All questions are for separate science students only

Q1.

This question is about chemical cells and batteries.

(a) Three different types of battery can be used to power a TV remote control.

The table below gives information about these batteries.

	Zinc-carbon battery	Alkaline battery	Nickel-metal hydride battery
Cost of battery in £ (pounds)	0.17	0.50	1.50
Rechargeable?	No	No	Yes
Time before needing to replace or recharge in months	5	12	8

Give one advantage of each type of battery.

Zinc-carbon _____

_____

Alkaline _____

_____

Nickel-metal hydride _____

_____

(3)

(b) Figure 1 shows a symbol printed on batteries.

Figure 1

This symbol shows that batteries should not be put in household waste. Suggest why batteries should not be put in household waste.

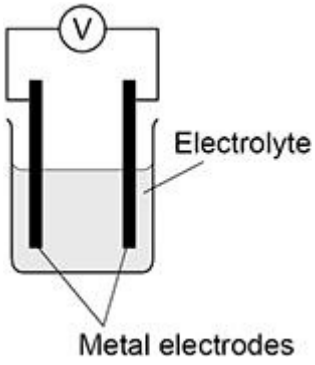
_____

_____

(1)

Figure 2 shows a chemical cell.

Figure 2



(c) The order of reactivity of three metals is shown below.

Iron	(Most reactive)
Tin	↑
Copper	(Least reactive)

Which combination of metal electrodes would give the highest voltage in the chemical cell in Figure 2?
Tick (✓) one box.

Copper and iron ☐

Iron and tin ☐

Tin and copper ☐

(1)

(d) The voltage produced by the cell in Figure 2 depends on the type of electrodes and the type of electrolyte.

Suggest one other factor that could affect the voltage produced.

_____

_____

(1)

(e) Water is produced in a hydrogen fuel cell.

Complete the word equation to show the reaction that produces water in a hydrogen fuel cell.

_____ + _____ → water

(2)
(Total 8 marks)

Q2.

This question is about chemical reactions and energy.

Hydrogen reacts with oxygen to produce water.

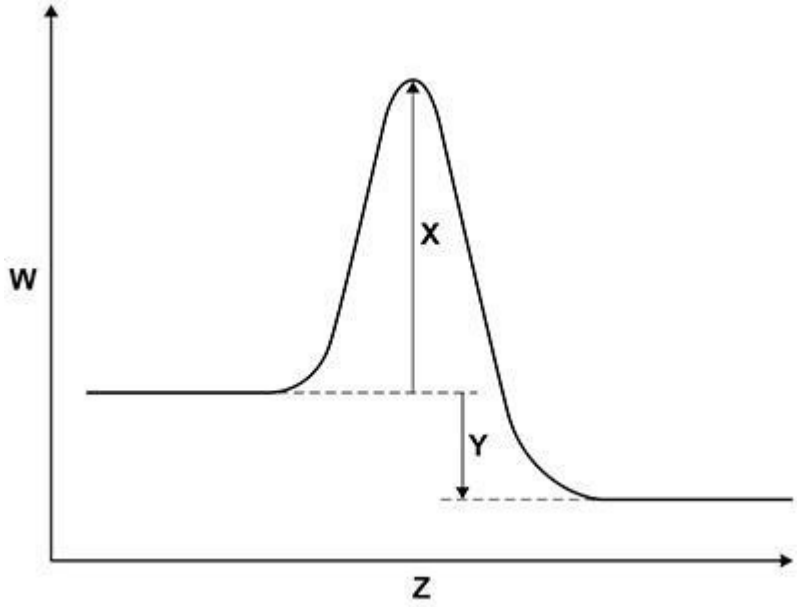
This reaction releases energy.

(a) Complete the word equation for the reaction.

hydrogen + oxygen → _____

(1)

(b) The graph below shows a reaction profile for the reaction between hydrogen and oxygen.



What do the labels W, X, Y and Zrepresent?

Choose answers from the box.

activation energy	energy	overall energy change
products	progress of reaction	reactants

W _____

X _____

Y _____

Z _____

(4)

(c) The reaction between hydrogen and oxygen is used in a hydrogen fuel cell.

What is the reason for using this reaction in a fuel cell?

Tick (✓) one box.

To produce a change of state	☐
To produce a potential difference	☐
To produce a temperature change	☐

(1)

(d) A student investigated the voltage produced by a chemical cell.

The student used different metals as the electrodes in the cell.

The metals used were:

- copper
- iron
- magnesium.

Which two metal electrodes would produce the greatest voltage when used in the chemical cell?
Give one reason for your answer.

