

Appendix 2

12. The effect of altering the concentration on an equilibrium reaction – Student Sheet

Your teacher has introduced you to Le Chatelier's Principle. You are now going to use this principle to predict the effect of changing the concentrations of the reactants on the equilibrium position.

Background information

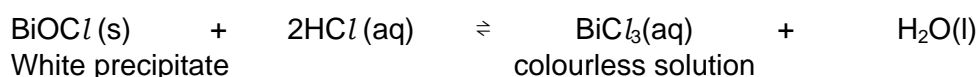
Le Chatelier's Principle applies to systems in dynamic equilibrium. One way of stating this is:

The position of the equilibrium of a system changes to minimise the effect of any imposed change in conditions.

Question

- 1 What conditions, other than concentration, could affect the position of equilibrium?

Your teacher is going to demonstrate the effects of changing the concentration of substances in this dynamic equilibrium mixture:



Question

- 2 Explain what is meant by the terms 'reversible reaction' and 'dynamic equilibrium'.

Your teacher will prepare a solution of bismuth trichloride from bismuth oxide chloride.

Question

- 3 How might your teacher prepare bismuth trichloride?

Your teacher will add water to the above equilibrium mixture.

Questions

- 4 (a) Predict what you will observe when water is added.
(b) Use Le Chatelier's Principle to explain your prediction.

Following the addition of water, your teacher will add concentrated hydrochloric acid to the equilibrium mixture.

Questions

- 5 What safety precautions should your teacher adopt?
6 (a) Predict what you will observe when concentrated hydrochloric acid is added.
(b) Use Le Chatelier's Principle to explain your prediction.

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12. Introducing equilibria through two demonstrations – Teachers' Notes

This is an effective way of introducing the syllabus section on equilibria. It shows a reversible reaction and allows a dynamic equilibrium to be reached. The system at equilibrium is then subjected to changes in concentration and temperature, thus demonstrating Le Chatelier's Principle. The Student Sheet is intended to accompany the second demonstration.

Learning outcomes

By the end of this lesson students should:

- understand what is meant by a reversible reaction and a dynamic equilibrium;
- have been introduced to Le Chatelier's Principle;
- have observed the effects of changes of concentration and pressure on the equilibrium position.

A suggested approach

Begin the lesson with Demonstration 1. Use this to cover the intended learning outcomes. With discussion of the underlying theory, this could easily take 25 minutes. Now give out the Student Sheet, 'The effect of altering the concentration on an equilibrium reaction', and ask students to use it to predict what will happen in Demonstration 2. Test their predictions by doing the second demonstration.

Demonstration 1: The equilibrium between $\text{Co}(\text{H}_2\text{O})_6^{2+}(\text{aq})$ and $\text{CoCl}_4^{2-}(\text{aq})$

Theory

The equilibrium is:





This experiment allows you to demonstrate the effect of concentration and temperature on the equilibrium position of this reaction. The changes seen are in accordance with Le Chatelier's Principle.

Technical information

Six boiling tubes and a rack
 100 cm³ measuring cylinder
 Three 250 cm³ beakers
 Two dropping pipettes
 Access to a balance
 4 g cobalt chloride-6-water ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$)
 100 cm³ of concentrated hydrochloric acid
 200 cm³ of crushed ice

Safety

	You must wear eye protection throughout this experiment.
	Hydrochloric acid is corrosive . (It has a highly exothermic reaction with water, so always add the concentrated acid to the aqueous solution, never do it the other way round).

It is the teacher's responsibility to ensure that a full risk assessment is carried out prior to the demonstration.

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Procedure

Before the demonstration. Boil a beaker of water and prepare a beaker of crushed ice and water. Dissolve about 4 g cobalt(II) chloride-6-water in 40 cm³ of water. A pink solution containing $\text{Co}(\text{H}_2\text{O})_6^{2+}$ will be formed.

The demonstration. Take the pink cobalt chloride solution and make it up to 100 cm³ with concentrated hydrochloric acid using a measuring cylinder. A violet solution will be formed. Adding more hydrochloric acid will produce a blue solution containing more CoCl₄²⁻(aq), while adding water will restore the pink colour. By trial and error, produce the 'in between' violet coloured solution containing both cobalt ions. Place 2 cm depth in each of the six boiling tubes. Place these on the bench in groups of three.

1 Effect of concentration

Keep one boiling tube as a control. Use a dropping pipette to add water to a second tube and concentrated hydrochloric acid to a third. Following an explanation of why this demonstrates Le Chatelier's Principle, you can reverse the changes.

2 Effect of temperature

Keep one boiling tube as a control. Place a second tube in hot water (over 90°C). It will go blue because this is an endothermic reaction in the forward direction. Then put the third tube in the ice/water beaker and this will change to pink. Again, this shows Le Chatelier's Principle well and you can reverse the changes.

Demonstration 2: The equilibrium between bismuth oxide chloride and bismuth trichloride

Theory

The equilibrium is:





This experiment allows you to demonstrate the effect of concentration on the equilibrium position of this reaction. The changes seen are in accordance with Le Chatelier's Principle.

Technical information

Boiling tube and rack
100 cm³ beaker
250 cm³ beaker
Dropping pipette
Stirring rod
2.6 g bismuth oxide chloride
Concentrated hydrochloric acid

Safety

	<p>Wear eye protection.</p>
	<p>Hydrochloric acid is corrosive. (It has a highly exothermic reaction with water, so always add the concentrated acid to the aqueous solution, never do it the other way round).</p>

Procedure

Dissolve a little bismuth oxide chloride (approximately 2.6 g) into 3 cm³ concentrated hydrochloric acid in a test tube. This gives a colourless solution of bismuth trichloride. Pour

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this slowly into another boiling tube containing about 12 cm³ water. (Never do this the other way round!) A white precipitate of bismuth oxide chloride immediately appears. Transfer the mixture into a 100 cm³ beaker and add another 2 cm³ of concentrated hydrochloric acid and stir. The precipitate re-dissolves. Now add 25 cm³ of water and the precipitate re-appears. Adding 3 cm³ of concentrated hydrochloric acid will again shift the equilibrium to the colourless side. You can continue doing this by transferring the mixture to a 250 cm³ beaker.

Answers to questions on the Student Sheet

- 1 Temperature and pressure.
- 2 Reversible reactions take place in either direction.
Dynamic equilibrium is one where the rate of the forward reaction is equal to the rate of the reverse reaction.
- 3 By adding hydrochloric acid to bismuth oxide chloride.
- 4 (a) A white precipitate will form.
(b) Water appears on the right-hand side of the equilibrium equation. Adding more water is an imposed change of condition. By Le Chatelier's Principle, the equilibrium will shift to the left to minimise the effect of the added water.
- 5 Expect 'Wear safety goggles'. You might wish to point out that the risk to the eyes really started at the beginning of the demonstration. You should also add that concentrated acids often have a highly exothermic reaction if water (or a dilute solution) is added to them. Concentrated acids should always be added slowly to the water and never the other way around.
- 6 (a) The white precipitate dissolves to leave a colourless solution.
(b) Hydrochloric acid appears on the left-hand side of the equilibrium equation. The changed condition that is imposed is that the concentration of hydrochloric acid increases in the equilibrium mixture. This imposed condition is minimised by the equilibrium shifting to the right-hand side.