

# 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.

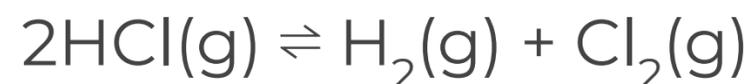


- 1) What effect does lowering the temperature have on the position of equilibrium?
- 2) What effect does increasing temperature have on the  $\text{Cl}_2$  yield?
- 3) What effect does increasing pressure have on the equilibrium?
- 4) Explain your answer from question 3.



# Answers

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



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  $\text{Cl}_2$  yield?

*Increasing temperature increases the  $\text{Cl}_2$  yield.*

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

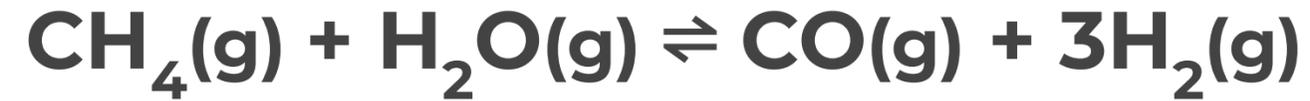
*No effect.*

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

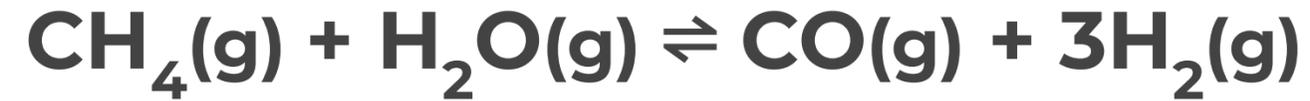


In industrial processes where the forward reaction is endothermic, increasing the temperature increases yield.

- Disadvantage of using high temperature?
- Disadvantage of using low temperature?



# Production of hydrogen gas



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



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



# Production of ethanol



- 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)



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



# Production of ammonia (Haber process)



- 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



- Advantage of using high pressure?
- Disadvantage of using high pressure?



# Production of sulphuric acid



- 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**

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





**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





**What is the disadvantage of using a very high temperature?**

C

Expensive





**What is the disadvantage of using a low pressure?**

**A**

Reaction is too fast

**B**

Reaction is too slow

**C**

Expensive

**D**

Low yield





**What is the disadvantage of using a low pressure?**

**D**

Low yield





**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





**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.



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



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



- 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.



- 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.*

