Cambridge Assessment International Education

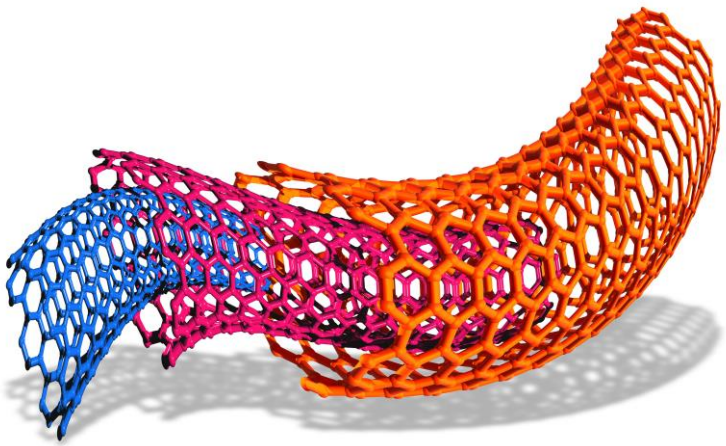
Teaching Pack

The reversible reaction between two cobalt species

Cambridge IGCSE™

Chemistry 0620

This *Teaching Pack* can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge IGCSE™ Chemistry (US) **0439**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge IGCSE™ Co-ordinated Sciences (Double Award) **0654**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**



Version 2.0

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

Lab option 1: *Run the experiment*

Lab option 2: *Virtual experiment*

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note

Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1: run the experiment	**Option 2: virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases this also includes the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: The reversible reaction between two cobalt species

This *Teaching Pack* focuses on a reversible reaction.

Many reactions are reversible – there is a forward and a backward reaction. This can often be demonstrated by a change in colour during the experiment. This experiment shows the colour changes between two cobalt series.

The syllabus reference for this experiment is:

- 6.3 Reversible reactions

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations**:

- plan experiments and investigations
- demonstrate knowledge of how to safely use techniques, apparatus and materials
- make and record observations.

Prior knowledge

Knowledge from the following syllabus topics is required for this experiment.

- 6.1 Physical and chemical changes

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about reactants, products, conditions of reactions and rates of reactions.

Briefing lesson: Making observations and planning

Resources	• Worksheets A, B, C and D
Learning objectives	By the end of the lesson: • ***all*** learners should be able to Identify equipment used for an experiment • ***most*** learners should apply complete a simple risk assessment • ***some*** learners will be able to identify any hazards involved with the reagents being used.

Timings	Activity
15 min	**Starter/Introduction** **Loop game** (in pairs) Print out Worksheet A and cut out the individual cards containing a question and an answer (these could be laminated). 1. Give out the cards to each pair. 2. **Learner 1** starts the game by picking up the **START** card and asking the question on it. 3. **Learner 2** then finds the correct answer. 4. When **Learner 2** has found the correct answer, they should ask the next question on that card to **Learner 1**. 5. Learners should place their cards in the order they answer them. 6. The game continues until the learners get to the **FINISH** card.
30 min	**Main lesson** Divide learners into groups of four and ask them the following question: *How would you plan an experiment to investigate a definitive test for water?* Discuss with learners that in the next lesson you will demonstrate a test for water using cobalt(II) chloride. In their group, ask the learners to identify two aims for the experiment. They should record this on Worksheet B. Also ask learners to identify any dependent or independent variables associated with their experiment. Give learners Worksheet D for support in planning their experiment. **Note:** it is important not to correct their plans at this stage as they will be assessing them in the debriefing lesson.
15 min	**Plenary** Now that your learners have identified the aims and variables for their experiment, give them Worksheet C. Ask them to think about the equipment needed for the demonstration with cobalt(II) chloride and get them to draw a diagram of what is needed.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • *Teacher Walkthrough video* • Equipment as outlined in the notes • Worksheets C and E
Learning objectives	By the end of the lesson: • ***all*** learners should understand what a reversible reaction is • ***most*** learners should be able to identify the changes in the reversible reaction of two cobalt species • ***some*** learners will be able to relate the changes to change in temperature.

