GCSE Chemistry

Le Chatelier's Principle

Question Paper

Time available: 61 minutes
Marks available: 59 marks

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1. This question is about reactions between gases.

When hydrogen gas is heated with iodine gas, hydrogen iodide gas is produced.

The equation for this reversible reaction is:

$$\text{hydrogen} + \text{iodine} \rightleftharpoons \text{hydrogen iodide}$$

This reversible reaction reaches equilibrium in a sealed container.

(a) How does the equation show that the reaction is reversible?

_____

(1)

(b) Which **two** statements are correct when the reaction reaches equilibrium?

Tick (✓) **two** boxes.

The forward reaction and reverse reaction are both exothermic.	☐
The gases have escaped from the container.	☐
The hydrogen no longer reacts with iodine.	☐
The mass of each substance does not change.	☐
The rates of the forward reaction and reverse reaction are equal.	☐

(2)

(c) The initial mixture of hydrogen and iodine in the sealed container is purple.

Hydrogen iodide is colourless.

How will the colour of the mixture in the sealed container have changed when equilibrium is reached?

Tick (✓) **one** box.

The mixture will have become a deeper purple. ☐

The mixture will have become a paler purple. ☐

The mixture will have become colourless. ☐

(1)

(d) The rate of reaction between gases is affected by changing the pressure.

Complete the sentences.

When the pressure of the reacting gases is increased,

the rate of reaction _____.

This is because at higher pressures the distance

between the particles _____.

This means that the frequency of collisions _____.

(3)

(e) Give **one** other way of changing the rate of reaction between gases.

You should **not** refer to pressure in your answer.

_____

_____

(1)

(Total 8 marks)

2. This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

(a) Name the process used to produce ethene from large hydrocarbon molecules.

_____

(1)

(b) Describe the conditions used to produce ethene from large hydrocarbon molecules.

_____

_____

_____

_____

(2)

(c) Ethanol can be produced from ethene and steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

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_____

(6)

(d) Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

_____

(1)

(e) Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast.

Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

_____

_____

_____

_____

(2)

Ethanol and butanol can be used as fuels for cars.

(f) A car needs an average of 1.95 kJ of energy to travel 1 m

Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol).

Calculate the number of moles of ethanol needed by the car to travel 200 km

_____

_____

_____

_____

_____

Number of moles = _____ mol

(3)

(g) When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do **not** need to include state symbols.

_____

(2)

(Total 17 marks)

3. This question is about methanol.

(a) Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

Tick **one** box.

- Amino acid ☐
- Enzyme ☐
- Ester ☐
- Nucleotide ☐

(1)

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(b) How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

Tick **one** box.

- 1.0×10^3 moles ☐
- 2.0×10^3 moles ☐
- 4.0×10^3 moles ☐
- 8.0×10^3 moles ☐

(1)

(c) The reaction is carried out at a temperature of 250 °C and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 °C is used.

(2)

(d) A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol and an increased rate of reaction.

Explain why.

(4)

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

(e) Explain how a catalyst increases the rate of a reaction.

_____

_____

_____

_____

(2)

(f) Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

_____

_____

(1)

(g) Suggest the effect of using the catalyst on the equilibrium yield of methanol.

_____

_____

(1)

(Total 12 marks)

4. The monomer chloroethene is made from ethene in a two-stage process,

(a) The first stage is to convert ethene to 1,2-dichloroethane.

$$2C_2H_4(g) + 4HC1(g) + O_2(g) \rightleftharpoons 2C_2H_4Cl_2(g) + 2H_2O(g)$$

ethene 1,2-dichloroethane

State and explain the effect of increasing the pressure on:

(i) the yield of 1,2-dichloroethane;

_____

_____

(2)

(ii) the rate of reaction.

_____

_____

(2)

(b) In the second stage 1,2-dichloroethane is converted into chloroethene.

$C_2H_4C1_2 \rightarrow C_2H_3C1 + HCl$

This reaction is a thermal decomposition.

Suggest what would need to be done to decompose 1,2-dichloroethane.

_____

_____

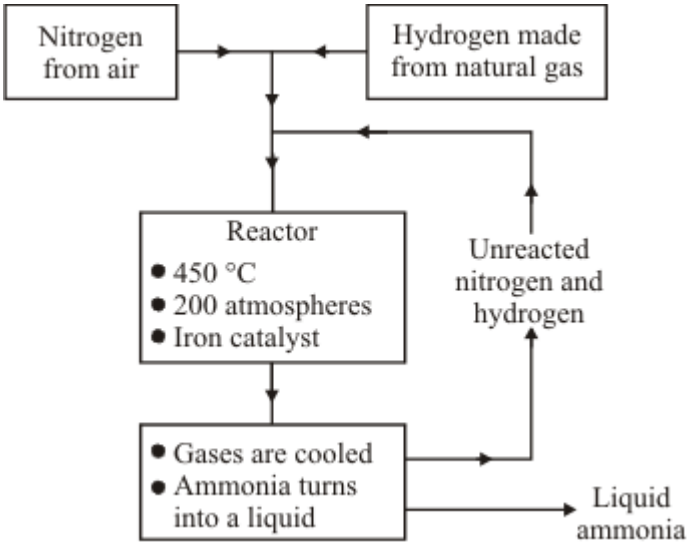
(1)

