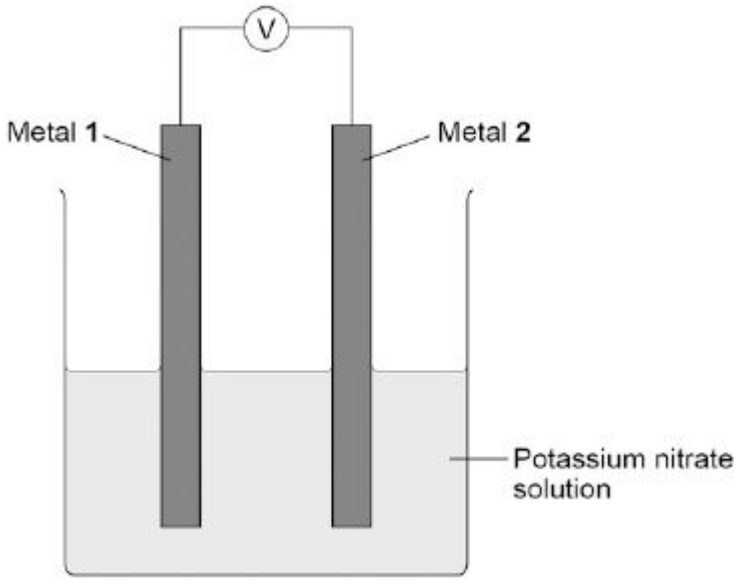
1 A student investigated simple cells using the apparatus shown in the figure below.



- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

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

Metal 2 / Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

(a) The ionic equation for the reaction occuring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

$$Zn \rightarrow Zn^{2+} + 2e^{-}$$

Zinc is oxidised in this reaction.

Give a reason why this is oxidation.

.....

.....

(1)

(b) Look at the table above.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

Metal .....

Reason .....

.....

.....

(2)

(c) Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.

Explain your answer.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(d) Hydrogen fuel cells have been developed for cars.

Write a word equation for the overall reaction that takes place in a hydrogen fuel cell.

.....

(1)

(e) Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

.....

.....

.....

.....

(2)
(Total 9 marks)

2 Some cars are powered by hydrogen fuel cells.

Figure 1

(a) What type of energy is released by hydrogen fuel cells?

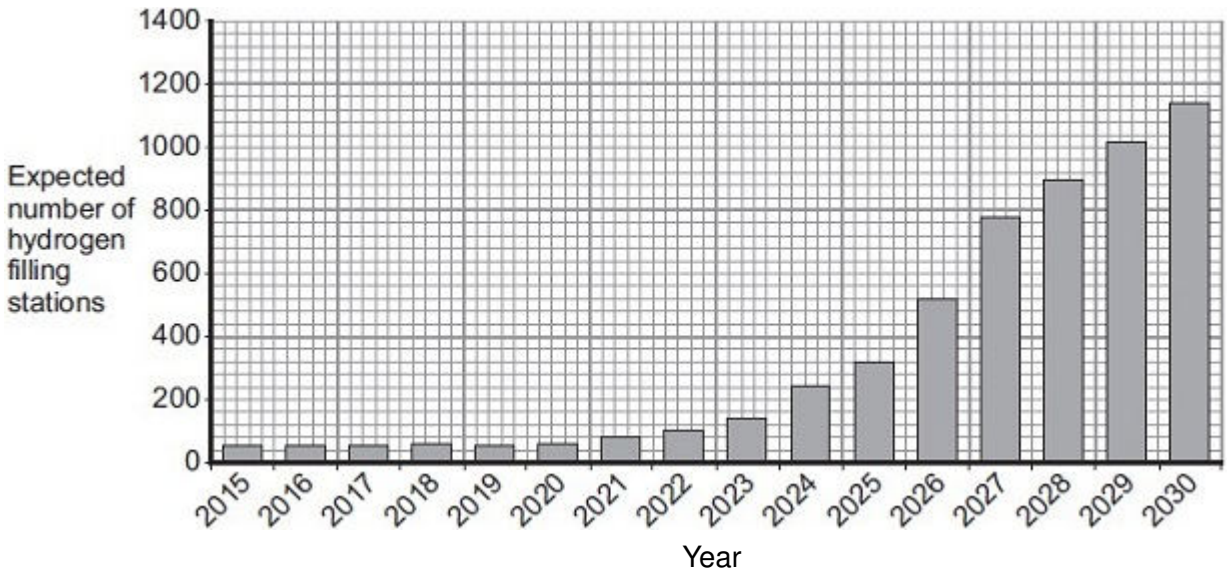
.....

