

Lawrie Ryan and Roger Norris
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Lawrie Ryan and Roger Norris
Frontmatter
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Example answers and all other end-of-chapter questions were written by the authors.

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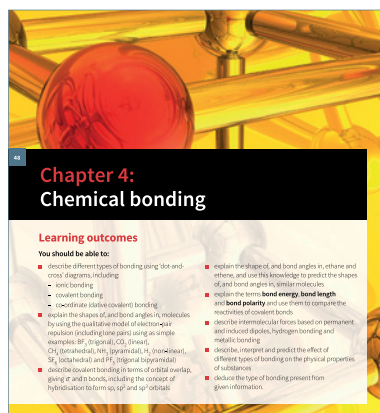
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How to use this book

Each chapter begins with a short list of the facts and concepts that are explained in it.



There is a short context at the beginning of each chapter, containing an example of how the material covered in the chapter relates to the 'real world'.

Introduction

In the last chapter we looked at the types of forces that keep the particles in solids and liquids together and make it possible to liquefy gases. In this chapter, we

shall also consider how the closeness and motion of the particles influences the properties of these three states of matter (Figure 5.1).



Figure 5.1 The three states of water are ice, water and steam. The 'steam' we see from the kettle is condensed droplets of water. The real gaseous water is in the area between this condensation and the spout of the kettle. We can't see it because it is colourless.

This book does not contain detailed instructions for doing particular experiments, but you will find background information about the practical work you need to do in these boxes. There are also two chapters, P1 and P2, which provide detailed information about the practical skills you need to develop during the course.

Important equations and other facts are shown in highlight boxes.

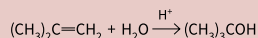
Fluoroalkanes least reactive
 Chloroalkanes ↓
 Bromoalkanes ↓
 Iodoalkanes most reactive

Questions throughout the text give you a chance to check that you have understood the topic you have just read about. You can find the answers to these questions on the CD-ROM.

The text and illustrations describe and explain all of the facts and concepts that you need to know. The chapters, and often the content within them as well, are arranged in the same sequence as in your syllabus.

METHODS FOR FOLLOWING THE COURSE OF A REACTION (CONTINUED)

The progress of some reactions can be followed by measuring small changes in the volume of the reaction mixture. For example, during the hydration of methylpropene, the volume decreases.



An instrument called a dilatometer (Figure 22.4) is used to measure the small changes in volume. The temperature has to be controlled to an accuracy of $\pm 0.001^\circ\text{C}$. Can you think why?

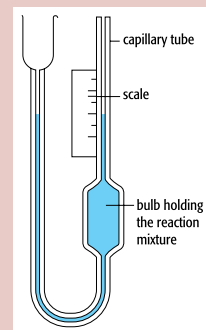


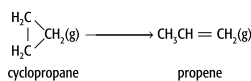
Figure 22.4 A dilatometer.

QUESTION

- 2 a Suggest a suitable method for following the progress of each of these reactions:
- $\text{H}_2\text{O}_2(\text{aq}) + 2\text{I}^-(\text{aq}) + 2\text{H}^+(\text{aq}) \longrightarrow 2\text{H}_2\text{O}(\text{l}) + \text{I}_2(\text{aq})$
 - $\text{HCOOCH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{HCOOH}(\text{aq}) + \text{CH}_3\text{OH}(\text{aq})$
 - $2\text{H}_2\text{O}_2(\text{aq}) \longrightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
 - $\text{BrO}_3^-(\text{aq}) + 5\text{Br}^-(\text{aq}) + 6\text{H}^+(\text{aq}) \longrightarrow 3\text{Br}_2(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$
- b Why is it essential that the temperature is kept constant when measuring the progress of a reaction?

Calculating rate of reaction graphically

Rate of reaction usually changes as the reaction proceeds. This is because the concentration of reactants is decreasing. Taking the isomerisation of cyclopropane to propene as an example:



The progress of this reaction can be followed by measuring the decrease in concentration of cyclopropane or increase

in concentration of propene. Table 22.1 shows these changes at 500°C . The measurements were all made at the same temperature because reaction rate is affected markedly by temperature.

Time / min	[cyclopropane] / mol dm ⁻³	[propene] / mol dm ⁻³
0	1.50	0.00
5	1.23	0.27
10	1.00	0.50
15	0.82	0.68
20	0.67	0.83
25	0.55	0.95
30	0.45	1.05
35	0.37	1.13
40	0.33	1.17

Table 22.1 Concentrations of reactant (cyclopropane) and product (propene) at 5-minute intervals (temperature = 500°C (773 K)).

Note that we put square brackets, [], around the cyclopropane and propene to indicate concentration; [propene] means 'concentration of propene'.

Figure 22.5 shows how the concentration of propene changes with time.

Wherever you need to know how to use a formula to carry out a calculation, there are worked example boxes to show you how to do this.

