# Aluminium Trichloride Formation

A Level

C C C

Using the following data, along with constructing a suitable cycle, determine the enthalpy change of formation for anhydrous aluminium trichloride, $\mathrm{AlCl_3\,(s)}$.

**A**: $\mathrm{Al\,(s) + 3\,HCl(aq) \rightleftharpoons AlCl_3\,(aq) + \frac{3}{2}\,H_2\,(g)}; \Delta H = -503.0\,\mathrm{kJ\,mol^{-1}}$

**B**: $\mathrm{H_2\,(g) + Cl_2\,(g) \rightleftharpoons 2\,HCl\,(g)}; \Delta H = -184.0\,\mathrm{kJ\,mol^{-1}}$

**C**: $\mathrm{HCl(g) \rightleftharpoons HCl\,(aq)}; \Delta H = -72.7\,\mathrm{kJ\,mol^{-1}}$

**D**: $\mathrm{AlCl_3\,(s) \rightleftharpoons AlCl_3\,(aq)}; \Delta H = -645.5\,\mathrm{kJ\,mol^{-1}}$

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# Essential Pre-Uni Chemistry I3.10

A Level Further A
C C C C C C

All questions refer to a temperature of $298\,\mathrm{K}$, unless otherwise stated. The density of water may be taken to be $1.00\,\mathrm{g\,cm^{-3}}$ at RTP.

$60.0\,\mathrm{cm^3}$ of a solution containing thallium(I) ions was treated with $20.0\,\mathrm{cm^3}$ of aqueous sodium chloride with a concentration of $1.00\,\mathrm{mol\,dm^{-3}}$. The precipitated thallium(I) chloride was weighed and found to have a mass of $0.173\,\mathrm{g}$. The solubility product of thallium(I) chloride is $1.75 \times 10^{-4}\,\mathrm{mol^2\,dm^{-6}}$. Calculate the concentration of thallium(I) ions in the original solution before treatment.

Home Chemistry Physical Kinetics Collision theory

# Collision theory

A Level

C C C

By making simplistic assumptions about the movement of gaseous particles, we can calculate the frequency of collisions as a function of certain quantities.

## Part A Collision cross-section

First of all, let us assume that we have particles of type **A** and **B**, and that these can be treated as spheres of radius $r_A$ and $r_B$ respectively.

Let us move into the frame of reference of a particle **A**. It is being approached by a particle **B** travelling in a straight-line trajectory. If we project this into a plane that is perpendicular to this trajectory, a collision will take place (i.e. the spheres will come into contact) if and only if the centre of **B** falls inside a circle centred on **A**. What will the area of this circle be (this is known as the collision cross-section, $\sigma$)?

The following symbols may be useful: `r_{A}, r_{B}`

## Part B Relative speed

The faster **A** and **B** particles move relative to one another, the frequent the collisions between them will be. At higher temperatures, particles will on average have kinetic energy. For a given kinetic energy, particles with a higher mass will move rapidly, and therefore collide frequently.

Items:

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## Part C Concentrations

Finally, the rate of collisions will also depend on the concentrations of particles **A** and **B**. If the initial rate of collisions is $x$, what would you expect the rate of collisions to be after both concentrations are doubled?

The following symbols may be useful: x

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# Double Bond Equivalents

A Level
C C C

While the molecular formula does not contain a lot of structural information about a compound, it is possible to extract the number of double bond equivalents (DBEs), a measure of degree of unsaturation of an organic compound.

## **Part A** Alkanes

How many hydrogen atoms does an alkane with $n$ carbon atoms contain?

The following symbols may be useful: n

## Part B Reducing the hydrogen count

Which of the following, if present in the structure, will reduce the number of hydrogens a hydrocarbon with a given number of carbon atoms contains?

- ☐ a ring
- ☐ a chiral centre
- ☐ a triple bond
- ☐ a double bond
- ☐ a branch

## Part C Unsaturated hydrocarbon

A hydrocarbon with $n$ carbons contains one ring, one double bond and one triple bond. How many hydrogens does it contain?

## Part D DBEs in hydrocarbons

Bearing in mind that each double bond equivalent removes two hydrogens compared to the alkane, how many double bond equivalents does a compound with the molecular formula $\mathrm{C}_x\mathrm{H}_y$ contain?

The following symbols may be useful: `x`, `y`

## Part E Other elements

The presence of other elements can also modify the number of hydrogens a compound contains. Halogens will the number of hydrogens present, as they take their place in structures and only form one bond. Oxygens will the number of hydrogens present, as they form two bonds. Meanwhile, nitrogens will the number of hydrogens present, as they form three bonds. Introducing an extra carbon will the number of hydrogens present, as expected from the general formulae of homologous series, and consistent with the trend, as they form four bonds.

Items:

increase by two | increase by one | not change | decrease by one | decrease by two

## Part F DBEs more generally

By first accounting for the impact of the non-carbon elements on the hydrogen count, and then using the formula previously derived (or by other means), calculate the number of double bond equivalents present in a compound with the molecular formula $C_8H_{10}N_4O_2$.

