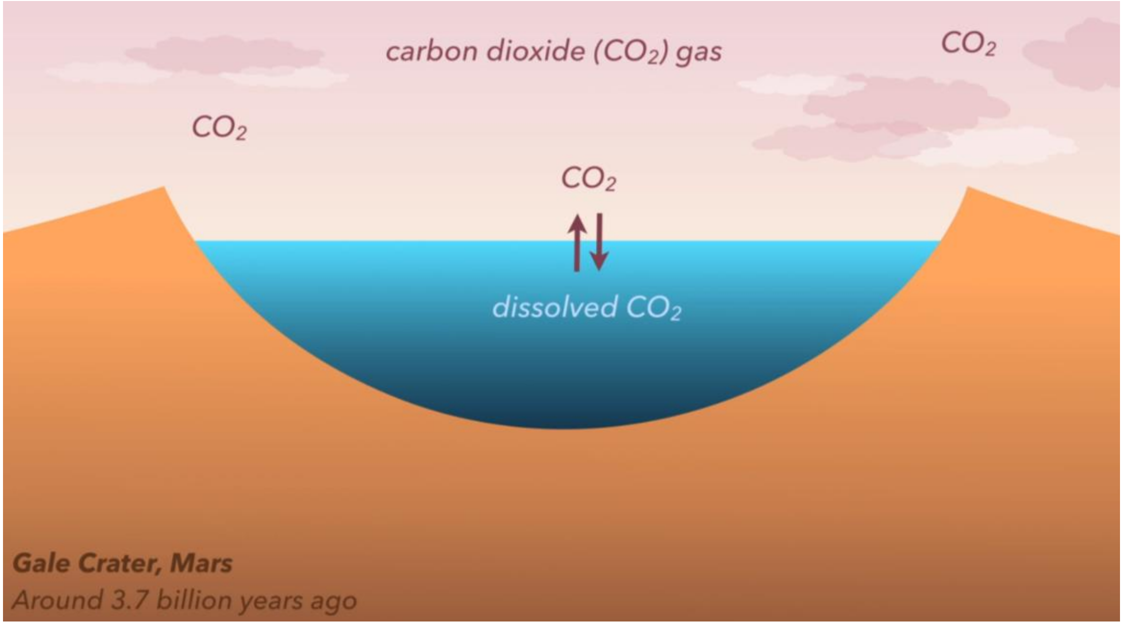
Key Stage 5 – Equilibrium on Mars

Notes for teachers

At a glance

Chemists at the University of Oxford's Department of Earth Sciences are researching what may have happened in the lakes on the surface of Mars 3.7 billion years ago. They are hoping that by recreating miniature lakes in the lab they can piece together the puzzle of Mars' watery past.

In this activity students carry out an investigation using Le Châtelier's principle before applying this to explaining how changes in atmospheric conditions on early Mars would have affected the equilibrium of reactions happening in the lakes on its surface.



Learning Outcomes

- Students apply their knowledge of reversible reactions and Le Châtelier's principle.
- Students use Le Châtelier's principle to predict what will happen in a reversible reaction at equilibrium when concentration and temperature are changed.

Each student will need

- Copy of student worksheet pages 1-2

The class will need access to

- eye protection and gloves
- hexaaquacobalt(II) ion solution (CORROSIVE/TOXIC)
- concentrated hydrochloric acid (CORROSIVE)
- boiling tubes and racks
- teat pipettes

Possible Lesson Activities

1. Starter activity

- Ask the class: 'why do you think scientists want to explore Mars?'. You can show them a short clip about Mars Rover Spirit (see web links).
- Discuss that one reason is the search for life, or evidence that there was once life and the 2020 new NASA rover mission to the Martian surface with one of its objectives to search for evidence of ancient life on the planet.
- Tell them that scientists across the world are researching what Mars might have been like billions of years ago. Introduce the research of Lucy Kissick, a PhD student at The University of Oxford by showing the class the Oxford Sparks clip 'Using your science to explore the climate history of Mars' (see web links).