Timings	Activity
10 min	**Starter/Introduction** **Safety** Before learners watch the teacher demonstration, ensure that they are all wearing fastened lab coats. They should also wear goggles and sit at a safe distance from the demonstration table. Ask learners to review their equipment from Worksheet C with the demonstration set-up. Are there any differences? Then ask the following questions as a warm up: • Can you predict what might happen when the cobalt(II) chloride is heated? • What might happen if more water is added? • What might happen if the temperature changes?
30 min	**Main lesson** **Safety** This experiment should be performed as a demonstration. All learners should wear eye protection. Protective gloves should be worn to carry out the experiment and by any learners wishing to touch the finished product. Give learners Worksheet E, which they should complete during the demonstration. Demonstrate the reversible reaction of cobalt(II) chloride with water following the teacher method provided. Point out along the way: • the colour change from pink to blue on heating • the reversible nature of the reaction on the addition of water • that the hydration reaction is exothermic (observed by the rise in temperature) and that the dehydration reaction is therefore endothermic • good lab practice. **Safety** Take care when handling cobalt(II) chloride. Wear protective gloves and use only a small amount.
10 min	After the demonstration, review with learners the process of equilibrium and how cobalt(II) chloride can be used as a definitive test for water. *Continues on next page …*

Timings	Activity
	**Plenary** Show learners this generic equation: REACTANTS ⇌ PRODUCTS (left) (right) Ask learners, in groups, to discuss the following question: *What effect does temperature have on the direction of the reaction?* Share with abler learners the equation for the reaction in the demonstration, then ask them the same question – can they relate their answer in terms of what would happen to the cobalt(II) chloride? (Note that learners do not need to memorise this equation.) $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6H_2O(l)$

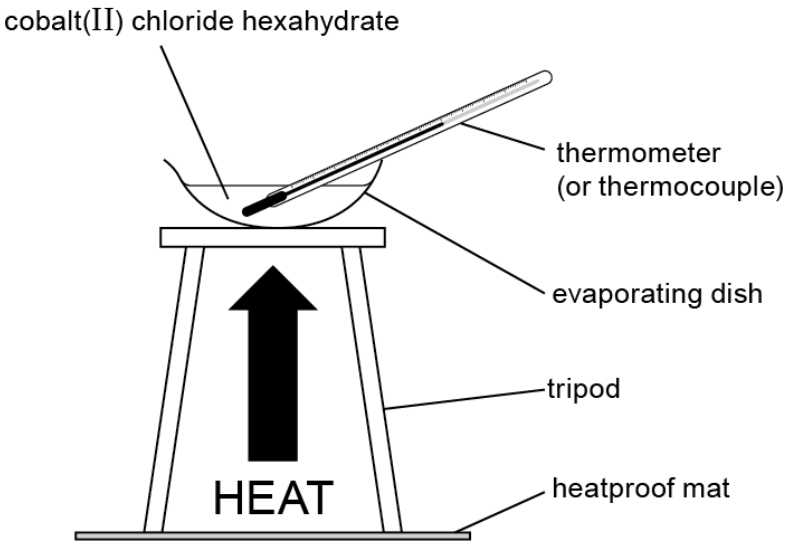
Teacher notes

Watch the *Teacher walkthrough* video for the cobalt chloride equilibrium and read these notes.

For the teacher demonstration, you will need:

- cobalt(II) chloride hexahydrate
- gauze
- a desiccator
- a thermometer or thermocouple
- a stop clock
- a Bunsen burner
- a pair of tongs
- a tripod
- an evaporating dish
- a test-tube of distilled water.

Experimental set-up



Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Cobalt(II) chloride hexahydrate (solid)	 GHS08 (*health hazard* **HH**)  GHS07 (*moderate hazard* **MH**)  GHS09 (*hazardous to the aquatic environment* **N**)	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water for 5 min. **Spilt on the floor, bench, etc.:** Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.
	Burns	Flood burnt area with water for at least 10 min. For serious injuries see a doctor.

Teacher method

This is your version of the method for this experiment.

As this is a demonstration there is no learner method.

Before you begin
Plan how you are going to carry out the demonstration.

Think about:

- the layout required so that learners can see the demonstration
- the amount of equipment/chemicals required
- the waste protocol for the lab
- the appropriate risk assessments and ensure they have been carried out.

