Background pattern

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**Year 10 – Teacher Booklet**

Key Stage 4 Science:

**Energy Changes**

Graphical user interface, text, application

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Shape

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Icon

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**This booklet is for use in your Science lessons. Please look after it in the same way you would your exercise book and ensure that your presentation is always PROUD.**

**Ensure that your booklet is returned to your class book box at the end of the lesson.**

**Lesson Breakdown**

Lesson 1: Exothermic and endothermic reactions (including evaluating applications).

Lesson 2: Required practical.

Lesson 3: Required practical – analysis and application.

Lesson 4: Representing exothermic and endothermic reactions graphically.

Lesson 5: (HT only). Calculating energy transferred in chemical reactions.

Lesson 6: (Chemistry only). Cells and batteries.

Lesson 7: (Chemistry only). Fuel cells.

**Keystone words**

1. Energy

2. Exothermic

3. Endothermic

4. Profile

5. Temperature

6. Activation

**Lesson 1: Exothermic and endothermic reactions (including evaluating applications).**

**Objective: You are learning to evaluate what people use endothermic and exothermic reactions for.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

In the KS4 Chemical Changes topic you learnt about the Reactivity Series.

You also learnt to determine the order of reactivity of different metals by observing what happens when they react.

The image below shows what happens when different metals are added to acid.

A picture containing text, cartoon, drawing, illustration

Description automatically generated

1. List the metals in order of reactivity.

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1. Explain how you can tell a chemical reaction is happening using information in the image.

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**Notes**

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Reactants Products Surroundings

Reactants Products Surroundings

1. Explain why exothermic reactions make the environment warmer.

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1. Explain why endothermic reactions make the environment cooler.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. The accountancy method can be used to show that the total amount of energy in the Universe is conserved.

For each situation shown below:

1. Identify whether it shows an exothermic or endothermic reaction.
2. Explain your reasoning.

1.

A picture containing text, screenshot, line, number

Description automatically generated

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2.

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3.

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Reactants Products Surroundings

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**Evaluations:**

In 2001, Nestle launched self-heating cans that could be used to produce hot drinks on demand. They competed for the same market as thermos flasks.

**Use the information provided below, and your own knowledge, to evaluate the use of self-heating cans.**

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Thermos** | **Self-heating can** |
| Maximum temperature | 100oC | 73oC |
| Temperature at time of use | Depends on when hot water was added. | 73oC |
| Source of heat | Kettle | Chemical reaction |
| Reusable | Yes | No |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Evaluations:**

Sports injuries are often treated by cooling them to reduce inflammation. This can reduce recovery time quite dramatically.

Traditionally, ice was used to cool the injured area. However, chemical-based sports injury packs, that use endothermic reactions, are now used.

**Evaluate the use of chemical-based sports injury packs using the information below and your own knowledge.**

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Sports injury ice pack** | **Ice** |
| Minimum temperature | 8oC | 0oC |
| Temperature at time of use | Depends on when hot water was added. | 73oC |
| Source of low temperature | Chemical reaction. | Physical change when cooled in freezer. |
| Reusable | No | Yes |

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**Lesson 2: Required practical.**

**Objective: You are learning how to carry out a practical to measure energy changes. You must do this safely.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
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**I wasn’t there but I still care. Using Chemistry text book pages 114, 115, 272**

**Define an endothermic reaction.**

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**Define an exothermic reaction.**

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**Which everyday products use endothermic principles?**

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**Which everyday products use exothermic principles?**

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**Connect:**

**Draw the following pieces of apparatus:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test tube** | **Beaker** | **Conical flask** | **Measuring cylinder** | **Tripod** |
|  |  |  |  |  |

Which piece of equipment should be used to measure temperature?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Which piece of equipment could be used to measure volume of liquids?

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What is a thermal insulator? Give an example.

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Thermal insulators are used in everyday items. Give examples of these everyday items and say how they work

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**Notes**

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**Method**

1. Measure 30 cm3 dilute hydrochloric acid and put it into the polystyrene cup.

2. Stand the cup inside the beaker. This will make it more stable.

3. Use the thermometer to measure the temperature of the acid. Record your result in a table like this.

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Description automatically generated

4. Measure 5 cm3 sodium hydroxide solution.

5. Pour the sodium hydroxide into the polystyrene cup. Fit the lid and gently stir the solution with the thermometer through the hole.

