Lesson 9: C6.9 – Reversible reactions and energy changes

Connection

Q1. State what is meant by activation energy

Q2. Describe what happens to the activation energy when a catalyst is used

Q3. Explain how a catalyst works in a reaction

Activation

LI: Explain how energy changes occur in reversible reactions

1. https://www.youtube.com/watch?v=ty9TczsW5ew
2. Make a note of the title and the LI
3. Read pages 210-211
4. Define the key words on page 210

Demonstration

Attempt questions 1-5
In 15 mins answer as many questions as you can.
Self mark the questions you have done making any necessary corrections in blue pen

Challenge yourself to answer as many as you can:
Green questions to GCSE Level 3
Blue questions to GCSE Level 6
Purple questions to GCSE Level 9

Consolidation

Complete and self assess the relevant past paper question for this topic - From the C6 DIP file

Extension

Make a note of one thing you think you understand well and one thing that you would like to ask your teacher

Answers:C6.9 – Reversible reactions and energy changes

Connection

1The energy required for a chemical reaction to happen

2 When a catalyst is used, the activation energy required is decreased

3 A catalyst works to make the collisions that take place between reacting particles more successful rather than increasing the number of colisions

Demonstration

1 a Irreversible.
b Reversible.
c Reversible.
2 It is reversible. Boil / evaporate the water and solid sodium chloride appears.
3 A reaction that takes in energy from the surroundings. It is often accompanied by a temperature decrease.
4 An increase in pressure causes the position of equilibrium to shift to the side with the smallest number of molecules. In the case of the Haber process, this is to the product side (4 to 2 molecules). As the pressure is increased, there is a greater increase in the number of successful collisions between reactant molecules compared to product molecules.
5 No effect. It doesn't alter the relative energies of reactants and products. It just lowers the activation energy.

Lesson 10: C6.10 – Equilibrium

Connection

Q1. State what is meant by a forwards reaction

Q2. State what is meant by a backwards reaction

Q3. Describe one way of increasing the forward reaction of the Haber process

Activation

LI: Describe how equilibrium is reached

1. https://www.youtube.com/watch?v=IYyoncESnmQ
2. Make a note of the title and the LI
3. Read pages 212-213
4. Define the key words on page 212
5. Draw the table on page 212 and fig 6.3 on page 213

Demonstration

Attempt questions 1-5
In 15 mins answer as many questions as you can.
Self mark the questions you have done making any necessary corrections in blue pen

Challenge yourself to answer as many as you can:
Green questions to GCSE Level 3
Blue questions to GCSE Level 6
Purple questions to GCSE Level 9

Consolidation

Complete and self assess the relevant past paper question for this topic - From the C6 DIP file

Extension

Make a note of one thing you think you understand well and one thing that you would like to ask your teacher

Answers:C6.10 – Equilibrium

Connection

1The reaction of the reactants forming products

2 The reverse reaction where products change back into the reactants

3 Increasing the pressure
Removing the product(ammonia)

Demonstration

1 As soon as the product is formed, it is lost. Therefore more product is formed and that is lost. And so on. So an equilibrium cannot be reached unless all the reactants and products are together.

2 The rate at which salt dissolves equals the rate at which the ions form solid salt again.

3 The position of equilibrium lies to the left - the reactant side.

4 The position of equilibrium will shift left to the reactant side. This is to minimise the increase in product concentration.

5 Adding water: A (white) precipitate of BiOCl would form since the position of equilibrium will shift left to counteract the increased water concentration. Adding hydrochloric acid: The (white) precipitate of BiOCl would disappear since the position of equilibrium will shift right to counteract the increased hydrochloric acid concentration.

Lesson 11: C6.11 – Changing concentration and equilibrium(Higher tier only)

Connection

Q1. State what is meant by equilibrium

Q2. Describe what le chateliers principle is

Q3. If a reaction is at equilibrium, describe a way to increase the rate of the forward reaction

Activation

LI: Identify reactants and products in a reversible reaction

1. https://www.youtube.com/watch?v=utmV4Q0t6MI
2. Make a note of the title and the LI
3. Read pages 214-215
4. Define the key words on page 214
5. Draw fig 6.33 and its matching equation page 215

Demonstration

Attempt questions 1-3
In 15 mins answer as many questions as you can.
Self mark the questions you have done making any necessary corrections in blue pen

Challenge yourself to answer as many as you can:
Green questions to GCSE Level 3
Blue questions to GCSE Level 6
Purple questions to GCSE Level 9

Consolidation

Complete and self assess the relevant past paper question for this topic - From the C6 DIP file

Extension

Make a note of one thing you think you understand well and one thing that you would like to ask your teacher

Answers:C6.11 – Changing concentration and equilibrium

Connection

1 Equilibrium happens when the forwards and backwards reaction in a reversible reaction occur at the same rate

2 Le chateliers states that if a reaction is at equilibrium and there is a change to the conditions then the reaction responds to counteract the changes

3 Increase the concentration of the reactants

Demonstration

1 SO_3 would need to be removed to make more product. The position of equilbrium shifts right to minimise the reduction in SO_3 concentration.

