

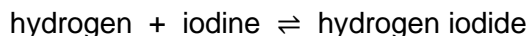
Questions are for both separate science and combined science students unless indicated in the question

**Q1.**

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:



This reversible reaction reaches equilibrium in a sealed container.

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

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(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.

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(1)

(Total 8 marks)

## Q2.

This question is about ammonia and fertilisers.

Ammonia is produced from nitrogen and hydrogen.

A catalyst is used to speed up the reaction.

The word equation for the reaction is:



- (a) What does the symbol  $\rightleftharpoons$  show about the reaction?

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(1)

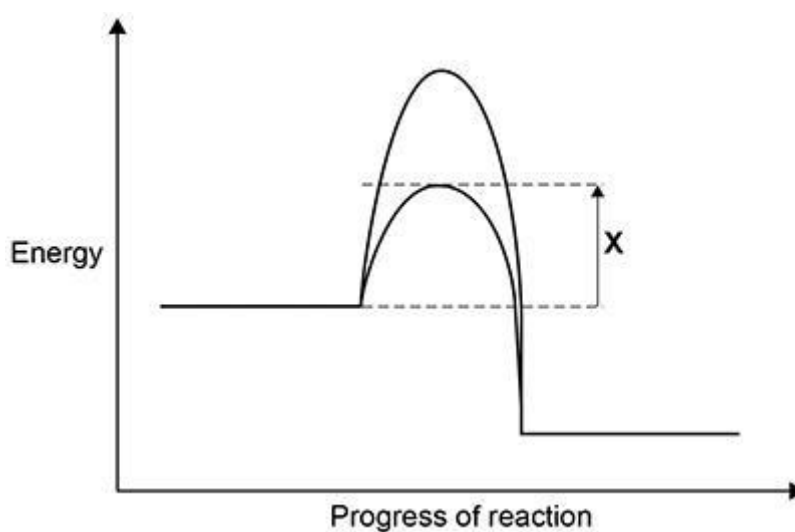
- (b) Which catalyst is used when ammonia is produced from nitrogen and hydrogen?

Tick (✓) **one** box. (separate only)

- Chlorine
- Iron
- Oxygen

(1)

- (c) The diagram below shows the reaction profile for the production of ammonia both with a catalyst and without a catalyst.



What is represented by label **X**?

Tick (✓) **one** box.

- Activation energy with a catalyst
- Activation energy without a catalyst
- Overall energy change with a catalyst
- Overall energy change without a catalyst

(1)

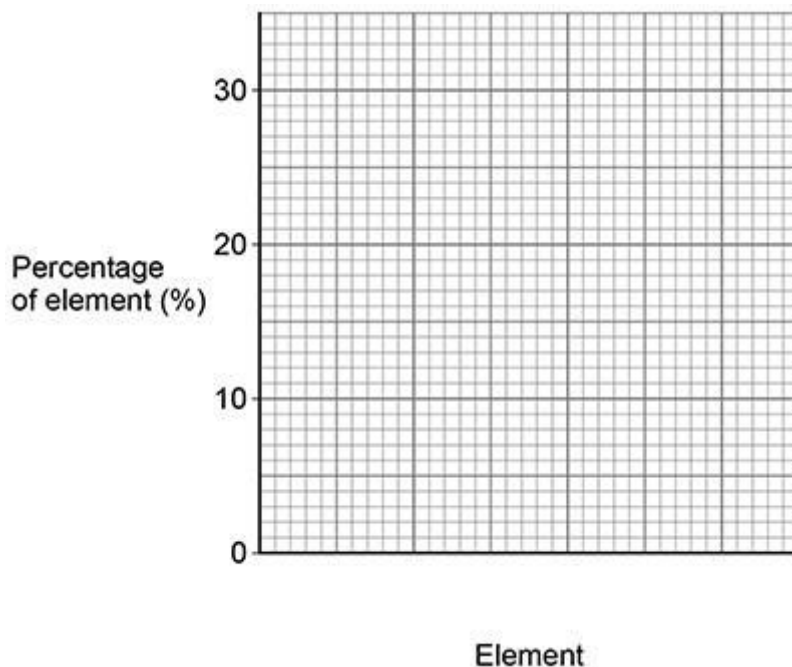
Ammonia is used to produce fertilisers.

NPK fertilisers contain the elements nitrogen, phosphorus and potassium.

A fertiliser contains:

- 22% phosphorus
- 25% potassium.