6. Look carefully at the temperature rise on the thermometer.

7. When the reading on the thermometer stops changing, record the highest temperature reached in the table.

8. Repeat steps 4–7 to add further 5 cm3amounts of sodium hydroxide to the cup each time, recording your temperature reading in the results table.

9. Repeat until a maximum of 40cm3of sodium hydroxide has been added.

10. Wash out all the equipment and repeat the experiment for your second trial.

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**Types of variables**

**For the investigation described above, identify:**

1. **Independent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
2. **Dependent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
3. **Control variables: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Hazards, risks and control measures.**

For the hazards identified below, identify the risk and appropriate control measures.

Identify a fourth hazard and the associated risks and control measures / risk reductions.

|  |  |  |
| --- | --- | --- |
| Hazard | Risk | Control measures / risk reductions. |
| Use of hydrochloric acid. |  |  |
| Use of sodium hydroxide. |  |  |
| Stirring the mixture with a thermometer. |  |  |
|  |  |  |

**Complete your results table and work out the mean value for each volume of sodium hydroxide used.**

**Record these values in your results table.**

1. **Show how you calculated the mean value for the reactions where 20cm3 of sodium hydroxide were reacted with 30cm3 of hydrochloric acid.**

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1. **You repeated each experiment twice. Why can’t you calculate a meaningful mode value?**

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1. **Why can’t you calculate the median value for each volume of sodium hydroxide used?**

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1. **Systematic errors make results less accurate (the larger the systematic error, the further the results are from the true value).**

**What might have caused systematic errors in the measurement of temperature in your experiment?**

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**Lesson 3: Required practical – analysis and application.**

**Objective: You are learning how to carry out a practical to measure energy changes. You must do this safely.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there but I still care:**

**Last lesson was a required practical. Below is a set of results you can use.**

**Calculate the mean ready for drawing your graph.**

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**Connect:**

You have studied insulation in the key stage 3 topic Heating and cooling.

List a minimum of 3 ways in which we insulate our homes.

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**Notes**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Plot the results that you obtained yesterday.**

The x-axis should show the independent variable (volume of sodium hydroxide added).

The -axis should show the dependent variable (mean maximum temperature).

A graph paper with blue grid

Description automatically generated with low confidence

**Conclusion.**

1. **Describe the shape of your graph.**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **Write a simple conclusion that relates your independent variable and dependent variable.**

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1. **Look back at the other lessons in this topic. What scientific ideas could you use to explain the shape of your graph?**

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1. **Use the scientific ideas that you identified to explain the shape of your graph.**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Q1.**

Many people use a sleeping bag when they sleep in a tent. Sleeping bags, designed to keep a person warm, have a fibre filling.

A picture containing black, darkness

Description automatically generatedA picture containing sketch, drawing, kitchenware, art

Description automatically generated

(i)      Complete the sentence by choosing the correct words from the box.

|  |
| --- |
| conduction      convection       radiation |

The fibre is designed to reduce heat transfer by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(ii)      Explain why the fibre is good at reducing heat loss from a person sleeping in the bag.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(Total 3 marks)**

**You Do Task**

**Q1.** Some students investigated the change in temperature as sodium hydroxide solution is added to dilute sulfuric acid. This is the method used.

1.     Put 25 cm3 of dilute sulfuric acid into a polystyrene cup.

2.     Measure the initial temperature of the dilute sulfuric acid.

3.     Add 4 cm3 of sodium hydroxide solution to the dilute sulfuric acid.

4.     Stir the mixture.

5.     Measure the highest temperature of the mixture.

6.     Repeat steps 3‒5 until 40 cm3 of sodium hydroxide solution have been added.

**Figure 1** shows the apparatus the student used.

**Figure 1**

**A diagram of a solution and a thermometer

Description automatically generated with low confidence**

(a)     The volume of sodium hydroxide solution is a variable. Which **two** words can be used to describe this type of variable?

Tick **two** boxes.

|  |  |
| --- | --- |
| Categoric |  |
| Continuous |  |
| Control |  |
| Dependent |  |
| Independent |  |

**(2)**

(b)     The dilute sulfuric acid has an initial temperature of 24.0 °C

**Figure 2** shows the highest temperature.

**Figure 2**

**A close-up of a thermometer

Description automatically generated**

Calculate the change in temperature.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Temperature = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ °C

**(2)**

**Figure 3** shows the students’ results.

**Figure 3**

**A picture containing line, receipt, diagram, plot

Description automatically generated**

(c)     Determine the volume of sodium hydroxide solution that gives the highest temperature change. Use **Figure 3** to help you answer this question.

