AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.2.2

Fuel cells

Past-paper questions

Tier	**Higher**
Question groups	**10**
Available paper years	**2007–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.5.2.2 Fuel cells

Question 01

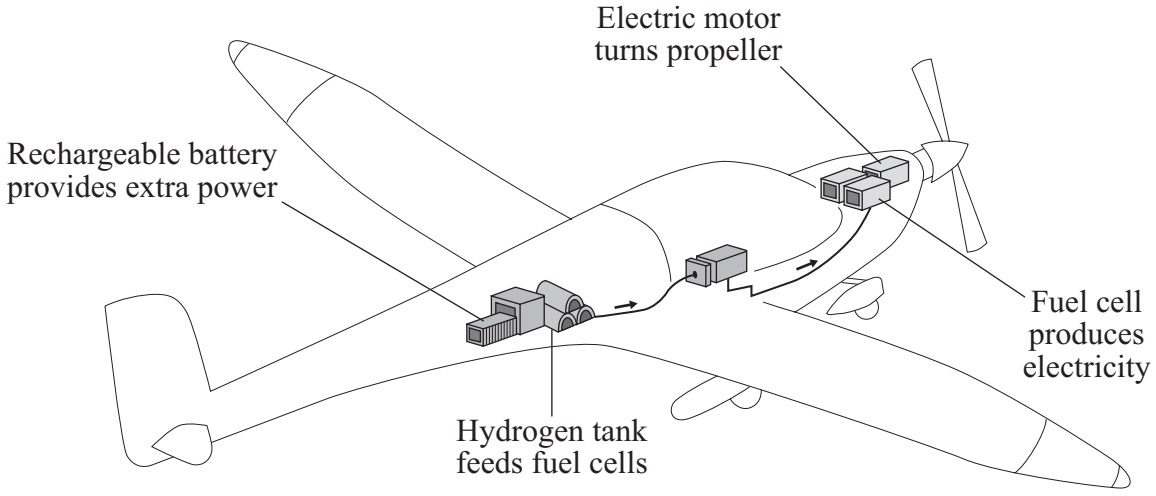
June 2007 | CHY1A | Original Q9 | Legacy

QUESTION NINE

This information is an edited newspaper article about aircraft research.

Greening the skies

'Emission-free aircraft'



Conventional aircraft use very large volumes of kerosene fuel which is a mixture of hydrocarbons. Research is being carried out into the use of hydrogen as a fuel.

In the fuel cell, hydrogen is chemically combined with oxygen to produce electricity, to drive a motor which turns the propeller. Fuel cells are bulky and expensive but have no moving parts and run silently.

Most commercially produced hydrogen is obtained from natural gas, and carbon dioxide is generated as a by-product. It has been called 'black hydrogen' by some groups.

As an aircraft fuel, mass for mass, hydrogen will deliver about three times as much energy as kerosene; however, the volume of the hydrogen is much greater.

One problem with kerosene fuel is that aircraft sometimes have to dump large volumes of fuel, if, for example, they are turned back to the take-off airport.

4.5.2.2 Fuel cells

Question 01 · continued

9A There are several reasons why this research is being carried out.

Which of the following is **not** one of those reasons?

1 There could be a shortage of kerosene in the future.

2 There is political pressure to reduce air travel.

3 Kerosene is obtained from a non-renewable source.

4 There is political pressure to reduce emission of gases which may cause global warming.

9B In this article, 'emission free' means . . .

1 there are no waste products when hydrogen is used in a fuel cell.

2 the fuel cell only produces carbon dioxide and water as waste.

3 there are no harmful gases produced by the fuel cell.

4 the fuel cell reduces noise pollution from aircraft.

9C One reason why some groups refer to the commercially produced hydrogen as 'black hydrogen' is that . . .

1 the hydrogen is impure.

2 the hydrogen is made from a fossil fuel.

3 the hydrogen burns to produce more carbon dioxide.

4 sulfur dioxide is a by-product of the process.

9D Even if hydrogen-powered aircraft are used commercially in the future, there will probably still be pressure groups against increased air travel.

One reason for objection to increased air travel could be that . . .

1 hydrogen-powered aircraft are too noisy.

2 hydrogen is a dangerous fuel to use in an aircraft.

3 agricultural land will be lost to the building of new runways.