2 Remove / liquify the methanol. The position of equilibrium would shift right to try to increase the methanol concentration again. Alternatively, increase the concentration of CO / H_2. The position of equilibrium would shift right to try to decrease the CO / H_2 concentration again.

3 Sodium chloride is a source of chloride ions, Cl^- . So the position of equilibrium would shift left to try to reduce the Cl^- concentration again. More white $PbCl_2$ precipitate would be seen to form.

Lesson 12: C6.12 – Changing temperature and equilibrium (Higher tier only)

Connection

Q1. State the product made in the contact process

Q2. State the balanced symbol equation for the Haber process

Q3. Use Le Chateliers principle to explain why removing ammonia in the Haber process increases the forward reaction

Activation

LI: Apply Le Chatelier's principle to reactions in equilibrium

1. https://www.youtube.com/watch?v=ImIsT-DzqzY
2. Make a note of the title and the LI
3. Read pages 216-217
4. Define the key words on page 216
5. Draw table in grey page 217

Demonstration

Attempt questions 1-4
In 15 mins answer as many questions as you can.
Self mark the questions you have done making any necessary corrections in blue pen

Challenge yourself to answer as many as you can:
Green questions to GCSE Level 3
Blue questions to GCSE Level 6
Purple questions to GCSE Level 9

Extension

Make a note of one thing you think you understand well and one thing that you would like to ask your teacher

Consolidation

Complete and self assess the relevant past paper question for this topic - From the C6 DIP file

Answers:C6.12 – Changing temperature and equilibrium

Connection

1 Sulfur trioxide (SO_3)

2 $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

3 Le Chateliers states that if a reaction is at equilibrium and there is a change to the conditions then the reaction responds to counteract the changes. Therefore if ammonia is removed from the system then the system will respond by increasing the forward reaction to replace the ammonia and bring it back to equilibrium

Demonstration

1 a A: 54 %. B: 46 % b A: 58 %. B: 42 %

2 As the temperature is increased, heat is added. The position equilibrium moves in the direction that takes in (and minimises) the added heat and lower the temperature again. Endothermic reactions take in heat from the surroundings. So the products would be favoured.

3 As temperature increases heat is added. The position of equilibrium will move in the direction which removes the added heat - the endothermic direction. The graph shows that as temperature increases, the position of equilibrium shifts left since the % conversion decreases. So left is endothermic and the reaction is exothermic in the forward direction.

4 a As temperature increases, the position of equilibrium shifts right since the % conversion increases. b Endothermic in the forward direction. As temperature is increased more heat is added. The equilibrium will shift in the direction that removes the heat - the endothermic direction. This is to the right since % conversion has increased. c As pressure increases, the position of equilibrium shifts to the left to the side with fewest molecules. With fewer molecules the pressure is less. So the increase in pressure is relieved. This is reflected in a decrease in % conversion with increasing pressure.

Lesson 13: C6.13 – Changing pressure and equilibrium (Higher tier only)

Connection

Q1. Sate what happens to the amount of product when the temperature is increased for an endothermic reaction at equilibrium

Q2. Explain why this happens

Q3. Predict what will happen to the yield of ammonia in the Haber process if the temperature is increased

Activation

LI: Predict the effects of changes in pressure

1. https://www.youtube.com/watch?v=zRCrfkOcfTs
2. Make a note of the title and the LI
3. Read pages 218-219
4. Define the key words on page 219

Demonstration

Attempt questions 1-4
In 15 mins answer as many questions as you can.
Self mark the questions you have done making any necessary corrections in blue pen

Challenge yourself to answer as many as you can:
Green questions to GCSE Level 3
Blue questions to GCSE Level 6
Purple questions to GCSE Level 9

Consolidation

Complete and self assess the relevant past paper question for this topic - From the C6 DIP file

Extension

Make a note of one thing you think you understand well and one thing that you would like to ask your teacher

Answers:C6.13 – Changing temperature and equilibrium

Connection

1 The relative amount of products increases

2 If the temperature is increased, more heat energy is being supplied. If the forward reaction is endothermic then it will require energy from the surroundings. As more heat energy is being supplied this will increase the forward reaction and thus more product is formed

3 As the Haber process is an exothermic reaction, increasing the temperature will decrease the amount of product formed

Demonstration

1 49 % reactants and 51 % products.

