainless steel	iron, nickel, chromium	resistant to corrosion; used in cooking implements
Brass	copper and zinc	pipes
Bronze	copper and tin	coins, medals, tools
Pewter	tin, copper, antimony	decorative ornaments
Solder	lead and tin	low melting point; used to join metals in electrical circuits
Nichrome	nickel and chromium	heating elements

Exercises: Suggest an alloy for the following uses with a reason for your choice.

1. To use in electrical circuits.

2. To make water pipes.

3. To use in an ornament.

4. To construct a bridge.

5. To make a saucepan.

Structure 2.4.4

Understandings:

- Polymers are large molecules, or macromolecules, made from repeating subunits called monomers.

Learning outcomes:

- Describe the common properties of plastics in terms of their structure.

Additional notes:

- Examples of natural and synthetic polymers should be discussed.

Linking questions:

- Structure 3.2 What are the structural features of some plastics that make them biodegradable?

Polymers

- A polymer is a substance that consists of very large molecules called macromolecules, composed of many repeating subunits, which are known as monomers.
- Polymers can be natural or synthetic.

Natural polymers	Synthetic polymers
Cellulose	Nylon
Starch	Polyethene
Collagen	PVC (polyvinyl chloride)

Properties of synthetic polymers

Property	Explanation
Electrical and heat insulator	No delocalised electrons to conduct electricity or heat
Flexible	Weak intermolecular forces between the polymer chains
Durable	Strong covalent bonds between the atoms in the polymer chains
Can be moulded into different shapes	The weak intermolecular forces between the polymer chains can be overcome by heat
Lightweight / low densities	Polymer chains do not pack closely together

Structure 2.4.5

Understandings:

- Addition polymers form by the breaking of a double bond in each monomer.

Learning outcomes:

- Represent the repeating unit of an addition polymer from given monomer structures.

Additional notes:

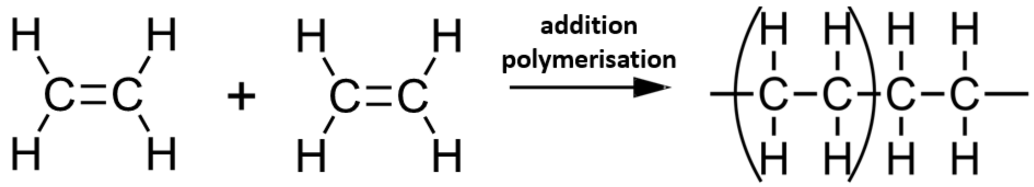
- Examples should include polymerisation reactions of alkenes.
- Structures of monomers do not have to be learned but will be provided or will need to be deduced from the polymer.

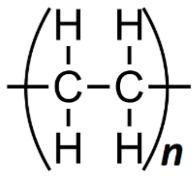
Linking questions:

- Structure 3.2 What functional groups in molecules can enable them to act as monomers for addition reactions?
- Reactivity 2.1 Why is the atom economy 100% for an addition polymerisation reaction?

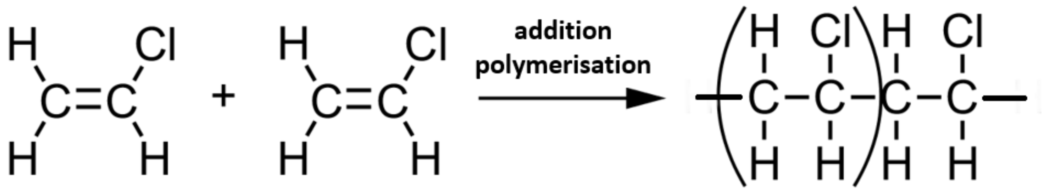
Addition polymerisation

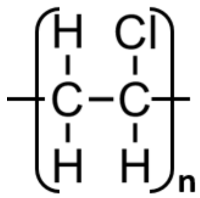
- Addition polymers are formed when smaller unsaturated molecules (monomers) react together.
- Poly(ethene) is formed when ethene monomers react together to form





- PVC or poly(vinyl chloride) is a polymer made from the monomer unit chloroethene (vinyl chloride).





Exercise: Draw the structure of the polymer made from three 2-methylpropene monomer units.