4 dumping large volumes of hydrogen is dangerous.

END OF TEST

4.5.2.2 Fuel cells

Question 02

June 2008 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

Cars are being developed that use hydrogen as a fuel instead of petrol or diesel. When hydrogen burns, the only product is water. Hydrogen can be used to power fuel cells that produce electricity to run the car, rather than burning it in a traditional engine.

Hydrogen can be obtained from water by electrolysis. This method is both expensive and slow, so scientists are trying other methods.
A company has developed cells that can convert 8% of solar energy directly into hydrogen. They must reach an efficiency of 10% before the process becomes commercially viable.

8A In the electrolysis of water, the products are hydrogen together with . . .

1 oxygen only.

2 oxygen and carbon dioxide.

3 carbon dioxide only.

4 carbon dioxide and nitrogen.

8B One advantage that a hydrogen-powered vehicle has over a petrol-powered vehicle is that . . .

1 no sulfur dioxide is produced.

2 it causes only half the global dimming.

3 hydrogen-powered cars run on solar energy.

4 it is safer because hydrogen does not burn.

8C Hydrogen-powered cars are **not** common on roads yet because . . .

1 hydrogen resources are scarce.

2 fuel cell technology has been expensive to develop.

3 the vehicles will only move during summer.

4 electrolysis is a slow process in the car.

4.5.2.2 Fuel cells

Question 02 · continued June 2008 | CHY1AP | Original Q8 | Legacy

A scientist has claimed that there are a number of technical and financial stumbling blocks. He said that the development of hydrogen-powered cars also required development of the cells to produce hydrogen. He described this by saying, 'there is a chicken and egg issue here'.

8D The statement, 'there is a chicken and egg issue here' made by the scientist means that . . .

1 the technology is basic at the moment but it will develop well by 2020.

2 there is no point producing a hydrogen-powered car if hydrogen fuel is not widely available.

3 people will **not** want to buy the first hydrogen cars as they will be slow.

4 we must develop other fuels before oil runs out.

Turn over for the next question

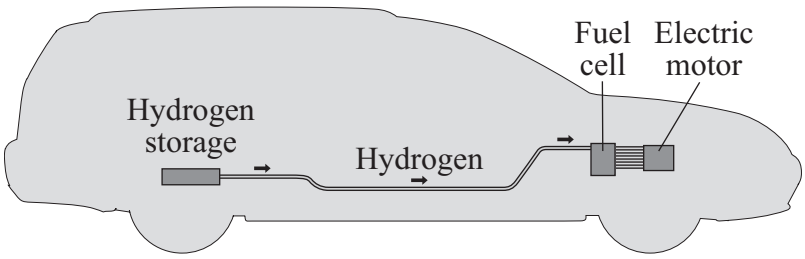
4.5.2.2 Fuel cells

Question 03

June 2009 | CHY2H | Original Q5 | Legacy

5 Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

4.5.2.2 Fuel cells

Question 03 · continued

for mark

5 (a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

5 (a) (i) Why are hydrogen ions attracted to the negative electrode?

.....

.....

.....

(1 mark)

5 (a) (ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

.....

.....

.....

(1 mark)

5 (b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... Li + N_2 → ..... Li_3N

(1 mark)

Question 5 continues on the next page

4.5.2.2 Fuel cells

Question 03 · continued

for mark

5 (c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

.....

.....

(1 mark)

5 (c) (ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

.....

.....

.....

.....

.....

(2 marks)

5 (d) (i) State how 'nanosized' particles will be different from normal sized particles of lithium nitride.

.....

.....

(1 mark)

5 (d) (ii) Suggest why the 'nanosized' particles of lithium nitride absorb and release the hydrogen more quickly than normal sized particles.

.....

.....

.....

(1 mark)

4.5.2.2 Fuel cells

Question 03 · continued

for mark

5 (e) Lithium nitride is an ionic compound which contains lithium ions (Li^+) and nitride ions (N^{3-}).

5 (e) (i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

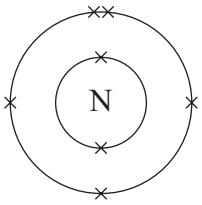
Explain why.

.....

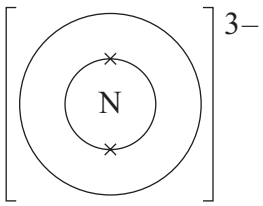
.....