Volume = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm3

**(1)**

(d)     In **Figure 3** the temperature when 16 cm3 of sodium hydroxide solution is added is anomalous. Suggest **one** error that could have been made in the method which would cause this anomalous result.

**(1)**

**Q2.** Mountaineers can warm their food in self-heating, sealed containers.

A picture containing sketch, art, drawing, black and white

Description automatically generated

(a)     The water is allowed to react with the lime. The heat from the reaction warms the food. What type of reaction causes a rise in temperature?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Some students investigated the effect of adding different sized lumps of lime to water. The results of their investigation are shown.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Temperature in °C** | | |
| **Time in minutes** | **Large lumps of lime** | **Small lumps of lime** | **Powdered lime** |
| 0 | 18 | 18 | 18 |
| 1 | 19 | 20 | 28 |
| 2 | 21 | 23 | 43 |
| 3 | 24 | 27 | 63 |
| 4 | 28 | 32 | 88 |
| 5 | 33 | 38 | 100 |

          What do these results show? Give an explanation for your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     Suggest and explain **one** disadvantage of using powdered lime to heat food.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 5 marks)**

**Q1.**

(a)     The diagram shows hot water being poured into a mug.

A picture containing sketch, drawing, black and white, design

Description automatically generated

(i)      Complete the sentence by choosing the correct words from the box. Each word may be used once or not at all.

|  |
| --- |
| air               mug               table               water |

Heat energy is being transferred from the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to

the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(1)**

(ii)     When will this transfer of heat energy stop?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     In the box are the names of four types of fuel used to heat homes.

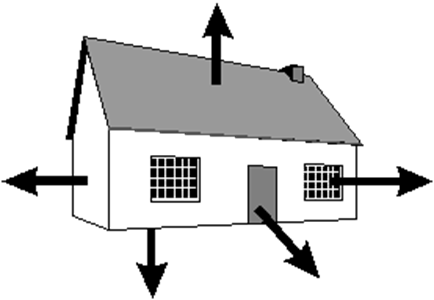
|  |
| --- |
| coal               gas               oil               wood |

Which **one** of these types of fuel is renewable?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     The diagram shows where heat energy is lost from a house.



(i)      Complete the sentences by choosing the correct words from the box. Each word may be used once or not at all.

|  |
| --- |
| conduction    conductor    electric    evaporation    insulator |

The amount of heat energy lost through the windows by

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can be reduced by using thick

curtains. The curtains trap a layer of air and air is a good

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(2)**

(ii)     Write down **one** other way of reducing heat loss from a house.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

**(Total 6 marks)**

**Lesson 4: Representing exothermic and endothermic reactions graphically.**

**Objective: You are learning about how exothermic and endothermic reactions can be representing using energy profile diagrams.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

Icon

Description automatically generated with low confidence

**I wasn’t there but I still care:**

The last lesson was a required practical – Investigating temperature changes.

Use the AQA Chemistry text book 🡪 Page 113.

1. How would you measure the temperature change in a chemical reaction?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Sketch and label a diagram of the apparatus you would need for this investigation:

Icon

Description automatically generated with low confidence

**Connect**

You studied exothermic and endothermic reactions as part of the **KS3 Chemical energy topic**.

You have also looked at them again earlier in this topic.

1. Explain, in terms of energy transfers, what happens during an exothermic reaction.

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1. Explain, in terms of energy transfers, what happens during an endothermic reaction.

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1. In order for any chemical reaction to begin, energy is needed. What name is given to this initial energy requirement?

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**Notes**

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**YOU DO (task 1):**

1. Explain, in terms of bonds being broken and bonds

being made, why some reactions are exothermic.