Steps	Notes
1. Add the cobalt(II) chloride to the evaporating dish.	*Use a spatula and wear protective gloves. An alternative method would be to use a boiling tube to heat the cobalt(II) chloride if no evaporating dish is available.*
2. Place the evaporating dish on the gauze and heat gently.	
3. Get groups of learners to come up towards the demonstration to observe what is going on in the evaporating dish.	
4. Stop heating and allow the evaporating dish to cool. At this point show learners the end result in the dish.	*Ask learners what they observe at this point. They should note that there has been a colour change from pink to blue.*
5. Place the dish in a desiccator to avoid water being absorbed from the atmosphere for around 5 min.	*You might need to explain to learners that the cobalt chloride will start to immediately change colour as it cools, since it absorbs water from the atmosphere.*
6. Now cooled add a thermometer (or thermocouple) to the dish and ask learners to record the temperature.	
7. Add the distilled water from the test-tube to the dish. Ask a group of learners to observe what happens in the dish and to the temperature by watching the thermometer.	*Learners should note that as water is added the temperature rises. They should be able to deduce that this means the hydration reaction is exothermic and the dehydration reaction is endothermic.*

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual experiment video* for cobalt chloride equilibrium • Worksheets E and F
Learning objectives	By the end of the lesson: • ***all*** learners should understand what a reversible reaction is • ***most*** learners should be able to identify the changes in the reversible reaction of two cobalt species • ***some*** learners will be able to relate the changes to change in temperature, and/or concentration.

Timings	Activity
15 min	**Starter/Introduction** Ask learners to review their equipment with the demonstration set-up. Are there any differences? Then ask the following questions as a warm up: • Can you predict what might happen when the cobalt(II) chloride is heated? • What might happen if more water is added? • What might happen if the temperature changes? • What safety measures might need to be taken?
35 min	**Main lesson** Give learners Worksheet E and show them the video for the cobalt(II) chloride reaction. Learners need to fill in Worksheet E as the video plays. There will also be additional questions for the learners to answer on screen. These will stop the video automatically. Note: you may need to play the video more than once so that all learners can fill in their worksheets. After playing the video, discuss with the class any safety issues they noticed during the video, what the risk was and how it was dealt with. They should record this on Worksheet F.
10 min	**Plenary** Show learners this generic equation: REACTANTS ⇌ PRODUCTS (left) (right) Ask learners, in groups, to discuss the following question: *What effect does temperature have on the direction of the reaction?* Share with abler learners the equation for the reaction in the demonstration, then ask them the same question – can they relate their answer in terms of what would happen to the cobalt(II) chloride? (Note learners do not need to memorise this equation.) $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6H_2O(l)$

Debriefing lesson: Assessing plans

Resources	• Worksheets G and H • Sticky notes
Learning objectives	By the end of the lesson: • ***all*** learners should have a clear plan and write-up of the experiment • ***most*** learners should be able to evaluate their own plans for the experiment • ***some*** learners will be able to relate that feedback to their own plan.

Timings	Activity
10 min	**Starter/Introduction** In groups, ask the learners to discuss the characteristics of a good scientific plan. Get them to write out the suggestions and stick these onto one side of the classroom board using sticky notes. These will be used as a focal point of a classroom discussion later on in the lesson. They are likely to suggest things like: clear aims / hypothesis; flexible; concise language; uses technical language clearly; accompanied by a clear experiment diagram, etc.
20 min 20 min	**Main lesson** Ask learners to write-up the experiment using Worksheet G. (**Note:** there are two versions of this worksheet available for you to use with learners.) They should include an experimental diagram (fully labelled) and a method. The method should contain enough detail for someone else to do the demonstration. Remind learners that they should include any safety issues in their report. Next, hand out Worksheet H, and ask the learners to assess their plan from the briefing lesson. What improvements would they make based on what they have learned about planning an experiment?
10 min	**Plenary** Lead a discussion around the sticky notes placed on the board. Is there anything missing? Group the notes into common themes and ideas and come up with a checklist for what makes a good plan that learners could use as revision.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson*:		
A: Reversible reactions loop game	**15**	**27**
B: Aims and hypothesis	**16–17**	**—**
C: Choosing the correct equipment	**18–19**	**—**
D: Planning an experiment	**20**	**—**
For use in *Lab lesson: Option 1*:		
E: Observations	**21–22**	**28**
For use in *Lab lesson: Option 2*:		
E: Observations	**21–22**	**28**
F: Risk assessment	**23**	**—**
For use in the *Debriefing lesson*:		
G: Writing a method	**24–25**	**—**
H: Assessing your plan	**26**	**—**