Metals _____ and _____

Reason _____

_____

(2)

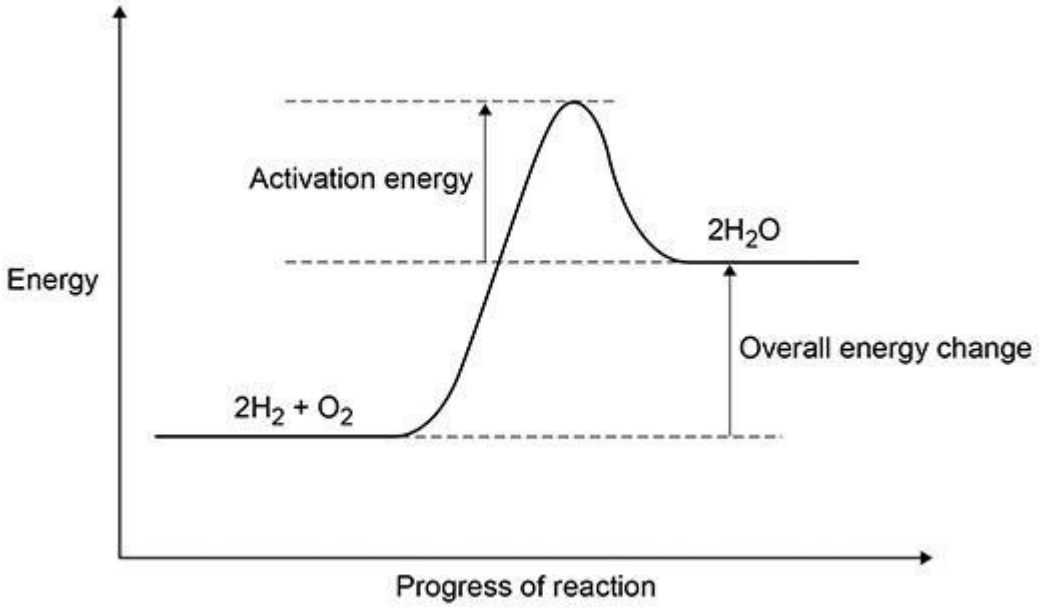
(Total 8 marks)

Q3.

The reaction between hydrogen and oxygen releases energy.

(a) A student drew a reaction profile for the reaction between hydrogen and oxygen.
Figure 1 shows the student's reaction profile.

Figure 1



The student made two errors when drawing the reaction profile.

Describe the two errors. 1

_____

_____ 2

_____

_____

(2)

(b) 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.

1 _____

_____

2 _____

_____

(2)

(c) 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.

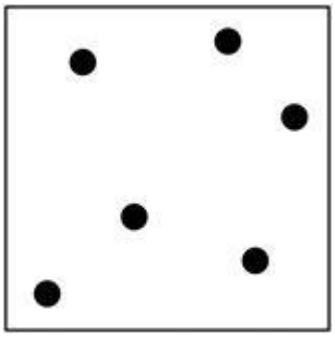
_____

(1)

(d) The three states of matter can be represented by a simple particle model.

Figure 2 shows a simple particle model for hydrogen gas.

Figure 2



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

1 _____

_____

2 _____

_____

(2)

(e) 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)

(f) 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 dm3

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

_____

_____

_____

_____

_____

_____

_____

_____

Volume of hydrogen gas = _____ dm3

(4)

(Total 12 marks)

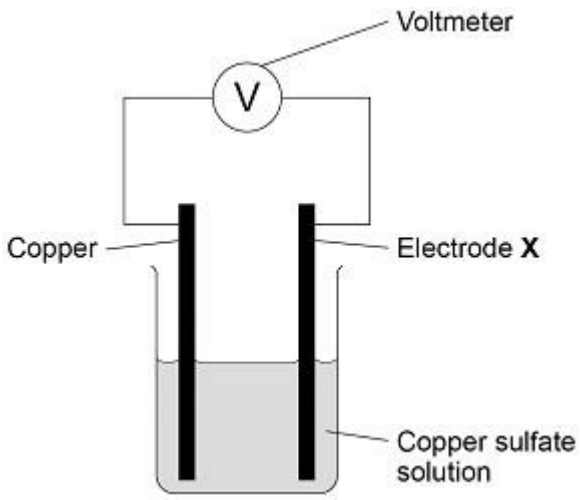
Q4.

This question is about chemical cells and batteries.

A student investigated the voltage produced by different chemical cells.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Use cobalt metal as electrode X.

2. Record the cell voltage.

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

(a) Suggest two variables the student should keep the same to make the investigation valid.

