

Key concept (age 14-16)

CCR8.1: Dynamic equilibrium

Progression toolkit: Dynamic equilibrium

Learning focus	At dynamic equilibrium the rate of the forwards reaction is equal to the rate of the reverse reaction meaning that the reaction mixture contains both reactants and products.				
As students' conceptual understanding progresses they can:					
Diagnostic questions	Reacting magnesium	Ammonium chloride	Sealed container	Constant colour	Manufacturing ammonia
Response activities	Excess reactant	Petri dish reaction	Molecule explanation	Molecule representations	
				Escalator analogy	

<h3>Reacting the magnesium</h3> <p>BEST STUDENT WORKSHEET</p> <p>Reacting magnesium</p> <p>A student adds a small piece of magnesium to a beaker containing dilute hydrochloric acid.</p> <p>Magnesium reacts with hydrochloric acid to form magnesium chloride solution and hydrogen gas.</p> <p>The chemical equation for the reaction is: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$</p> <p>The student observes the reaction until it finishes.</p> <p>Which substances are in the beaker at the end of the reaction? For each statement, tick (✓) any substance that you think is present.</p> <table border="1"> <thead> <tr> <th></th> <th>1. gas above the liquid</th> <th>2. clear liquid</th> <th>3. dark brown solid</th> <th>4. white solid</th> <th>5. grey solid</th> <th>6. white solid</th> </tr> </thead> <tbody> <tr> <td>A. magnesium chloride solution and hydrogen</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B. magnesium chloride solution</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C. magnesium chloride solution and hydrochloric acid</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>D. magnesium chloride solution, hydrochloric acid and magnesium</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>		1. gas above the liquid	2. clear liquid	3. dark brown solid	4. white solid	5. grey solid	6. white solid	A. magnesium chloride solution and hydrogen							B. magnesium chloride solution							C. magnesium chloride solution and hydrochloric acid							D. magnesium chloride solution, hydrochloric acid and magnesium							<h3>Ammonium chloride</h3> <p>BEST STUDENT WORKSHEET</p> <p>Ammonium chloride</p> <p>Some students discuss whether the reverse reaction is possible. Can ammonia and hydrogen chloride react to form ammonium chloride? Who do you agree with and why?</p> <p>Adelle: Yes. The ammonia and hydrogen chloride could react to make ammonium chloride.</p> <p>Maya: No. A chemical change is irreversible.</p> <p>Shweta: No. I can't tell without knowing more about ammonia, hydrogen chloride and ammonium chloride.</p> <p>Laila: No. Ammonium chloride is the reactant. It cannot become the product.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<h3>Sealed container</h3> <p>BEST STUDENT WORKSHEET</p> <p>Sealed container</p> <p>Nitrogen dioxide (NO₂) gas is dark brown.</p> <p>Dinitrogen tetroxide (N₂O₄) gas is colourless.</p> <p>A mixture of nitrogen dioxide and dinitrogen tetroxide is light brown.</p> <p>The equation for the reversible reaction between the two gases is shown below: $2NO_2 \rightleftharpoons N_2O_4$</p> <p>The reversible reaction takes place inside a sealed glass container.</p> <p>Select the diagram that best shows the colour or colours that will be observed.</p> <p>The colour changes from dark brown to colourless.</p> <p>The colour changes slightly from dark brown to colourless.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<h3>Constant colour</h3> <p>BEST STUDENT WORKSHEET</p> <p>Constant colour</p> <p>Nitrogen dioxide (NO₂) gas is dark brown.</p> <p>Dinitrogen tetroxide (N₂O₄) gas is colourless.</p> <p>A mixture of nitrogen dioxide and dinitrogen tetroxide is light brown.</p> <p>The reversible reaction between the two gases takes place inside a sealed glass container.</p> <p>The reaction reaches dynamic equilibrium. $2NO_2 \rightleftharpoons N_2O_4$</p> <p>The colour observed is light brown.</p> <p>Explain why the light brown colour does not change.</p> <p>For each statement, tick (✓) any gas capable of showing colour (see table).</p> <table border="1"> <thead> <tr> <th></th> <th>1. gas above the liquid</th> <th>2. clear liquid</th> <th>3. dark brown solid</th> <th>4. white solid</th> <th>5. grey solid</th> <th>6. white solid</th> </tr> </thead> <tbody> <tr> <td>A. 