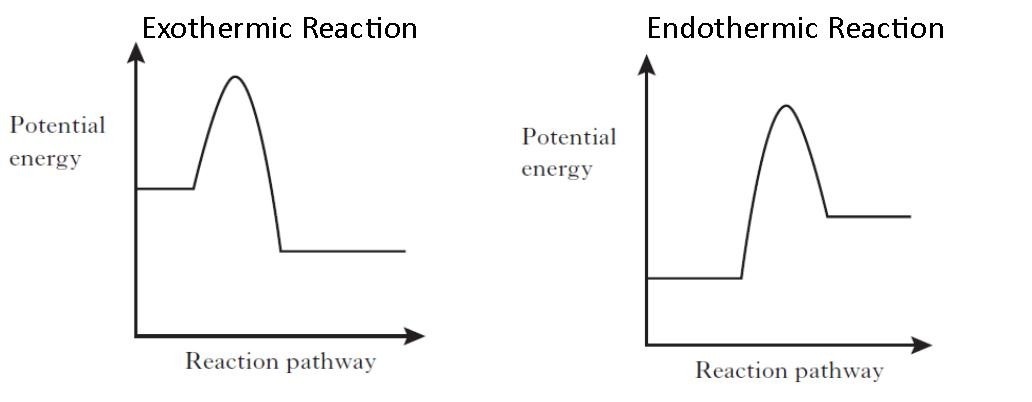
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1. Explain, in terms of bonds being broken and bonds being made, why some reactions are endothermic.

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1. Explain why reactions cannot occur without the particles first having enough energy.

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**Modelling progress:**

We have looked at exothermic reactions as those that transfer energy to their surroundings. This must mean that the products contain **less** energy than the reactants originally did.

On the contrary, endothermic reactions are those where energy must be transferred into the reaction from their surroundings. This must mean that the products have **more** energy than the reactants originally did.

We can represent these energy changes using graphs called **energy profile diagrams**:

* The x-axis represents the progress of the reaction as the reactants are turned into products.
* The y-axis represents the amount of energy in the chemical stores of the reactants and products.

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Chemical store (products)

Chemical store (products)

Chemical store (products)

Chemical store (products)

The products have more energy than the reactants. This energy is transferred in from the thermal store of the surroundings.

Chemical store (reactants)

Chemical store (reactants)

Thermal store (surroundings)

Thermal store (surroundings)

Thermal store (surroundings)

Thermal store (surroundings)

Chemical store (reactantss)

Chemical store (reactants)

The reactants have more energy than the products. This energy is transferred to the thermal store of the surroundings.

Energy profile diagrams show the same information and the energy accounting model seen previously in the **KS4 Energy topic**.

For an exothermic reaction:

For an endothermic reaction:

The advantage that energy profile diagrams have over the energy accounting model is that they can show us the activation energy needed at the start of a reaction.

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**YOU DO (task 2):**

1. For each energy profile diagram below, decide whether it would be an **exothermic** reaction or an **endothermic** reaction.
2. Compare the energy of the reactants to the energy of the products in:
   1. An exothermic reaction:

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* 1. An endothermic reaction:

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**A picture containing diagram, plan, text, line

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**YOU DO (task 3):**

Complete the following past paper questions:

**A diagram of energy

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**A picture containing text, receipt, screenshot, line

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**Lesson 5: (HT only). Calculating energy transferred in chemical reactions.**

**Objective: You are learning to calculate the energy change in chemical reactions and classify them as exothermic or endothermic**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there but I still care:**

1. What is activation energy?

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1. What is meant by ∆H?

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1. Sketch 2 reaction profiles, 1 for an exothermic reaction, 1 for an endothermic reaction.

**Connect**

Complete the following questions based on your prior learning:

1. How would you classify a chemical reaction that transferred energy to its surroundings?

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1. How could you measure the transfer of this energy to the surroundings?

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1. Sketch a graph that would represent this type of chemical reaction. Label reactants, products, activation energy and ∆H.
2. Why does diamond have a high melting point?