(d) Draw a bar chart on the graph below to show the percentages of phosphorus and of potassium in this fertiliser. **(separate only)**



(2)

(e) Why do the percentages of phosphorus and of potassium in this fertiliser **not** add up to 100%? **(separate only)**

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(1)

Fertilisers help plants grow by adding essential elements to soil.

The table below shows the percentages of nitrogen, phosphorus and potassium in four fertilisers, **A**, **B**, **C** and **D**.

Fertiliser	Percentage (%) of essential element		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
<b>A</b>	14	0	39
<b>B</b>	25	16	23
<b>C</b>	21	23	0
<b>D</b>	21	0	0

- (f) Plants lacking essential elements do not grow well because:
- too little phosphorus can cause slow plant growth
  - too little potassium can cause leaves to have brown edges.

Which fertiliser helps prevent slow plant growth **and** brown leaf edges?

Use the table above.

Tick (✓) **one** box. (separate only)

A       B       C       D

(1)

- (g) Which fertiliser has the greatest total percentage of essential elements?

Use the table above.

Tick (✓) **one** box. (separate only)

A       B       C       D

(1)

(Total 8 marks)

### Q3.

This question is about a reversible reaction.

The reaction between solutions of iron(III) ions ( $\text{Fe}^{3+}$ ) and thiocyanate ions ( $\text{SCN}^-$ ) is reversible.

The ionic equation for the reaction is:



The colour of the equilibrium mixture is orange at room temperature.

- (a) Give the name of the solvent used to dissolve the ions in this reaction.

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(1)

- (b) A few drops of a colourless solution containing a high concentration of thiocyanate ions ( $\text{SCN}^-$ ) are added to the orange equilibrium mixture.

Explain the colour change observed.

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(3)

- (c) A water bath is set up at a temperature above room temperature.

When a test tube containing the orange equilibrium mixture is placed in the water bath, the mixture becomes more yellow.

Explain what this shows about the energy change for the forward reaction.

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(3)

- (d) Explain why a change in pressure does **not** affect the colour of the equilibrium mixture.

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(2)

- (e) Other metal ions form coloured equilibrium mixtures with thiocyanate ions.

Which metal ion could form a coloured equilibrium mixture with thiocyanate ions?

Tick (✓) **one** box.

Al<sup>3+</sup>

Co<sup>2+</sup>

Mg<sup>2+</sup>

Na<sup>+</sup>

(1)

(Total 10 marks)

**Q4.**

Hydrogen is a raw material in the Haber process.

Hydrogen is produced from methane.

The word equation for the reaction is:



(a) How can you tell that the reaction is reversible?

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(1)

(b) The forward reaction is endothermic.

Name the type of energy change in the reverse reaction.

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(1)

(c) A nickel catalyst is used in this reaction.

Why is a catalyst used in this reaction?

Tick (✓) **two** boxes.