2. Main activity: Investigating Le Châtelier's principle

- Give each student a copy of page 1 of the student worksheet and ask them to read through it. This outlines Lucy's research, as well as informing the students about the reversible reactions involved in the chemistry of the Martian lakes.
- If needed, remind students about Le Châtelier's principle using an example they have already learnt about.
- Ask the class to work in pairs. Give each pair a copy of one half of page 2 of the student worksheet and access to the practical equipment. They follow the instructions to investigate Le Châtelier's principle using the reaction between hexaaquacobalt(II) ions when in excess of chloride ions.
- Students should then carry out tasks 2 and 3 on page 1 of the student worksheet. When discussing the answer to question 2, discuss how they could prove that it is the chloride ions, not the hydrogen ions, which result in the colour change (add a chloride salt solution rather than hydrochloric acid).
  Answers:
  2. If you add water to the hexaaquacobalt(II) ion solution it will stay pink. This is because the position of equilibrium will move so that the concentration of water decreases again - by reacting it with cobalt tetrachloride ions ($CoCl_4^{2-}$(aq)) so more pink hexaaquacobalt(II) ions are formed. The position of equilibrium moves to the left. Adding hydrochloric acid will result in a colour change – the solution will turn blue. This is because by adding chloride ions the position of the equilibrium will move to the right in order to remove the chloride ions so more blue cobalt chloride ions are formed.
  3. Place one test tube of hexaaquacobalt(II) ion solution into a hot water bath and one into an ice bath. Raising the temperature will favour the reaction in the endothermic direction. So, if the solution turns blue when heated it shows that the forward reaction is endothermic (positive enthalpy change). If it goes blue when cooled the forward reaction is exothermic (negative enthalpy change).

3. **Main activity: Applying this to Mars lakes**
   - Ask students to complete questions 3-4 on page 2 of the student worksheet. At this point you may want to replay the section of the Oxford Sparks clip that shows the chemical reactions involved.

     Answers:
     3. As the concentration of carbon dioxide in the atmosphere increased there would be more new minerals formed. If the concentration of carbon dioxide in the atmosphere increased, according to Le Châtelier's principle the equilibrium system will act to oppose the change, so more carbon dioxide would dissolve into the lake water to form carbonic acid. The higher the concentration of carbonic acid in the water, the higher the concentration of hydrogen ions, so the lower the pH. The lower the pH, the more iron will dissolve from the lake walls to form new carbonate minerals.
     4. An increase in temperature would decrease the amount of carbonate minerals formed. The solubility of carbon dioxide decreases with temperature, so the higher the temperature, the less carbon dioxide would dissolve and react with water to form carbonic acid.

4. **Plenary**
   - Explain that carbonate-rich rocks have been found on Mars but not as many as scientists predict, if the theory about it having a carbon dioxide rich atmosphere in the past is correct. One part of Lucy's research is finding out possible reasons for this. For your information, more information based similar research can be found in the web links.

5. **Suggested homework**
   You may wish to use this as an opportunity to set further questions based on examples of Le Châtelier's principle based on other reactions.

Web links

Oxford Sparks Clip: 'Using your science to explore the climate history of Mars':

https://www.oxfordsparks.ox.ac.uk/content/using-your-science-explore-climate-history-mars

Mars Rover Spirit

https://www.youtube.com/watch?v=SwxVgCGmOjQOxford Sparks video:

Article about carbonate-rich rocks on Mars

https://www.planetary.org/blogs/emily-lakdawalla/2010/2540.html

Safety disclaimer: The practical work suggestions given here have not been tested by us for safety. While the suggested practical work is based on existing laboratory experiments, you should always carry out your own risk assessment, especially before using or making a hazardous procedure, chemical or material. All practical work should be supervised by a qualified science teacher with suitable knowledge of the equipment used and carried out in a properly equipped and maintained laboratory. For more information, refer to www.cleapss.org.uk/.