Worksheet A: Reversible reactions loop game

START	⇌	*temperature*	*high temperature, high pressure*
What is the correct symbol for an equilibrium reaction?	Pressure, concentration and ……. affect the equilibrium.	In the Haber process, which conditions favour a high yield of ammonia at equilibrium?	The forward reaction in the Haber process is exothermic. What does this tell you about the reverse reaction?
it is endothermic	*increases until it is going at the same rate as the forward reaction*	*that a reaction can go forwards and backwards*	*no effect*
At equilibrium, how does the rate of the forward reaction compare to the rate of the backward reaction?	What does reversible reaction mean?	What effect does a catalyst have on the equilibrium?	Nitrogen + ……..… ⇌ ammonia
hydrogen	*closed system*	*it is equal*	*sulfur*
A stable equilibrium can be achieved in a ……?	At equilibrium, if the rate of the forward reaction increases the rate of the reverse reaction……..……..…?	Which element is a common material for the contact process?	Hydrogen can be manufactured from methane by which process?
steam reforming			
FINISH			

Worksheet B: Aims and hypothesis

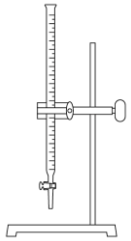
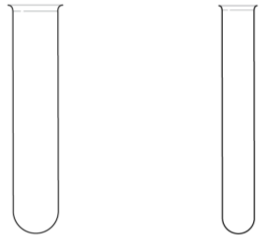
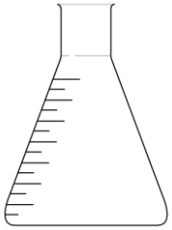
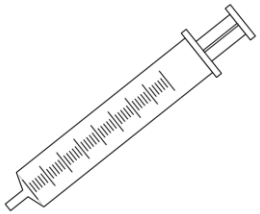
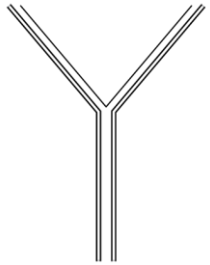
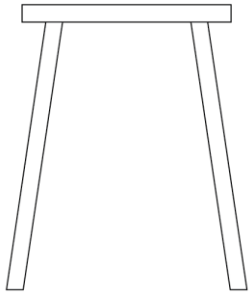
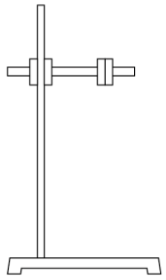
Title	…….
Background information	…… …… ……
Aims	**Aim 1:** …… …… **Aim 2:** …… ……

Worksheet B: Aims and hypothesis

Experimental variables	**Changed (independent) variables** …… …… **Measured (dependent) variables** …… …… **Fixed variables** …… ……
What will happen? (hypothesis)	…… ……

Worksheet C: Choosing the correct equipment

Here is a range of some common lab equipment.

			
burette	**evaporating dish**	**a heat source**	**boiling-tube and test-tube**
			
conical flask	**syringe**	**measuring cylinder**	**filter funnel**
			
tripod	**thermometer**	**boss, clamp and stand**	**pipette**

Worksheet C: Choosing the correct equipment

Use the space provided, and the list of equipment given, draw the demonstration set-up for investigating the reversible reaction of cobalt(II) chloride.

You should refer back to your plan as your experiment aims may affect your equipment choices.

Worksheet D: Planning an experiment

Use the suggestions below to help you decide how you could use the equipment you have been shown to demonstrate the reversible reaction of cobalt(II) chloride.

Depending on how confident you feel about planning your method, choose the column you feel gives you the right level of support.

Low-level support	Mid-level support	High-level support
How could we store the anhydrous cobalt(II) chloride? Why should we do this?	How could you limit the contact the dry cobalt(II) chloride would have with moisture with the atmosphere using a desiccator?	If you use a desiccator for storing the dry cobalt(II) chloride after it has been heated this will preserve it (so minimal colour change from blue to pink). Desiccators are used for preserving moisture sensitive materials.
Is there a better way of recording the temperature when adding water to the crucible? What would the benefits be?	What benefits would a thermocouple bring to this experiment?	A thermocouple, with a digital display, would be easier to read for recording the increase in temperature for the exothermic reaction.
Is there a better way of doing this reaction to what is shown in the video?	How could a test-tube be used in order to provide an easier method for this experiment?	An easier method would be to use a test-tube with a small amount of cobalt(II) chloride.