2 Increasing pressure results in a decrease in percentage of products (decrease in yield). This suggests that there are more product molecules than reactant molecules.

3 a Increasing pressure shifts the position of equilibrium to the right to the side with fewest molecules (5 to 2).
b Decreasing pressure shifts the position of equilibrium to the right to the side with the larger number of molecules (2 to 3).
c Decreasing pressure shifts the position of equilibrium to the right to the side with the larger number of molecules (2 to 3).

4 In both reactions there is a compromise between rate and yield. Low temperature increases yield because the position of equilibrium shifts right in the exothermic direction. But the rate is too slow at low temperatures. So temperature is increased to give reasonable rates at the expense of yield. High pressure in the Haber process increases rate and also moves the position of equilibrium to the right to the side with fewest molecules i.e. increases yield. The same would be true of the Contact process. However, at low pressures, the yield of SO3 is high anyway. The extra cost of having high pressure equipment is not worth the small increase in yield or rate.

C6 - Revision

Connection

Q1. How does pressure affect the equilibrium of a reaction where the reactants and products are gases?

Q2. Why is a compromise between concentration, pressure and temperature important in equilibrium reactions?

Activation

LI: Create a topic summary sheet

1. Fold an A3 sheet so it is divided into 8 sections
2. Look back over you lesson and group them into 8 main headings
3. Summarise the key points into each section, use keywords and diagrams and symbols rather than sentences

Demonstration

Test yourself by working with the person sitting next to you by talking though each box on your summary sheet and seeing how many key facts you can remember

Consolidation

Look though the relevant past paper questions for this topic - From the C6 DIP file – see if you can complete any additional questions

Extension

Make a list of anything that you would like to ask your teacher to go over again

Answers Lesson – C5 revision

Connection

1. Pressure cause the reaction to move in the direction of where there is the smallest volume (1mole of gas occupies 24L)

2. A compromise is important because to obtain the most economic yield. Extremes of heat and pressure are expensive conditions to create. Also temperature may increase the rate of reaction overall but may also influence the reverse reaction if the reaction is exothermic so finding a balance is important.

DART C6 - Catalysts

Energy researchers break the catalytic speed limit

May 28, 2019
University of Minnesota

A team of researchers from the University of Minnesota and University of Massachusetts Amherst has discovered new technology that can speed up chemical reactions 10,000 times faster than the current reaction rate limit. These findings could increase the speed and lower the cost of thousands of chemical processes used in developing fertilizers, foods, fuels, plastics, and more.

In chemical reactions, scientists use what are called catalysts to speed reactions. A reaction occurring on a catalyst surface, such as a metal, will speed up, but it can only go as fast as permitted by what is called the Sabatier's principle. Often called the "Goldilocks principle" of catalysis, the best possible catalyst aims to perfectly balance two parts of a chemical reaction. Reacting molecules should stick to a metal surface to react neither too strong nor too weakly, but "just right." Since this principle was established quantitatively in 1960, the Sabatier maximum has remained the catalytic speed limit.

Researchers of the Catalysis Center for Energy Innovation, funded by the U.S. Department of Energy, found that they could break the speed limit by applying waves to the catalyst to create an oscillating catalyst. The wave has a peak and a trough, and when applied, it permits both parts of a chemical reaction to occur independently at different speeds. When the wave applied to the catalyst surface matched the natural frequency of a chemical reaction, the rate went up dramatically via a mechanism called "resonance."

"We realized early on that catalysts need to change with time, and it turns out that kilohertz to megahertz frequencies dramatically accelerate catalyst rates," said Paul Dauenhauer, a professor of chemical engineering and materials science at the University of Minnesota and one of the authors of the study.

"The best catalysts need to rapidly flip between strong and weak binding conditions," said Alex Ardagh, post-doctoral scholar in the Catalysis Center for Energy Innovation. "If we flip binding strength quickly enough, catalysts that jump between strong and weak binding actually perform above the catalytic speed limit."

