0 1 Hydrogen fuel cells have been developed for cars.

0 1 . 1 What type of energy is released by hydrogen fuel cells?

[1 mark]

electrical

The equation for the reaction of hydrogen with oxygen is:

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

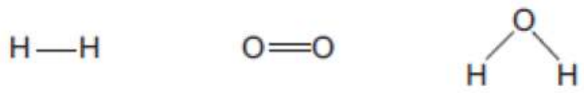
Energy is released when new bonds are made to form the product.

Bond energies for the reaction are given in the table below.

Bond	Bond energy in kJ
H—H	436
O=O	498
O—H	464

The structures of the reactants and product are shown in **Figure 3**.

Figure 3



hydrogen oxygen water

0 1 . 2 Calculate the energy change for the reaction:

[3 marks]

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

(2 × 436) + 498 = 1370 [1]

4 × 464 = 1856 [1]

Energy change = (−)486 kJ [3]

0 1 . 3 Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

[2 marks]

Alternative correct answer (*not in video*):
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

From video:
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Positive electrode: .....

$H_2 \rightarrow 2H^+ + 2e^-$

Negative electrode: $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$ *or* $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$

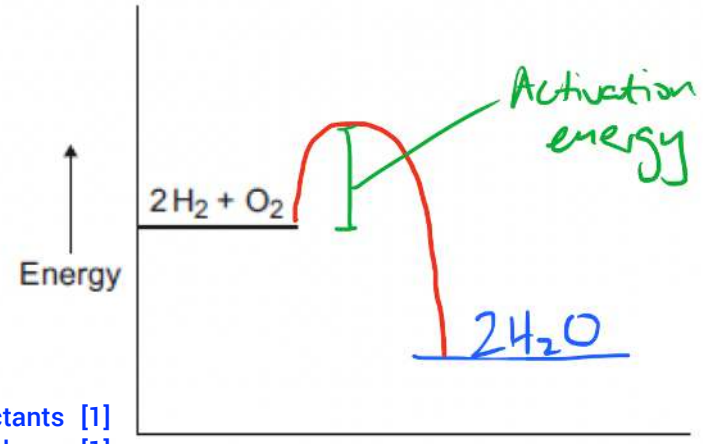
0 1 . 4 The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 4**.

Clearly label the activation energy.

[3 marks]

Figure 4



products lower than reactants [1]
reaction curve correctly drawn [1]
activation energy labelled [1]

(Total 9 marks)

End