1 _____

_____

2 _____

_____

(2)

The following table shows the student's results.

Electrode X	Voltage of the cell in volts
cobalt	0.62
magnesium	2.71
zinc	1.10

(b) Write the three metals used for electrode X in order of reactivity.

Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) Copper is used as electrode X in Figure 1.

Predict the voltage of this cell.

Give one reason for your answer.

Voltage = _____ volts

Reason_____

_____

(2)

(d) Describe how to make a 12 V battery using 1.5 V cells.

_____

_____

_____

_____

(2)

(e) Which is the most suitable use for a non-rechargeable cell?

Tick (√) one box.

Electric toy ☐

Laptop computer ☐

Mobile phone ☐

(1)

(f) Hydrogen fuel cells or rechargeable cells can be used to power electric vehicles.

Suggest one advantage and one disadvantage of using a hydrogen fuel cell compared with a rechargeable cell.

Advantage of hydrogen fuel cell _____

_____

Disadvantage of hydrogen fuel cell _____

_____

(2)

(Total 10 marks)

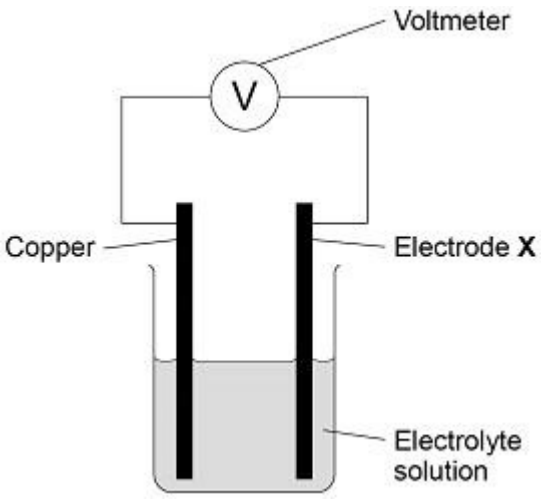
Q5.

This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 1 shows the apparatus.

Figure 1



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.

(a) Suggest two control variables used in this investigation. 1

_____

_____ 2

_____

_____

(2)

The following table shows the student's results.

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

(b) Write the six metals used for electrode X in order of reactivity.

Use the table above.

Justify your order of reactivity.

Most reactive _____

_____

_____

_____

_____

Least reactive _____

Justification

_____

_____

_____

_____

_____

(4)

(c) Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use the table above.

Tick (✓) one box.

Magnesium and cobalt ☐

Magnesium and tin ☐

Nickel and cobalt ☐

Nickel and tin ☐

(1)

(d) 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.

_____

_____

_____

_____

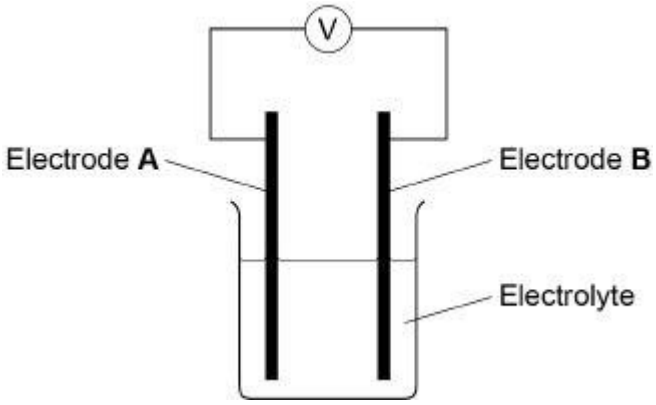
(2)

(Total 9 marks)

Q6.

Chemical reactions can produce electricity.

(a) The diagram below shows a simple cell.



Which of these combinations would not give a zero reading on the voltmeter in the diagram above?
Tick one box.

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

(1)

Alkaline batteries are non-rechargeable.

(b) Why do alkaline batteries eventually stop working?

_____

_____

(1)

(c) Why can alkaline batteries not be recharged?

_____

_____

(1)

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

(d) Complete the balanced equation for the overall reaction in a hydrogen fuel cell.

_____ H_2 + _____ → _____ H_2O

(2)

(e) The table below shows data about different ways to power electric cars.