(1 mark)

5 (e) (ii) The diagram shows the electronic structure of a nitrogen atom.



Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1 mark)

10

4.5.2.2 Fuel cells

Question 04

November 2011 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

Petrol and diesel are the fuels used for most cars.

Several companies are researching the use of hydrogen as a fuel for cars, instead of petrol or diesel.

Hydrogen can be used to power fuel cells. In a fuel cell, hydrogen is chemically combined with oxygen to generate electricity to run the car.

Hydrogen can be produced from natural gas or from water.

9A There are several reasons why this research is being carried out.

Which of the following is **not** one of the reasons?

1 There could be a shortage of petrol and diesel in the future.

2 There is political pressure to increase the number of cars on the road.

3 Petrol and diesel are obtained from a non-renewable source.

4 There is political pressure to reduce carbon emissions.

9B One reason why there are only a few hydrogen-powered cars on the road is that . . .

1 the raw materials to make hydrogen are scarce.

2 only water is produced when hydrogen burns.

3 fuel cell technology has been difficult to develop.

4 hydrogen-powered cars are made by only a few companies.

9C The development of hydrogen as a fuel for cars could be delayed even further if . . .

1 new, large deposits of crude oil are discovered.

2 a safe way of storing hydrogen is found.

3 hydrogen can be made more cheaply.

4 global warming continues to be a concern.

4.5.2.2 Fuel cells

Question 04 · continued

9D The very rare and expensive metal called palladium is capable of storing many hundreds of times its own volume of hydrogen.

Which statement would be true if palladium was used in hydrogen-powered cars?

1 The increased demand for palladium would cause its price to fall.

2 Hydrogen that had been stored in palladium would have a lower density.

3 Hydrogen that had been stored in palladium would be hard to burn.

4 The cars would be safer than those that store hydrogen in pressurised cylinders.

END OF TEST

4.5.2.2 Fuel cells

Question 05

June 2014 | CH3HP | Original Q6 | Legacy

6 Some cars are powered by hydrogen fuel cells.

Figure 6



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

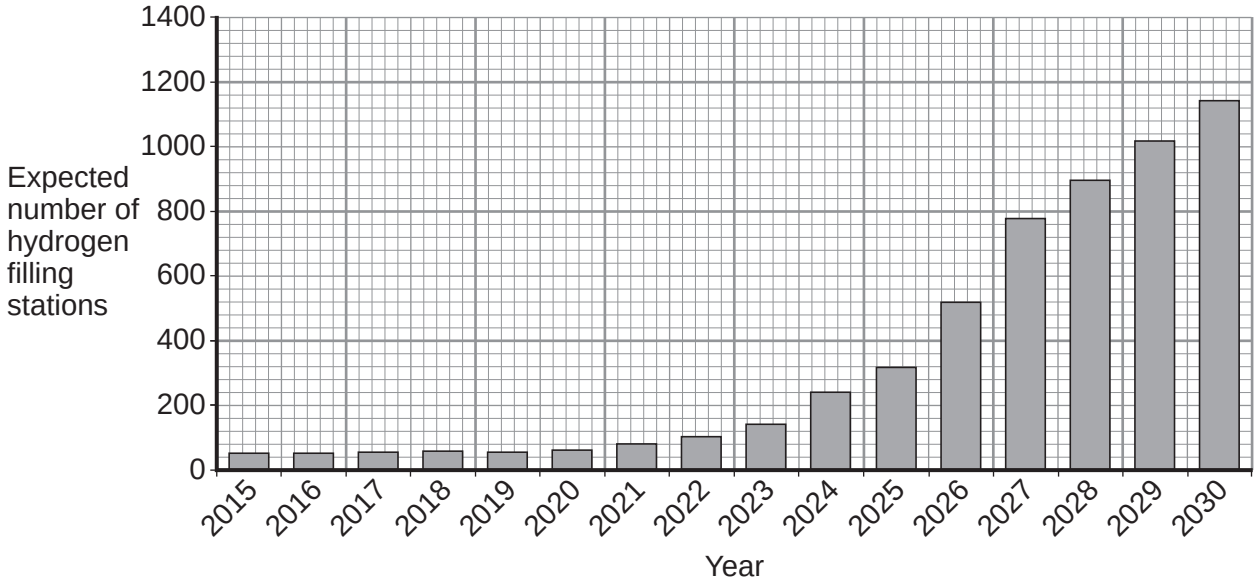
[1 mark]

.....