Worksheet E: Observations

While observing the cobalt(II) chloride demonstration, answer the following questions.

1. What colour is the hydrated cobalt(II) chloride?

……

2. What do you observe during the heating of cobalt(II) chloride?

……

……

……

……

3. What do you observe when the water is added to the anhydrous cobalt(II) chloride?

……

……

……

……

4. Is the addition of water to the cobalt(II) chloride an exothermic or endothermic reaction? Give your reasoning.

……

……

……

……

Worksheet E: Observations

5. What can you deduce about the dehydration reaction?

……

……

6. Looking at the reactions together, explain why this is a reversible reaction?

……

……

……

……

7. Write a short observation summary for the experiment, discussing the direction of the colour changes and if the reaction is exothermic or endothermic.

……

……

……

……

8. Draw the equilibrium symbol in the box provided.

Worksheet F: Risk assessment

A risk assessment should be written for all experiments where there are hazards.

Hazards can be the equipment or the chemicals being used.

Complete the table after watching the video for the cobalt(II) chloride experiment.

An example has been provided.

	Risk	How to reduce risk?	What to do if risk occurs?	How likely is this to happen?
Using glassware	Breaking glass may cut hands.	Ensure all glass is handled carefully.	Clean up glass, wash any cuts thoroughly, clean and dress.	Unlikely

Worksheet G: Writing a method

Use the space below to write your method.

An investigation to study the reversible reaction of cobalt(II) chloride

Equipment	Method
…… …… …… …… …… …… …… …… …… …… …… …… ……	…… …… …… …… …… …… …… …… …… …… …… …… ……

Don't forget to consider safety precautions

Worksheet G: Writing a method with support

Use the space below to write your method.

An investigation to study the reversible reaction of cobalt(II) chloride

Equipment	Method
…… …… …… …… …… …… …… …… …… …… …… …… …… ……	Think about these questions: **1.** What will you do with the equipment and the chemicals? **2.** How will you stop the dry cobalt(II) chloride from reacting with water in the air? Why? **3.** How will you tell which reaction is exothermic and which is endothermic? Why? **4.** What safety precautions are needed in your method? …… …… …… …… …… …… …… …… …… ……

Worksheet H: Assessing your plan

Report section	Success criteria	✓ or ×	Comments
Title	Does the report contain a simple and informative title?		
Background	Is there a brief explanation of a theory or concept linked to the experiment?		
Aim(s)	Does this section say what will be investigated?		
Variables	Does the report state what variables were changed, what variables were measured and what were fixed?		
Hypothesis	Does the report contain a clear hypothesis? For example, 'vitamin C in orange juice oxidises over time when exposed to the air'.		

Worksheet A: Answers

START	⇌	temperature	high temperature, high pressure
What is the correct symbol for an equilibrium reaction?	Pressure, concentration and ……. affect the equilibrium.	In the Haber process, which conditions favour a high yield of ammonia at equilibrium?	The forward reaction in the Haber process is exothermic. What does this tell you about the reverse reaction?
it is endothermic	increases until it is going at the same rate as the forward reaction	that a reaction can go forwards and backwards	no effect
At equilibrium, how does the rate of the forward reaction compare to the rate of the backward reaction?	What does reversible reaction mean?	What effect does a catalyst have on the equilibrium?	Nitrogen + ……..… ⇌ ammonia
hydrogen	closed system	it is equal	sulfur
A stable equilibrium can be achieved in a ……?	At equilibrium, if the rate of the forward reaction increases the rate of the reverse reaction……..……..…?	Which element is a common material for the contact process?	Hydrogen can be manufactured from methane by which process?
steam reforming			
FINISH			

Worksheet E: Answers

1. red/pink

2. The colour changes from red/pink to purple/blue.
   The solid appears wet before drying.

3. The colour changes from purple/blue to red/pink.
   There is a temperature change – the temperature rises.

4. The reaction is exothermic as the temperature rises and heat is released.

5. It is an endothermic reaction as it is the opposite reaction.

6. The experiment can go forwards (on heating) or backwards on the addition of water.

7. The forward reaction is endothermic. It requires heat and the colour changes from pink to blue.
   The backward reaction is exothermic. It gives out heat and the colour changes from blue to pink.

8. $\rightleftharpoons$

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