	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 the table above and your own knowledge.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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_____

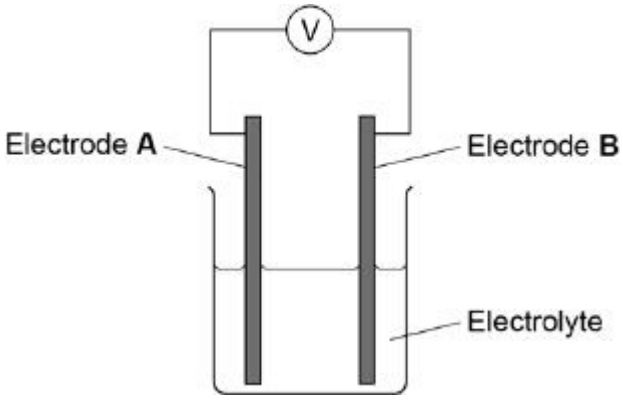
(6)

(Total 11 marks)

Q7.

A student investigated the voltage produced by simple cells.

The diagram shows the apparatus used.



The table shows the voltage produced with different metal electrodes.

Electrode A	Electrode B	Voltage in V
Copper	Copper	0.00
Copper	Iron	0.78
Copper	Magnesium	2.71
Copper	Tin	0.48
Copper	Zinc	1.10

(a) List the metals in the table in order of reactivity.

Most reactive _____

_____

_____

_____

Least reactive Copper

(2)

(b) Batteries consist of cells. Describe how a 6.0 V battery can be made from cells of voltage 1.5 V

_____

_____

_____

_____

(2)

(c) Why do non-rechargeable cells stop producing electricity?

_____

_____

_____

_____

(2)

(d) Complete the word equation for the reaction in a hydrogen fuel cell.

hydrogen + _____ → water

(1)

(e) Give two reasons why using a hydrogen fuel cell is seen as non-polluting.

Use the equation in part (d).

1. _____

_____

2. _____

_____

(2)

(Total 9 marks)

Q8.

Cells contain chemicals which react to produce electricity.

(a) Why can a rechargeable cell be recharged?

_____

_____

(1)

(b) Give two factors that affect the voltage produced by a cell. 1.

_____ 2.

_____

(2)

(c) Balance the half-equation for the reaction occurring at an electrode in one type of hydrogen fuel cell.

$$H_2 + OH^- \rightarrow H_2O + e^-$$

(1)

(d) Why is the fuel cell in Question (c) described as an alkaline fuel cell?

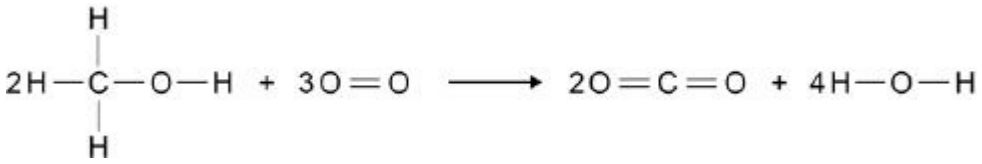
_____

_____

(1)

(e) Another type of fuel cell uses methanol instead of hydrogen.

The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

	C–H	C–O	O–H	O=O	C=O
Bond energy in kJ / mol	412	360	464	498	805

Calculate the overall energy change for the reaction.

Use the diagram and the table above.

_____

_____

_____

_____

_____

_____

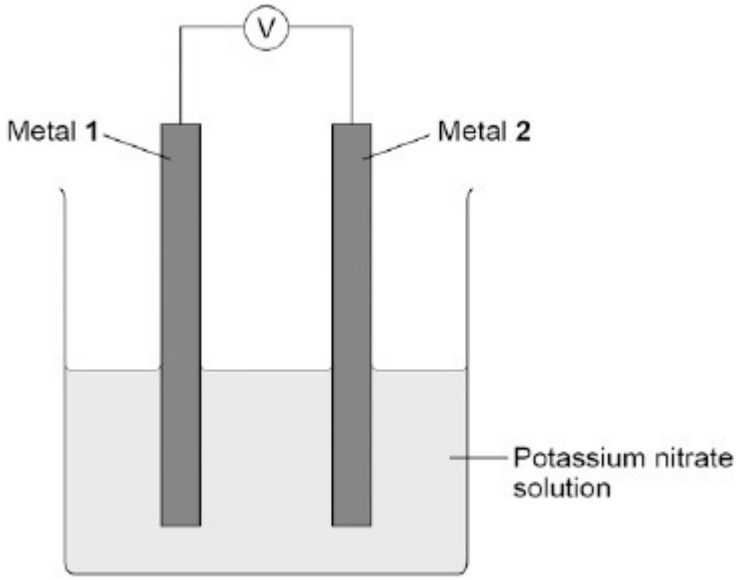
Overall energy change = _____ kJ / mol

(3)

(Total 8 marks)

Q9.

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:

$$Zn \rightarrow Zn2+ + 2e-$$

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)