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

Figure 7 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

Figure 7



4.5.2.2 Fuel cells

Question 05 · continued

Use the information in **Figure 7** 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 marks]

.....

.....

.....

.....

.....

Question 6 continues on the next page

Question 05 · continued

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

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

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.

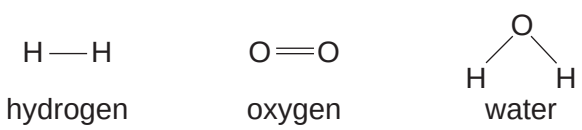
Bond energies for the reaction are given in **Table 1**.

Table 1

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 8**.

Figure 8



hydrogen oxygen water

6 (c) (i) Calculate the energy change for the reaction:

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

[3 marks]

.....

.....

.....

.....

.....

.....

Energy change = ... kJ

4.5.2.2 Fuel cells

Question 05 · continued

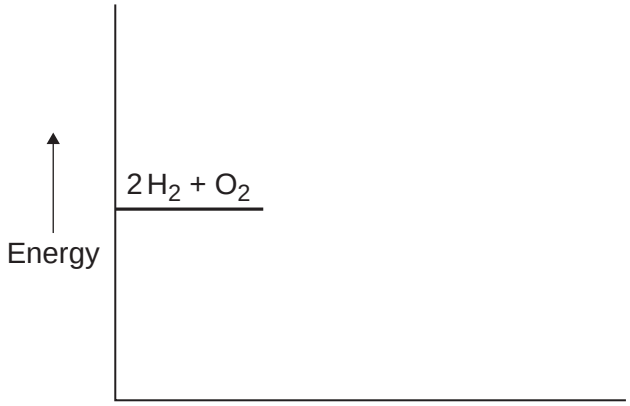
6 (c) (ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 9**.

Clearly label the activation energy.

[3 marks]

Figure 9



9

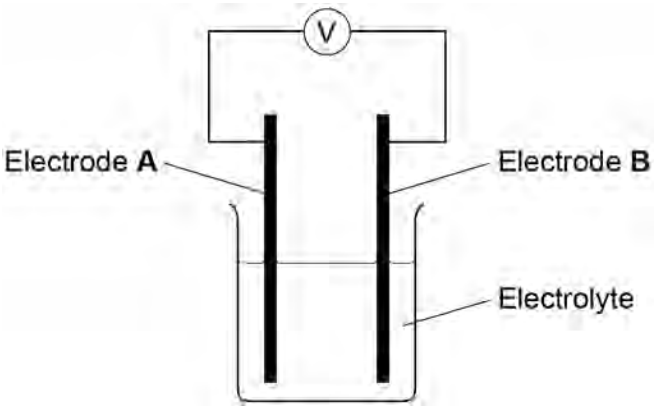
4.5.2.2 Fuel cells

Question 06

0 3 Chemical reactions can produce electricity.

0 3 . 1 **Figure 2** shows a simple cell.

Figure 2



Which of these combinations would **not** give a zero reading on the voltmeter in **Figure 2**?

[1 mark]

Tick **one** box.

Electrode A	Electrode B	Electrolyte	
Copper	Copper	Sodium chloride solution	☐
Zinc	Zinc	Water	☐
Copper	Zinc	Sodium chloride solution	☐
Copper	Zinc	Water	☐

4.5.2.2 Fuel cells

Question 06 · continued

Alkaline batteries are non-rechargeable.

0 3 . 2 Why do alkaline batteries eventually stop working?

[1 mark]

0 3 . 3 Why can alkaline batteries **not** be recharged?

[1 mark]

Question 3 continues on the next page

Question 06 · continued

Hydrogen fuel cells and rechargeable lithium-ion batteries can be used to power electric cars.

0 3 . 4 Complete the balanced equation for the overall reaction in a hydrogen fuel cell.

[2 marks]

_____ H_2 + _____ → _____ H_2O

0 3 . 5 **Table 1** shows data about different ways to power electric cars.