To increase the temperature

To produce less carbon monoxide

To reduce costs

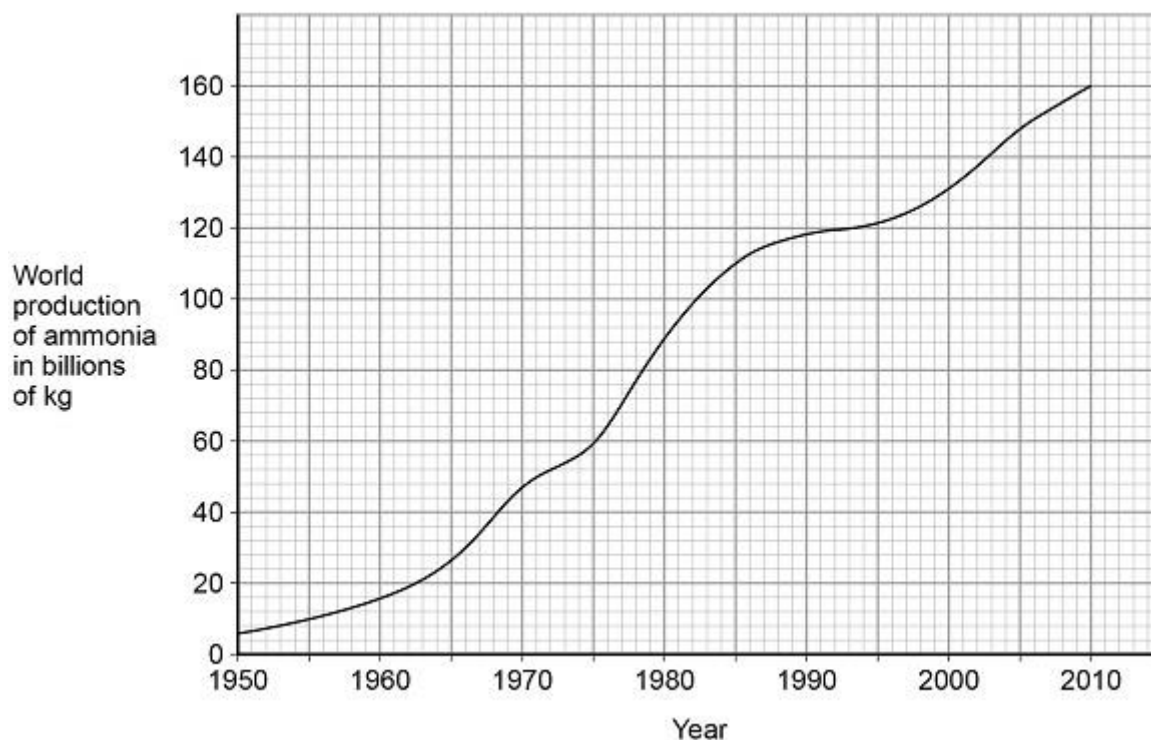
To use less energy

To use less methane

(2)

- (d) The Haber process also uses nitrogen to produce ammonia.

The graph below shows how the world production of ammonia changed between 1950 and 2010.



Describe how the world production of ammonia changed between 1950 and 2010.

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(2)

Most of the ammonia produced is used to make fertilisers.

- (e) Why did the world production of ammonia change between 1950 and 2010?

Tick (✓) **two** boxes. (separate only)

The demand for food changed.

The demand for fuels changed.

The nitrogen percentage in air changed.

The number of cars changed.

The world population changed.

(2)

The following table shows data about four fertilisers, **A**, **B**, **C** and **D**.

Fertiliser	Percentage by mass of nitrogen (%)	Percentage by mass of phosphorus (%)	Percentage by mass of potassium (%)
<b>A</b>	35.0	0.0	0.0
<b>B</b>	21.2	0.0	0.0
<b>C</b>	21.2	23.5	0.0
<b>D</b>	0.0	0.0	52.3

- (f) Which combination of fertilisers **A**, **B**, **C** and **D** provides all of the elements needed for an NPK fertiliser?

Use the table.

Tick (✓) **one** boxes. (separate only)

**A and C**

**A and D**

**B and C**

**C and D**

(1)

- (g) Which fertiliser is not made using ammonia?

Use the table above.

Tick (✓) **one** boxes. (separate only)

A	<input type="checkbox"/>
B	<input type="checkbox"/>
C	<input type="checkbox"/>
D	<input type="checkbox"/>

(1)  
(Total 10 marks)

**Q5.**

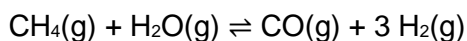
This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

**Stage 1** is the reaction of methane and steam to produce carbon monoxide and hydrogen.

The equation for the reaction is:



(a) Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses ( $A_r$ ): H = 1 C = 12 O = 16 (separate only)

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Atom economy = \_\_\_\_\_%

(2)

(b) Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

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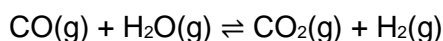
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(2)

(c) **Stage 2** uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen.

The equation for the reaction in **stage 2** is:



What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

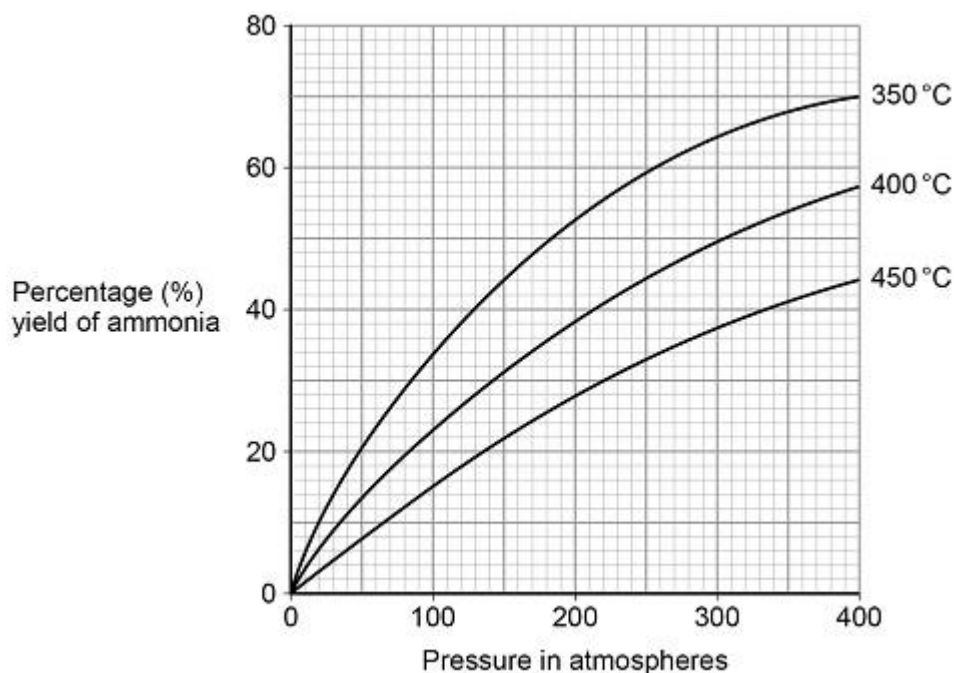
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(1)