WORKED EXAMPLE (CONTINUED)

Step 1 Draw a graph of concentration (of hydrochloric acid) against time (Figure 22.13).

Figure 22.13 The concentration of hydrochloric acid and methanol fall at the same rate as time passes.

Step 2 Draw tangents to the curve at various places corresponding to a range of concentrations. In Figure 22.13 the tangent drawn corresponds to $[\text{HCl}] = 1.04 \text{ mol dm}^{-3}$.

Step 3 For each tangent drawn, calculate the gradient and then the rate of reaction. In Figure 22.13, the rate corresponding to $[\text{HCl}] = 1.04 \text{ mol dm}^{-3}$ is

$$\frac{1.480}{2000 \times 60} = 1.23 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$$

(multiply by 60 to convert minutes to seconds)

Table 22.7 shows the rates corresponding to five different concentrations of hydrochloric acid.

Time / min	Concentration / mol dm^{-3}	Rate from graph / $\text{mol dm}^{-3} \text{ min}^{-1}$	Rate from graph / $\text{mol dm}^{-3} \text{ s}^{-1}$
0	1.84	2.30×10^{-3}	3.83×10^{-5}
200	1.45	1.46×10^{-3}	2.43×10^{-5}
400	1.22	1.05×10^{-3}	1.75×10^{-5}
600	1.04	0.74×10^{-3}	1.23×10^{-5}
800	0.91	0.54×10^{-3}	0.90×10^{-5}

WORKED EXAMPLE (CONTINUED)

the $[\text{CH}_3\text{OH}]$ because if you look at the data in Table 22.6, you will see that the concentration of CH_3OH is decreasing at the same rate as the decrease in concentration of HCl.

Figure 22.14 A graph showing how concentration changes of hydrochloric acid or methanol affect rate of reaction. The curve shows that the reaction is likely to be second order.

Figure 22.14 shows an upward curve. This indicates that the reaction is second order. But second order with respect to what? As the concentrations of both HCl and CH_3OH are decreasing at the same rate, either of these may be second order. The possibilities are:

- rate = $k[\text{CH}_3\text{OH}][\text{HCl}]$
- rate = $k[\text{CH}_3\text{OH}]^2$
- rate = $k[\text{HCl}]^2$

Further experiments would have to be carried out to confirm one or other of these possibilities. The only thing we can be sure of is that the reaction is second order overall.

Definitions that are required by the syllabus are shown in highlight boxes.

Oxidation Is Loss of electrons.
 Reduction Is Gain of electrons.
 The initial letters shown in bold spell OIL RIG. This may help you to remember these two definitions!

Key words are highlighted in the text when they are first introduced.

hydrolyse a protein and try to identify the amino acid residues present. This is when **two-way chromatography** is useful. In this technique, paper chromatography is carried out as normal but then the chromatogram produced is rotated by 90° and re-run in a different solvent. It is unlikely that the R_f values will coincide in two different solvents, so separation takes place (Figure 29.4).

You will also find definitions of these words in the Glossary.

two-way chromatography a technique used in paper or thin-layer chromatography in which one spot of a mixture is placed at the corner of a square sheet and is developed in the first solvent as usual. The sheet is then turned through 90° and developed in the second solvent, giving a better separation of components having similar R_f values.

There is a summary of key points at the end of each chapter. You might find this helpful when you are revising.

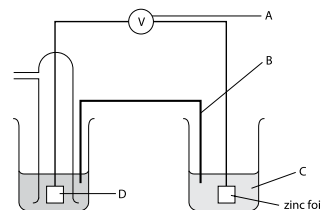
Summary

- Each of the transition elements forms at least one ion with a partially filled d orbital. They are metals with similar physical and chemical properties.
- When a transition element is oxidised, it loses electrons from the 4s subshell first and then the 3d subshell to form a positively charged ion.
- Transition elements can exist in several oxidation states.
- Some transition element complexes exist as geometrical (*cis-trans*) isomers, e.g. *cis-* and *trans-platin*; others, especially those associated with bidentate ligands with co-ordination number 6, may exist as optical isomers.
- *cis-platin* can be used as an anti-cancer drug by binding to DNA in cancer cells and preventing cell division.

Questions at the end of each chapter are more demanding exam-style questions, some of which may require use of knowledge from previous chapters. Answers to these questions can be found on the CD-ROM.

End-of-chapter questions

1 The diagram shows an electrochemical cell designed to find the standard electrode potential for zinc.



- a Name the apparatus labelled A and give a characteristic it should have. [2]
- b i Name part B and give its two functions. [3]
 ii Describe how part B can be prepared. [2]
- c What is C? [2]
- d Name part D and give its two functions. [3]
- e Give the three standard conditions for the measurement of a standard electrode potential. [3]

Total = 15