Le Chatelier’s Principle: Uses in Industry (Higher Tier) Worksheet

Combined Science - Chemistry - Key Stage 4

The Rate and Extent of Chemical Change

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Let’s try this one

The following reaction shows the decomposition of hydrogen chloride. The forward reaction is endothermic.

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

1) What effect does lowering the temperature have on the position of equilibrium?
2) What effect does increasing temperature have on the Cl_2 yield?
3) What effect does increasing pressure have on the equilibrium?
4) Explain your answer from question 3.

Answers

The following reaction shows the decomposition of hydrogen chloride. The forward reaction is endothermic:

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

1) What effect does lowering the temperature have on the position of equilibrium?

   Equilibrium shifts to the left, favouring exothermic reaction in the reverse direction.

2) What effect does increasing temperature have on the Cl_2 yield?

   Increasing temperature increases the Cl_2 yield.

3) What effect does increasing pressure have on the equilibrium?

   No effect.

4) Explain your answer from question 3.

   Equal numbers of gas molecules on each side of the reaction, equilibrium does not shift.

Production of hydrogen gas

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

In industrial processes where the forward reaction is endothermic, increasing the temperature increases yield.

- Disadvantage of using high temperature?

- Disadvantage of using low temperature?

Production of hydrogen gas

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In industrial processes where the forward reaction is endothermic, increasing the temperature increases yield.

- Disadvantage of using high temperature?

Expensive - a lot of energy required

- Disadvantage of using low temperature?

Reaction is too slow

Production of ethanol

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\ kJ/mol$$

- Is the forward reaction exothermic or endothermic?
- Disadvantage of using high temperature?
- Disadvantage of using low temperature?

Production of ethanol

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- Is the forward reaction exothermic or endothermic?

Exothermic

- Disadvantage of using high temperature?

Low yield

- Disadvantage of using low temperature?

Reaction is too slow

Production of ammonia (Haber process)

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.4\ kJ/mol$$

- Is the forward reaction exothermic or endothermic?

- Disadvantage of using low pressure?

- Disadvantage of using high pressure?

Production of ammonia (Haber process)

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.4\ kJ/mol$$

- Is the forward reaction exothermic or endothermic?

Exothermic

- Disadvantage of using low pressure?

Low yield

- Disadvantage of using high pressure?

Expensive - equipment required to safely contain the reaction becomes very costly

Production of sulphuric acid

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

- Advantage of using high pressure?

- Disadvantage of using high pressure?

Production of sulphuric acid

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

- Advantage of using high pressure?

High yield

- Disadvantage of using high pressure?

Expensive - equipment required to safely contain the reaction becomes very costly

Multiple choice quiz

The forward reaction of the Haber process is exothermic. What is the effect on yield when temperature is lowered?

A

Increases

B

Decreases

C

Stays the same

D

Expensive

The forward reaction of the Haber process is exothermic. What is the effect on yield when temperature is lowered?

A [redacted]

Increases

The forward reaction of the Haber process is exothermic. What is the disadvantage of using a very low temperature?

A

Increases yield

B

Decreases yield

C

Reaction is too fast

D

Reaction is too slow

The forward reaction of the Haber process is exothermic. What is the disadvantage of using a very low temperature?

D

Reaction is too slow

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +65\ kJ/mol$$

What is the disadvantage of using a very high temperature?

A

Reaction is too fast

B

Reaction is too slow

C

Expensive

D

Low yield

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +65\ kJ/mol$$

What is the disadvantage of using a very high temperature?

C

Expensive

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What is the disadvantage of using a low pressure?

A

Reaction is too fast

B

Reaction is too slow

C

Expensive

D

Low yield

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What is the disadvantage of using a low pressure?

D

Low yield

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What is the disadvantage of using a very high pressure?

A

Reaction is too fast

B

Reaction is too slow

C

Expensive

D

Low yield

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What is the disadvantage of using a very high pressure?

C

Expensive

Exam style questions

Exam style question 1

In the Haber process, ammonia is produced from nitrogen and hydrogen at 450°C and 200 atm in the presence of an iron catalyst.

$$\mathbf{N_2(g) + 3H_2(g) \rightleftharpoons 3NH_3(g)} \qquad \textit{ΔH = -92.4 kJ/mol}$$

a) Explain the effect on the yield of ammonia when a high pressure is used. (2)
b) Why is a pressure of not more than 200 atm used? (1)
c) Explain in terms of yield, why is a temperature of not more than 450°C used? (2)
d) Why is a temperature of not less than 450°C used? (1)

Exam style question 2

In the industrial production of ethanol, ethene and steam react together at 300°C and 60 atm in the presence of a catalyst.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\ kJ/mol$$

a) Use Le Chatelier's principle to predict the effect of increasing temperature on the ethanol yield produced at equilibrium. (2)
b) Explain how increasing the pressure of the reactants will affect the ethanol yield produced at equilibrium. (2)
c) Why is a temperature of lower than 300°C not used? (1)
d) What is the disadvantage of using a very high pressure? (1)

Exam style question 1 answer

In the Haber process, ammonia is produced from nitrogen and hydrogen at 450°C and 200 atm in the presence of an iron catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 3NH_3(g) \qquad \Delta H = -92.4\ kJ/mol$$

a) *When a high pressure is used, equilibrium shifts to the right to the side with fewer gas molecules. Yield of ammonia increases.*
b) *A pressure of not more than 200 atm used as it is expensive.*
c) *A temperature of not more than 450°C used because increasing temperature will shift the equilibrium to the left in favour of endothermic reaction. Yield of ammonia will decrease.*
d) *A temperature of not less than 450°C used as the reaction will be too slow.*

Exam style question 2 answers

In the industrial production of ethanol, ethene and steam react together at 300°C and 60 atm in the presence of a catalyst.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\ kJ/mol$$

a) *Increasing temperature shifts the equilibrium to the left in favour of endothermic reaction. This lowers the yield of ethanol produced.*
b) *Increasing the pressure of the reactants will shift the equilibrium to the right to the side with fewer molecules. The yield of ethanol will increase.*
c) *A temperature of lower than 300°C is not used as reaction is too slow.*
d) *Disadvantage of using a very high pressure - expensive.*