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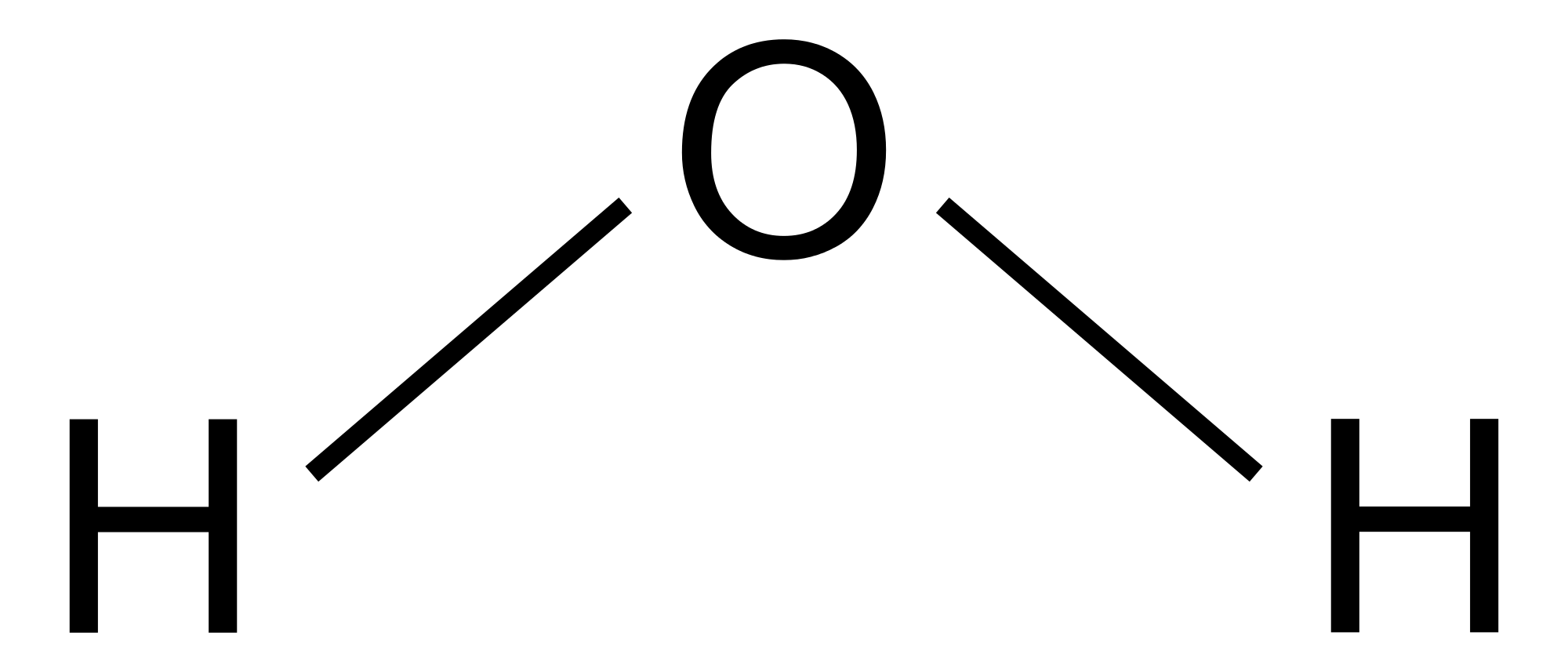
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**Notes**

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Task 1: Calculate the bond energy of the following substances:

1.  H2O, water (O-H = 428kJ/mol)

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1. A picture containing black, darkness

   Description automatically generated CO2, carbon dioxide (C=O = 799kJ/mol)

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When chemical reactions take place, the atoms that make up the reactants get rearranged into the new molecules and compounds that get produced. The atoms in these molecules are held together by strong covalent bonds. To break these covalent bonds, energy has to be put in. This separates the atoms, allowing them to rearranged into the product compounds and molecules. As the new bonds of the new substances are formed, energy is released.

Suppose a molecule has a C-H bond, and we wanted to break that bond apart into a C and an H. We’d have to put in some amount of energy. Let’s call this amount ‘x’. Once we put in x energy by, for example , adding heat, the C-H bond will break apart. What happened to ‘x’ though? The conservation of energy law says that ‘x’ didn’t just disappear; it just took on another form, in this case exciting the electrons in C and H. Some of the energy went to the C atom and some went to the H atom. If the C-H bond reformed, then ‘x’ would be released again. If the C went off and recombined with a different molecule for example a Cl, and so did the H with an F, for instance, then the energy released from the new pairings would be ‘x’ plus whatever energy the Cl and F had stored.

This energy that is required break and make bonds is called ‘bond energy’. Every bond has its own specific bond energy, and when you work out these bond energies for both the reactants and the products, you can work out if a chemical reaction is either exothermic, or endothermic overall.

