1. Fertilisers are used to help to grow food.

The first stage of making fertilisers uses hydrogen to make ammonia. Very large amounts of hydrogen are needed.

The equation for the process is:

methane + steam ⇌ hydrogen + carbon dioxide

$$CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$$

All of the methane is never used up in this reaction, there is always some left over.

(i) How does the equation show that the methane can never be all used up?

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[2]

(ii) The left over methane is recycled back into the start of the process.

Explain why this makes the process more sustainable.

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[2]

2. Scientists are working on a new process to produce hydrogen.

The new process splits water to make hydrogen. A catalyst is used in the process.

$$2H_2O \quad ? \quad 2H_2 \quad + \quad O_2$$

(i) What is the name of the by-product of this reaction?

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[1]

(ii) Using a catalyst reduces the energy needed to break up the water.

How does the catalyst work?

Put ticks (?) in the boxes next to the **two** correct answers.

The catalyst increases the time taken for the reaction. ☐

The catalyst lowers the activation energy. ☐

The catalyst provides a different route for the reaction ☐

The catalyst is used up instead of the water. ☐

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1		i	reversible reaction / explanation of reversible reaction ✓ idea that reaction never reaches 100% yield / all reactants do not react / reaction does not go to completion ✓	2	
		ii	does not waste raw materials / use less methane / methane is non-renewable ✓ less waste given out / less waste to dispose of ✓	2	
			Total	4	
2		i	oxygen (1)	1	Ignore O_2 Examiner's Comments The word 'by-product' did not seem to be well known. Less than half correctly identified oxygen as the by-product from the equation.
		ii	….lowers the activation energy (box 2); (1) … provides a different route (box 3); (1)	2	Examiner's Comments Most gained a single mark for identifying one or other of the two correct statements about catalysts.
			Total	3	