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# Hydroxylamine and Iron(III)

A Level

P P P

The following experiment was used to determine the equation for the reaction between hydroxylamine, $\mathrm{NH_2OH}$, and iron$\mathrm{(III)}$ ions. $0.0370\,\mathrm{g}$ of hydroxylamine was dissolved in water and made up to $25.0\,\mathrm{cm^3}$ . This solution was reacted with an excess of an acidified solution of an iron$\mathrm{(III)}$ salt. When the reaction was complete the iron$\mathrm{(II)}$ produced required $22.4\,\mathrm{cm^3}$ of $0.0200\,\mathrm{mol\,dm^{-3}}$ potassium manganate$\mathrm{(VII)}$ solution to oxidise the iron$\mathrm{(II)}$ back to iron$\mathrm{(III)}$.

## Part A Hydroxylamine oxidation number

What is the oxidation number of nitrogen in hydroxylamine, $\mathrm{NH_2OH}$?

## Part B Oxidation of iron$\mathrm{(II)}$

Write down the half-equation for the oxidation of iron$\mathrm{(II)}$ to iron$\mathrm{(III)}$ ions.

## Part C Reduction of manganate$\mathrm{(VII)}$

Write down the half-equation for the reduction of manganate$\mathrm{(VII)}$ to manganese$\mathrm{(II)}$ ions under acidic conditions.

## Part D Ionic equation

Deduce the ionic equation for the reaction between iron$\mathrm{(II)}$ ions and manganate$\mathrm{(VII)}$ ions under acidic conditions.

## Part E Moles of hydroxylamine

Calculate the amount, in moles, of hydroxylamine used in the reaction.

## Part F Moles of iron(II)

Calculate the amount, in moles, of iron(II) formed in the reaction.

## Part G Molar ratio of iron(III) to hydroxylamine

Determine the molar ratio of iron(III) to hydroxylamine reacting together.

## Part H Oxidation number of nitrogen in the product

Using the oxidation number of nitrogen in hydroxylamine, and the molar ratio of iron(III) to hydroxylamine, deduce the oxidation number of nitrogen in the product.

## Part I Nitrogen-containing product

Which of the following possible nitrogen-containing compounds is the most likely product of the reaction?

○ $N_2O_4$

○ $N_2$

○ $NH_3$

○ $NO$

○ $N_2O$

## Part J Hydroxylamine and iron(III) equation

Write the equation for the reaction between hydroxylamine and iron(III) ions. State symbols are not required.

Adapted with permission from OCSEB, A-Level Chemistry, June 1995, Paper 3/4, Question 5.

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# Monomer Units

A Level

P P P

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What are the respective monomer units that can be used to form the following polymers?

Use the structure editor to generate SMILES strings as your answers.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

## Part A $[CH(C_6H_5)CH_2]_n$

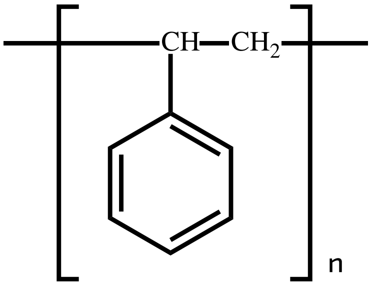

**Figure 1:** Structure of $[CH(C_6H_5)CH_2]_n$

## Part B $[COCH_2O]_n$

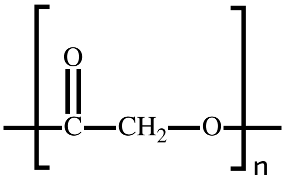

**Figure 2:** Structure of $[COCH_2O]_n$

## Part C $[\mathrm{COCH(CH_3)NH}]_n$

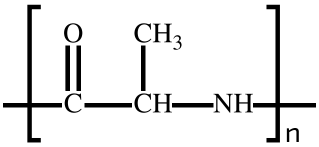

**Figure 3:** Structure of $[\mathrm{COCH(CH_3)NH}]_n$

## Part D $[\mathrm{C(CH_3)(COOCH_3)CH_2}]_n$

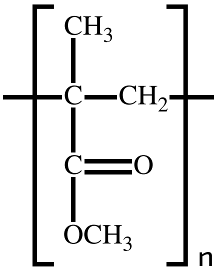

**Figure 4:** Structure of $[\mathrm{C(CH_3)(COOCH_3)CH_2}]_n$

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# Solubility product

A Level

C C C

The solubility product, $K_{sp}$, is the equilibrium constant for a dissolution process. For example, if a salt $\mathrm{AX\,(s)}$ partially dissolves in water to form a saturated solution of $\mathrm{A^+\,(aq)}$ and $\mathrm{X^-\,(aq)}$, the solubility product will be given by the product of the $\mathrm{A^+\,(aq)}$ and $\mathrm{X^-\,(aq)}$ concentrations.

## Part A Concentration of $\mathrm{Ag^+\,(aq)}$

Given the solubility product of silver(I) chloride is $2.0\ \times 10^{-10}\,\mathrm{mol^2\,dm^{-6}}$, calculate the concentration of $\mathrm{Ag^+\,(aq)}$ in a saturated solution of this salt (assuming all ions present originate from the salt).

## Part B Volume to dissolve one gram

Given the solubility product of silver(I) chloride is $2.0\ \times 10^{-10}\,\mathrm{mol^2\,dm^{-6}}$, what volume of pure water would be necessary to fully dissolve one gram of this salt?

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