(Total 5 marks)

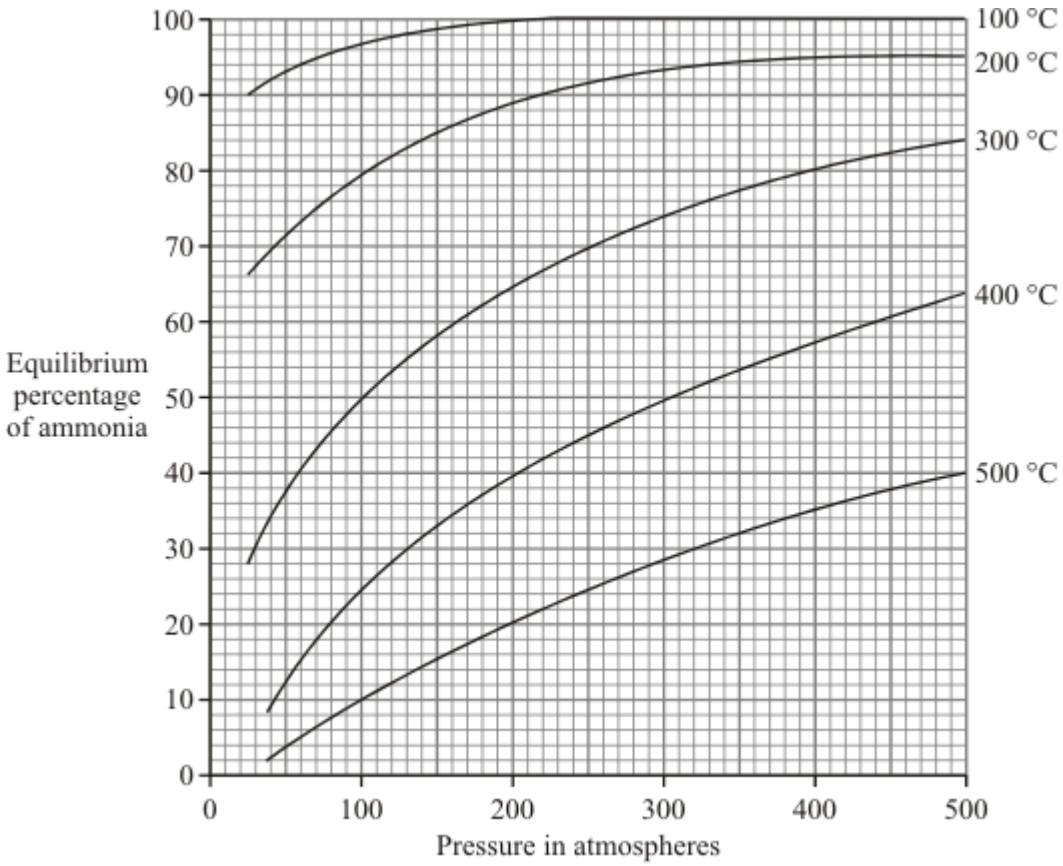
5. Ammonia is made from nitrogen and hydrogen in the Haber process.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ (+ heat)

Flow Chart for the Haber Process



Effect of temperature and pressure on the amount of ammonia at equilibrium



(a) Use the information given above and your knowledge of the Haber process and reversible reactions to help you to answer this question.

State which conditions of temperature and pressure would give the highest percentage of ammonia at equilibrium. Explain why.

(4)

(b) The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

Explain why these conditions are chosen.

(3)

(Total 7 marks)

6. The reaction of methane with steam is used in industry to make hydrogen.

(a) One of the reactions in this process is represented by this equation.

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

The forward reaction is endothermic.

State the conditions of temperature and pressure that would give the maximum yield of hydrogen.

Explain your answers.

(i) Temperature

(2)

(ii) Pressure

(2)

(iii) Which one of the following metals is most likely to be a catalyst for this process? Draw a ring around your answer.

aluminium **lead** **magnesium** **nickel** **sodium**

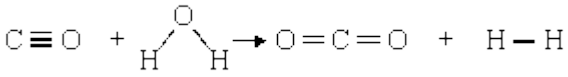
Give a reason for your choice.

_____

_____

(1)

(b) A second stage in this process is represented by this equation.



(i) Use the bond energies given in the table to help you to calculate the nett energy transfer (energy change) for this reaction.

Bond	Bond energy in kJ/mol
C º O	1077
C = O	805
H – H	436
O – H	464

_____

_____

_____

_____

_____

_____

Nett energy transfer = _____ kJ/mol

(3)

(ii) State whether this reaction is exothermic or endothermic. _____

Explain, by reference to your calculation, how you know.

_____

_____

_____

_____

(2)

(Total 10 marks)