Table 1

	Hydrogen fuel cell	Rechargeable lithium-ion battery
Time taken to refuel or recharge in minutes	5	30
Distance travelled before refuelling or recharging in miles	Up to 415	Up to 240
Distance travelled per unit of energy in km	22	66
Cost of refuelling or recharging in £	50	3
Minimum cost of car in £	60 000	18 000

Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use **Table 1** and your own knowledge.

[6 marks]

4.5.2.2 Fuel cells

Question 06 · continued

June 2018 | 8462/1H | Original Q3

4.5.2.2 Fuel cells

Question 07

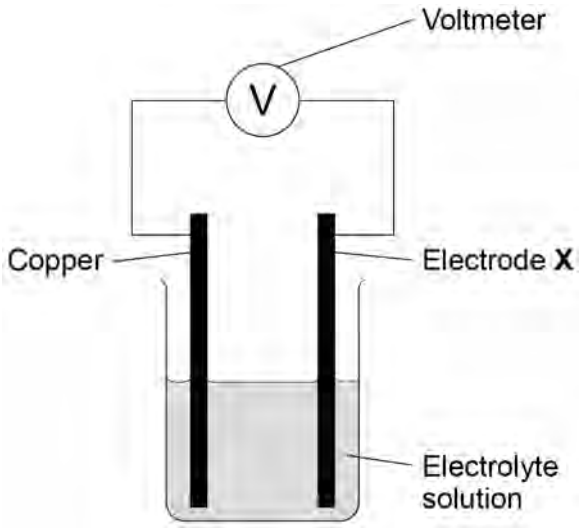
June 2019 | 8462/1H | Original Q6

0 6 This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 9 shows the apparatus.

Figure 9



This is the method used.

1. Use cobalt as electrode **X**.

2. Record the cell voltage.

3. Repeat steps 1 and 2 using different metals as electrode **X**.

0 6 . 1 Suggest **two** control variables used in this investigation.

[2 marks]

1 _____

_____

2 _____

_____

4.5.2.2 Fuel cells

Table 4 shows the student's results.

Table 4

Electrode X	Voltage of cell in volts
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	–0.46
tin	+0.48

0 6 . 2 Write the six metals used for electrode **X** in order of reactivity.

Use **Table 4**.

Justify your order of reactivity.

[4 marks]

Most reactive _____

_____

_____

_____

_____

Least reactive _____

Justification _____

_____

_____

_____

_____

4.5.2.2 Fuel cells

Question 07 · continued

0 6 . 3 Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

- Magnesium and cobalt ☐
- Magnesium and tin ☐
- Nickel and cobalt ☐
- Nickel and tin ☐

0 6 . 4 Hydrogen fuel cells can be used to power different forms of transport.

Some diesel trains are being converted to run on hydrogen fuel cells.

A newspaper article referred to the converted trains as the new 'steam trains'.

Suggest why.

[2 marks]