The graph below shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

(d) A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia

obtained would be.

Use the graph. **(separate only)**

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Percentage yield = \_\_\_\_\_ times greater

**(3)**

- (e) A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why. **(separate only)**

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**(1)**

- (f) How does the graph above show that the forward reaction in the Haber process is exothermic? **(separate only)**

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**(1)**

- (g) World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased. **(separate only)**

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**(2)**

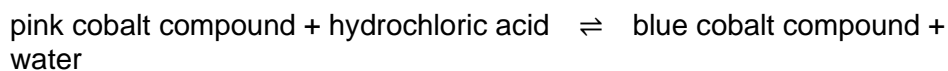
**(Total 12 marks)**

**Q6.**

Cobalt forms coloured compounds.

A pink cobalt compound reacts with hydrochloric acid.

The reaction can be represented as:



The forward reaction is endothermic.

When both cobalt compounds are present in a solution at equilibrium, the equilibrium mixture is purple.

(a) What is meant by equilibrium?

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(2)

(b) The equilibrium mixture is cooled.

Explain what happens to the concentration of the pink cobalt compound.

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(3)

(c) More hydrochloric acid is added.

Explain what happens to the colour of the equilibrium mixture

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(3)

(d) Why does cobalt form different coloured compounds?

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(1)

(e) An oxide of cobalt has the formula  $\text{Co}_2\text{O}_3$

Which cobalt ion is present in this oxide?

Tick (✓) **one** box.

$\text{Co}^+$

$\text{Co}^{2+}$

$\text{Co}^{3+}$

$\text{Co}^{4+}$

(1)

(f) Cobalt compounds can act as catalysts.

Which two statements about cobalt compounds are correct?

Tick (✓) **two** boxes.

They allow reactions to reach equilibrium more quickly.

They are reactants in reactions catalysed by cobalt compounds.

They are used up when acting as catalysts.

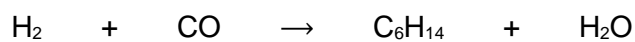
They increase the equilibrium yield of reactions.

They provide a different reaction pathway.

(2)

(g) The reaction of hydrogen with carbon monoxide is catalysed by cobalt metal.

Balance the equation for the reaction.



(1)

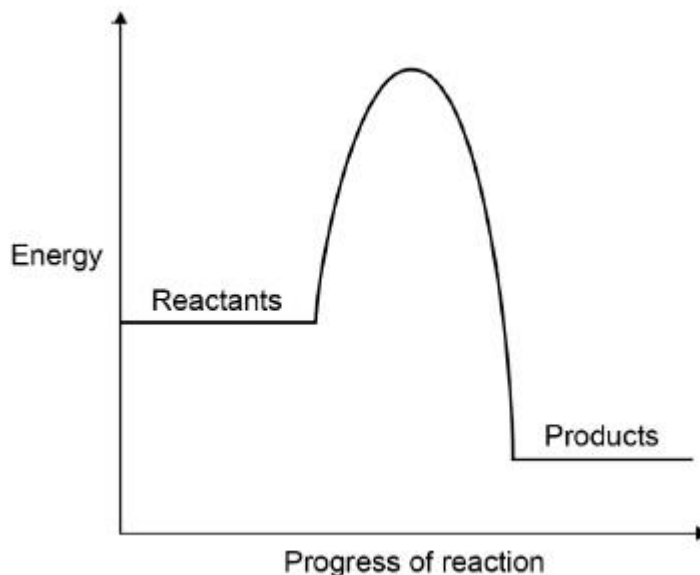
(h)  $\text{C}_6\text{H}_{14}$  is an alkane.