The ability to accelerate chemical reactions directly affects thousands of chemical and materials technologies used to develop fertilizers, foods, fuels, plastics, and more. In the past century, these products have been optimized using static catalysts such as supported metals. Enhanced reaction rates could significantly reduce the amount of equipment and time required to manufacture these materials and lower the overall costs of many everyday materials.

Dramatic enhancement in catalyst performance also has the potential to scale down systems for distributed and rural chemical processes. Due to cost savings in large-scale conventional catalyst systems, most materials are only manufactured in enormous centralized locations such as refineries. Faster dynamic systems can be smaller processes, which can be located in rural locations such as farms, ethanol plants, or military installations.

"This has the potential to completely change the way we manufacture almost all of our most basic chemicals, materials, and fuels," said Professor Dionisios Vlachos, director of the Catalysis Center for Energy Innovation. "The transition from conventional to dynamic catalysts will be as big as the change from direct to alternating current electricity."

Story Source:

The research is published online in *ACS Catalysis*, a journal of the American Chemical Society.

Journal Reference:

1. Matthew Alexander Ardagh, Omar Abdelrahman, Paul J. Dauenhauer. **Principles of Dynamic Heterogeneous Catalysis: Surface Resonance and Turnover Frequency Response**. *ACS Catalysis*, 2019 DOI: 10.1021/acscatal.9b01606

Questions

1a. How much faster is the new catalytic technology?

1b. Give two ways that the new technology affects chemical processes?

1c. This process could reduce the cost to produce which products?

2a. What is the name of the principle that controls the maximum rate of catalysis? When was it established?

2b. Why is the principle from Q2a. called the “goldilocks principle”?

2c. What is the name of the new type of catalysts? How are they created?

3a. How would you describe the term “resonance”? Why does resonance increase catalytic speed?

3b. How will super speedy catalysts reduce the costs associated with chemical processes?

3c. What invention is the idea of Oscillating catalysts likened to in terms of importance? Do you agree? Explain your rationale.

Answers DART C6 - Catalysts

1a. 10,000x faster
1b. Speed and cost of production
1c. Producing fertilisers, foods, fuels and plastics and many more

2a. Sabatier's Principle or the Goldilocks Principle. Established in 1960
2b. the catalyst does not bind the reactants too tightly or too weakly but "just right"
2c. Oscillating catalyst. Produced by a process called resonance.

3a. Resonance is caused by applying a wave to the catalyst, the peak and trough of the wave causes the catalyst to flip between strong and weak binding of the reactants
3b. Scale down processes by reducing the amount of equipment required, enhanced reaction rates reduce the time taken – together these will lower over-all costs, making everyday materials cheaper to manufacture.
3c. As big as the change form AC to DC.
Yes, because AC improved many areas in people's lives and oscillating catalysts affect many aspects of people's lives too. (Direct link)
OR
No, because AC was a visible and direct effect on peoples lives eg more powerful lighting; but oscillating catalysts are something that is more indirect eg reduces the cost of other products. (Indirect link)

The True Influence of AC

Nikola Tesla's plans for alternating current were finally taken seriously in the late 19th century, when George Westinghouse purchased Tesla's AC patents. They transformed the electrical industry to be able to power motors, transmission systems, and other machines. Not only could it provide power in more ways than one, but it could improve upon the lighting systems, too.
https://logicalways.com.sg/how-nikola-tesla-alternating-current-changed-the-world

Attainment Band :	C6 The rate and extent of chemical change (AQA) Knowledge and Understanding
Yellow Yellow Plus/	Draw tangents to the curves as a measure of the rate of reaction. Explain how rates are affected by different factors. Explain the effects of changes of a factor on rates of reaction using collision theory. Explain activation energy. Predict the effects of changes on systems at equilibrium. Interpret data to predict the effect of a change in concentration. Interpret appropriate data to predict the effect of a change in temperature on reactions at equilibrium. Apply Le Chatelier's principle to reactions in equilibrium.
Blue	Calculate the mean rate of a reaction. Explain how changes of surface area affect rates. Predict the effects of changing conditions on rates of reactions. Explain catalytic action. Describe how equilibrium is reached. Explain how changing concentrations changes equilibrium. Explain how endothermic reactions behave if the temperature changes. Explain why these effects of pressure change occur.
Green	Identify how to measure the amount of gas given off in a reaction. Identify which factors affect the rate of reactions. Analyse experimental data on rates of reaction. Identify catalysts in reactions. Identify a reversible reaction. Identify reactants and products in a reversible reaction. Explain how exothermic reactions behave if the temperature of systems at equilibrium changes. Predict the effects of changes in pressure.
White	Some elements of the above have been achieved