9

4.5.2.2 Fuel cells

Question 08

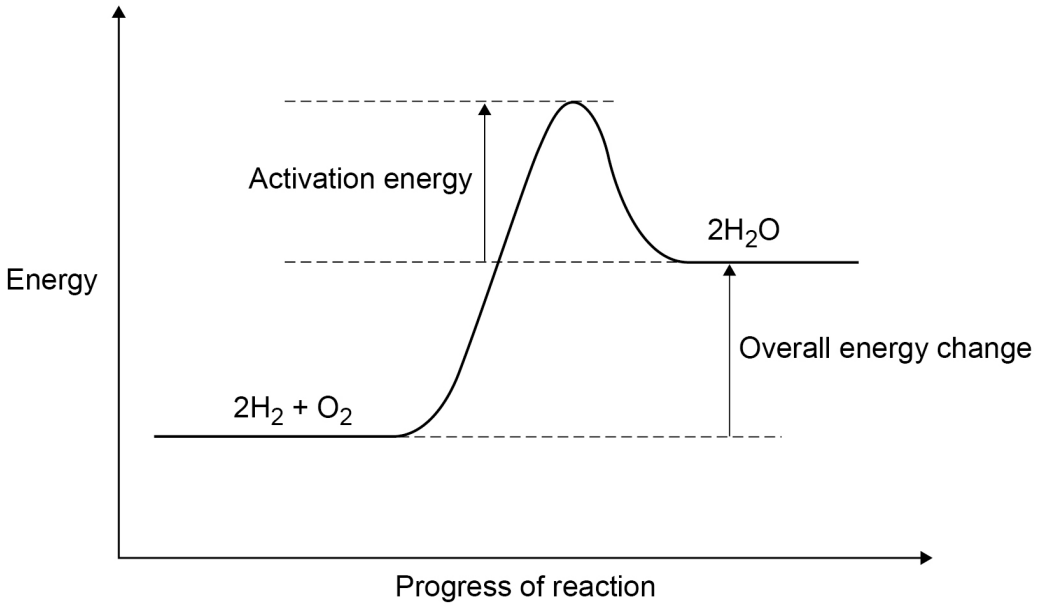
November 2020 | 8462/1H | Original Q7

0 7 The reaction between hydrogen and oxygen releases energy.

0 7 . 1 A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 3 shows the student's reaction profile.

Figure 3



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

[2 marks]

1 _____

_____

2 _____

_____

4.5.2.2 Fuel cells

Question 08 · continued

0 7 . 2 The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars.

[2 marks]

1 _____

_____

2 _____

_____

0 7 . 3 Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions.

[1 mark]

_____

Question 7 continues on the next page

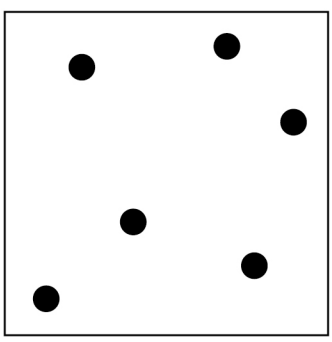
4.5.2.2 Fuel cells

Question 08 · continued

0 7 . 4 The three states of matter can be represented by a simple particle model.

Figure 4 shows a simple particle model for hydrogen gas.

Figure 4



Give **two** limitations of this simple particle model for hydrogen gas.

[2 marks]

1 _____

_____

2 _____

_____

0 7 . 5 The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

[1 mark]

_____

_____

4.5.2.2 Fuel cells

Question 08 · continued

0 7 . 6 The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58 megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km

[4 marks]

Volume of hydrogen gas = _____ dm^3

12

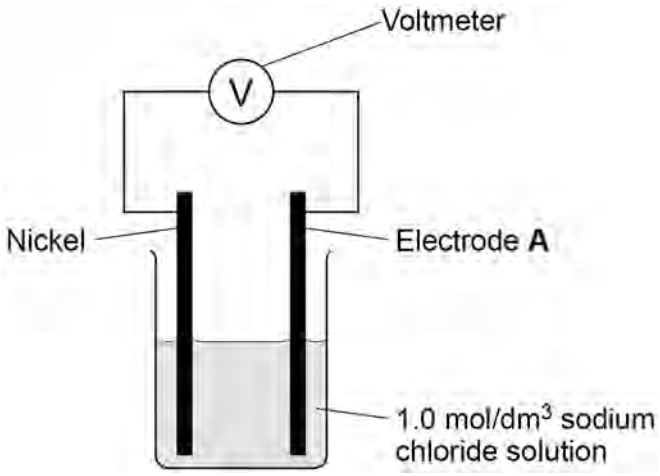
4.5.2.2 Fuel cells

Question 09

0 6 A student investigated the voltage produced by different pairs of metal electrodes in a chemical cell.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Place a nickel electrode and an electrode made from a different metal (electrode **A**) in 1.0 mol/dm^3 sodium chloride solution.
2. Measure the voltage produced.
3. Repeat using different metals for electrode **A**.

Table 3 shows the results.

Table 3

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	–0.59
Magnesium	Mg	2.12
Nickel	Ni	0.00
Silver	Ag	–1.05
Zinc	Zn	0.51

4.5.2.2 Fuel cells

Question 09 · continued

0 6 . 1 Write the symbols of the five metals in **Table 3** in order of reactivity.

Justify your answer.

[3 marks]

Most reactive _____ _____ _____ _____ _____ Least reactive

Justification _____

_____

0 6 . 2 The voltage produced by a chemical cell depends on the concentration of the electrolyte solution.

Plan an experiment to investigate how the voltage produced by a chemical cell varies with the **concentration** of the electrolyte solution.

The following substances are available:

- the metal electrodes in **Table 3**
- 1.0 mol/dm^3 sodium chloride solution
- pure water.