What is the formula of an alkane containing 18 hydrogen atoms?

\_\_\_\_\_

(1)

- (i) The graph shows a reaction profile diagram for a reaction **without** a catalyst.



On the graph:

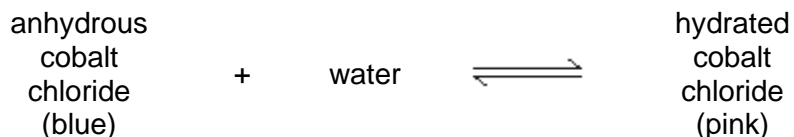
- draw the reaction profile diagram for a catalysed reaction
- draw and label an arrow to show the activation energy for the reaction **without** a catalyst.

(2)

(Total 16 marks)

**Q7.**

The word equation shows the reaction between anhydrous cobalt chloride and water.



- (a) Name the type of reaction shown by the sign  $\rightleftharpoons$

\_\_\_\_\_

(1)

- (b) When the student added water to anhydrous cobalt chloride what happened?

\_\_\_\_\_ (1)

- (c) A student measured the temperature rise when anhydrous cobalt chloride was added to water.

The student's results are shown in the table below.

	Trial 1	Trial 2	Trial 3
Temperature rise in °C	8.5	8.2	8.2

Calculate the mean temperature rise.

\_\_\_\_\_

Temperature = \_\_\_\_\_ °C (1)

- (d) When water was added to anhydrous cobalt chloride an exothermic reaction took place.

Name the type of reaction when hydrated cobalt chloride reacts to form anhydrous cobalt chloride and water.

\_\_\_\_\_

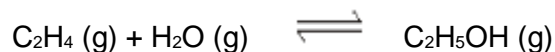
\_\_\_\_\_ (1)

(Total 4 marks)

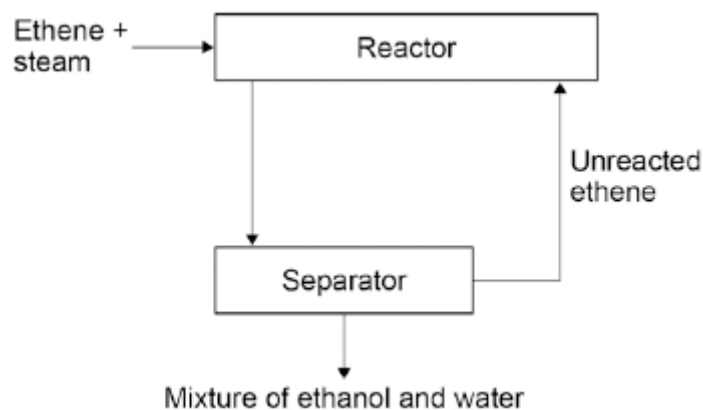
**Q8.**

In industry ethanol is produced by the reaction of ethene and steam at 300°C and 60 atmospheres pressure using a catalyst.

The equation for the reaction is:



The figure below shows a flow diagram of the process.



- (a) Why does the mixture from the separator contain ethanol and water?

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(1)

- (b) The forward reaction is exothermic.

Use Le Chatelier's Principle to predict the effect of increasing temperature on the amount of ethanol produced at equilibrium.

Give a reason for your prediction.

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(2)

- (c) Explain how increasing the pressure of the reactants will affect the amount of ethanol produced at equilibrium.

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(2)

(Total 5 marks)

**Q9.**

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?

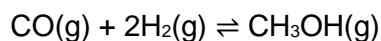
Tick **one** box.

- |            |                          |
|------------|--------------------------|
| Amino acid | <input type="checkbox"/> |
| Enzyme     | <input type="checkbox"/> |
| Ester      | <input type="checkbox"/> |
| Nucleotide | <input type="checkbox"/> |

(1)

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

The equation for the reaction is:



- (b) How many moles of carbon monoxide react completely with  $4.0 \times 10^3$  moles of hydrogen?

Tick **one** box.

- |                         |                          |
|-------------------------|--------------------------|
| $1.0 \times 10^3$ moles | <input type="checkbox"/> |
| $2.0 \times 10^3$ moles | <input type="checkbox"/> |
| $4.0 \times 10^3$ moles | <input type="checkbox"/> |
| $8.0 \times 10^3$ moles | <input type="checkbox"/> |

(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.

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(1)

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

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(1)

(Total 12 marks)