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Individual molecules are not changing.							<h3>Manufacturing ammonia</h3> <p>BEST STUDENT WORKSHEET</p> <p>Manufacturing ammonia</p> <p>In industry, ammonia gas is made by the reaction of nitrogen and hydrogen.</p> <p>The reaction is an equilibrium reaction. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$</p> <p>The maximum yield of ammonia that can be produced is equal to the quantity of ammonia would be obtained if all the nitrogen and hydrogen had converted into ammonia.</p> <p>What percentage of this maximum yield is actually achieved during ammonia manufacture? Put a tick (✓) in the box next to the best answer.</p> <p>A. 100% The nitrogen and hydrogen is all converted into ammonia. B. 100% Some of ammonia breaks apart and reforms nitrogen and hydrogen. C. 5% At equilibrium the amount of reactants and products is equal. D. 0% At the ammonium chloride breaks apart and reforms nitrogen and hydrogen.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>
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<p>BEST STUDENT WORKSHEET</p> <p>Excess reactant</p> <p>Some students add twenty spatulas of copper carbonate powder to a beaker containing dilute sulfuric acid. The students note any products.</p> <p>The chemical equation for the reaction is: $CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + CO_2(g) + H_2O(l)$</p> <p>Some students are discussing what is in the beaker when the reaction has finished.</p> <p>1. Who do you agree with? 2. Who do you disagree with and why?</p> <p>Frank: I can see some copper carbonate in the bottom of the beaker. The solution looks blue so there is copper sulfate and water too.</p> <p>Shweta: There is copper sulfate and water but also the reactant copper carbonate. Maybe there is some sulfuric acid left as well.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Petri dish reaction</p> <p>Your teacher will get you a micro-scale experiment to find out what happens when ammonia gas and hydrogen chloride gas are allowed to mix.</p> <p>Universal indicator is used to show the presence of the gases.</p> <p>Predict Describe what will be observed when the ammonia and hydrochloric acid are added and left to evaporate.</p> <p>Explain Why do you think these changes will happen?</p> <p>The teacher adds drops of concentrated hydrochloric acid and ammonia and replaces the lid.</p> <p>Observe Describe what you observe.</p> <p>Explain Have your prediction and explanation correct? Try to improve your first explanation to explain what happens more clearly.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Molecule explanation</p> <p>The molecules that make up nitrogen dioxide and dinitrogen tetroxide can be represented by the following diagrams.</p> <p>• Nitrogen dioxide (NO₂)</p> <p>• Dinitrogen tetroxide (N₂O₄)</p> <p>1. Match the molecule diagrams to the colour that would be observed.</p> <p>2. Explain why the light brown colour is what is observed for the equilibrium reaction $2NO_2 \rightleftharpoons N_2O_4$</p> <p>A. light brown B. dark brown C. colourless</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Molecule representations</p> <p>1. Which two diagrams represent a chemical reaction at dynamic equilibrium?</p> <p>A. There are an equal number of each type of molecule. B. There are different numbers of each type of molecule.</p> <p>2. Use molecules to explain why there are no observable changes when a chemical reaction is at equilibrium.</p> <p>3. Use molecules to explain why the maximum possible quantity of product is not formed by a chemical reaction that is at equilibrium.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Escalator analogy</p> <p>A reaction usually uses an analogy to help students to understand dynamic equilibrium.</p> <p>The analogy describes a person who runs up a down escalator. The person remains in the same position.</p> <p>1. State one way in which this analogy helps to explain dynamic equilibrium.</p> <p>2. State one way in which this analogy does not help to explain dynamic equilibrium.</p> <p><small>Developed by the University of York Science Education Group and the Salter's Institute. The document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>																																																																													
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