[6 marks]

4.5.2.2 Fuel cells

Question 09 · continued

0 6 . 3 Describe how a hydrogen fuel cell produces a potential difference.

[2 marks]

11

4.5.2.2 Fuel cells

Question 10

June 2025 | 8462/1H | Original Q7

0 7 Hydrazine (N_2H_4) is a compound of nitrogen and hydrogen.

0 7 . 1 Scientists are researching the use of hydrazine in fuel cells.

Table 2 gives some information about the use of hydrogen and hydrazine in fuel cells.

Table 2

	Hydrogen	**Hydrazine**
State at room temperature	Gas	Liquid
Hazards	Explosive	Toxic
Equation for fuel cell reaction	$2\ H_2\ +\ O_2\ \longrightarrow\ 2\ H_2O$	$N_2H_4\ +\ O_2\ \longrightarrow\ N_2\ +\ 2\ H_2O$
Voltage produced in volts	1.23	1.61
Catalyst needed for reaction	Platinum	None

Evaluate the use of hydrazine instead of hydrogen in a fuel cell.

[4 marks]

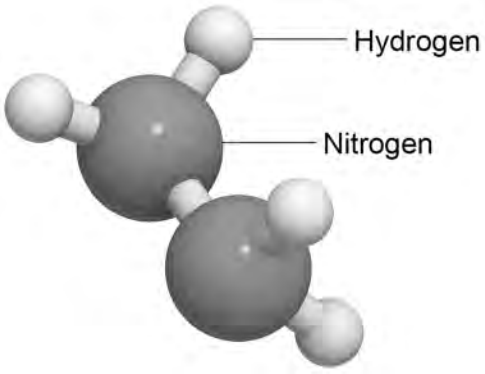
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4.5.2.2 Fuel cells

Question 10 · continued

Figure 6 shows a model of the hydrazine molecule.

Figure 6

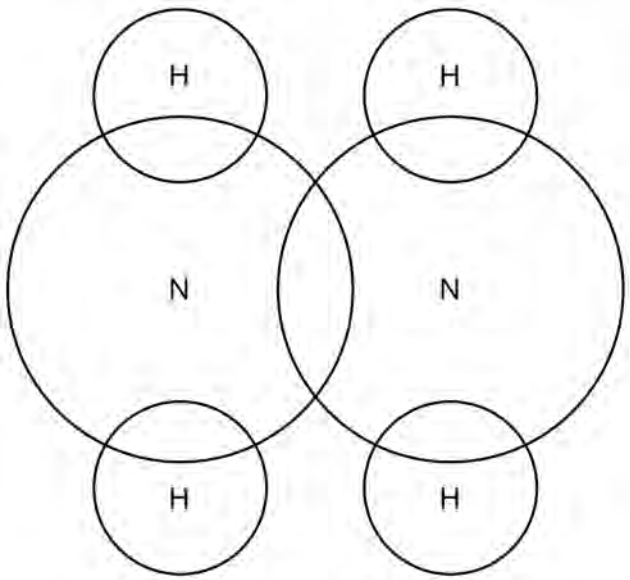


0 7 . 2 Complete the dot and cross diagram for hydrazine in **Figure 7**.

Show the outer shell electrons only.

[2 marks]

Figure 7

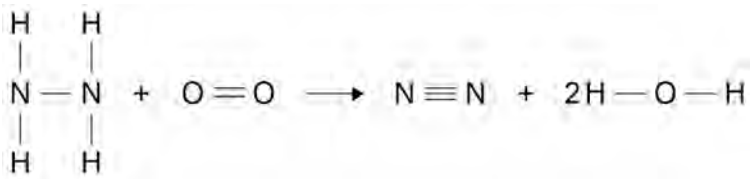


0 7 . 3 Give **one** advantage of the ball and stick model in **Figure 6** compared to the dot and cross diagram.

[1 mark]

0 7 . 4 **Figure 8** shows the displayed formula equation for the reaction of hydrazine with oxygen.

Figure 8



The reaction is exothermic.

The energy released forming new bonds is 581 kJ/mol greater than the energy needed to break existing bonds.

Table 3 shows some bond energies.

Table 3

Bond	N — N	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	X	391	498	945	464

Calculate the bond energy (**X**) of the N — N bond.

[4 marks]

X = _____ kJ/mol

11