(1)

(b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 2 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

Figure 2



Use the information in **Figure 2** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

.....

.....

.....

.....

.....

(2)

(c) The equation for the reaction of hydrogen with oxygen is:

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

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

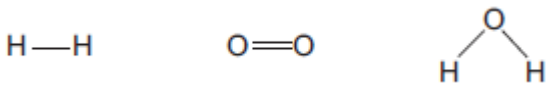
Energy is released when new bonds are made to form the product.

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

(i) Calculate the energy change for the reaction:

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

.....

.....

.....

.....

.....

.....

Energy change = ... kJ

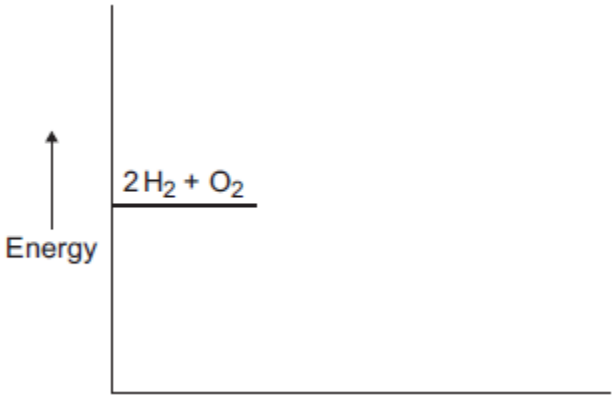
(3)

(ii) The reaction of hydrogen with oxygen is exothermic.

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

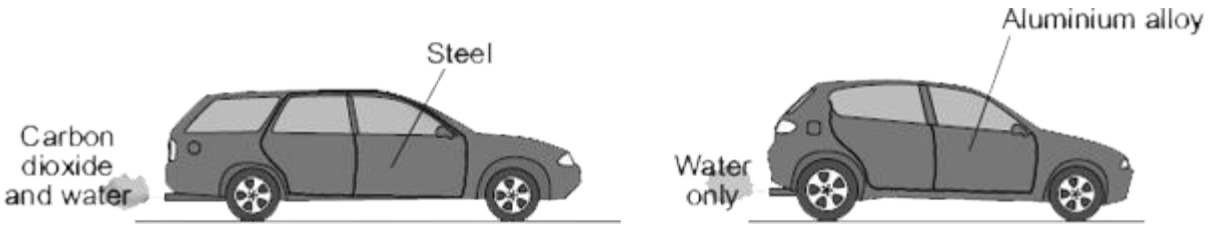
Clearly label the activation energy.

Figure 4



(3)
(Total 9 marks)

3 The picture shows two different cars.



(a) Some properties of aluminium are given below.

Tick (✓) **two** reasons why aluminium is better than steel for car bodies.

Reason	Tick (✓)
Aluminium is not a transition metal.	
Aluminium has a low density.	
Aluminium is expensive to extract.	
aluminium is resistant to corrosion.	

(2)

(b) Each car body is made from an *alloy*.

(i) What is an *alloy*?

.....

.....

(1)

(ii) An alloy is used to make a car body. A pure metal is **not** used to make a car body.

Suggest why.

.....

.....

(1)

(c) The car with a steel body uses petrol for fuel.

Draw a ring around the correct answer to complete each sentence.

(i) Petrol is made from

air.
crude oil.
metal ores.

(1)

(ii) Petrol is a mixture of

carbonates
hydrocarbons
polymers

including C_8H_{18}

(1)

(iii) In the car engine petrol reacts with

argon
nitrogen
oxygen

to produce carbon dioxide and water.

(1)

(d) Look at the substances coming out of each car's exhaust.

(i) Suggest the name of the fuel used in the car with the aluminium alloy body.

Name of fuel ..... .

(1)

(ii) Why is the fuel burned in the car with the aluminium alloy body better for the environment than petrol?

.....

.....

(1)

(Total 9 marks)