This is the displayed formula of methane (CH4). The displayed formula of a substance shows the relative position of the atoms in a substance and the bonds between them:



Methane is made of C-H bonds. The central C-atom has bonded with 4 separate H-atoms. This means that methane contains 4 C-H bonds. What is the total bond energy of methane? (C-H – 413kJ/mol)

Step 1: identify the number of particular bond type that is present: 4 C-H bonds are present

Step 2: multiply the number of the particular bond type by its bond energy: 4 x 413kJ/mol

Step 3: calculate the answer with the unit: 1652kJ/mol

1652kJ/mol is amount of energy needed to break the 4 C-H bonds of methane. It is also the amount of energy that would be given out if the 4 C-H bonds were to reform and make methane.

This method can be used to work the bond energies in a chemical reaction and determine if the reaction is exothermic or endothermic. When done, the resulting answer is referred to as the enthalpy change (∆H).

Hydrogen reacts with oxygen to form water and can be represented by the following equation:

2H2 + O2 → 2H2O

The displayed formula of this reaction is:

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Description automatically generated

(H-H = 432kJ/mol, O=O = 495kJ/mol, O-H = 428kJ/mol)

To work out if the reaction is exothermic or endothermic:

Step 1: Determine what bonds are present in the reactants: 2 H-H bonds, 1 O=O bond

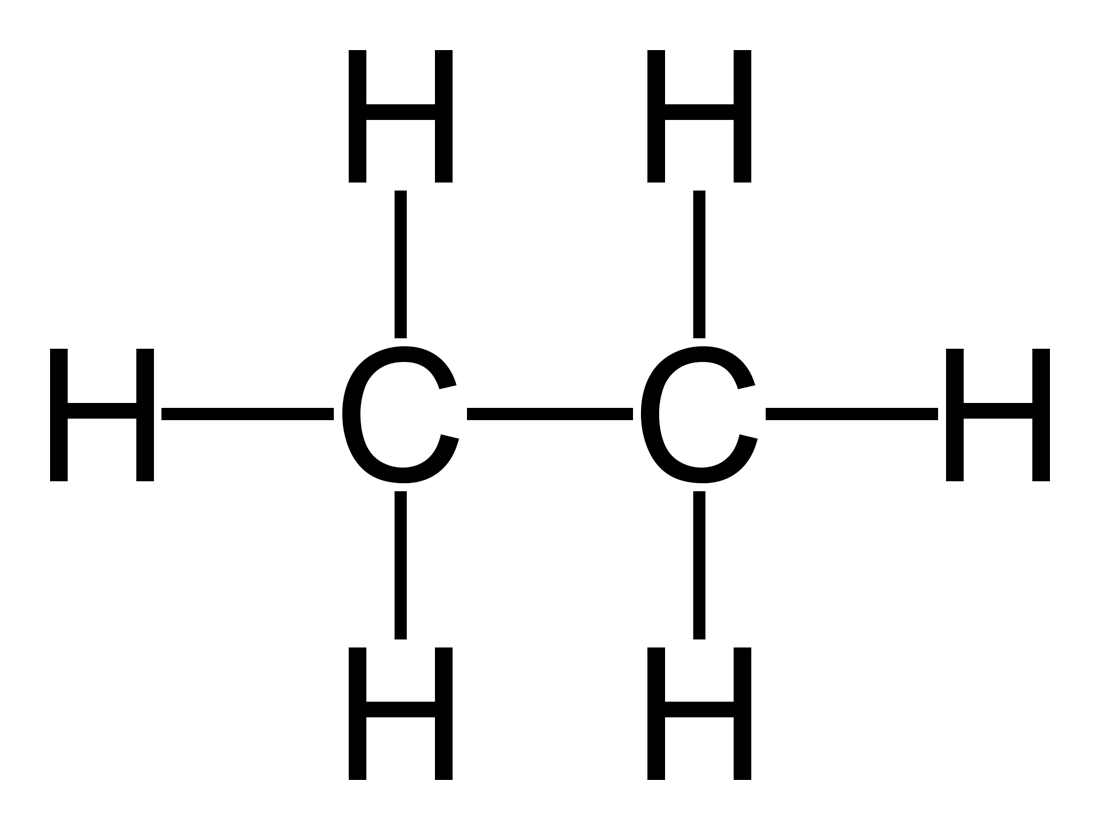
Step 2: Calculate the bond energies of the reactants: (2 x 432) + 495 = 864kJ/mol

Step 3: Determine what bonds are present in the products: 4 O-H bonds

Step 4: Calculate the bond energies of the products: 4 x 428 = 1712kJ/mol

Step 5: Reactant bond energy – Product bond energy: 864 – 1712 = -848kJ/mol

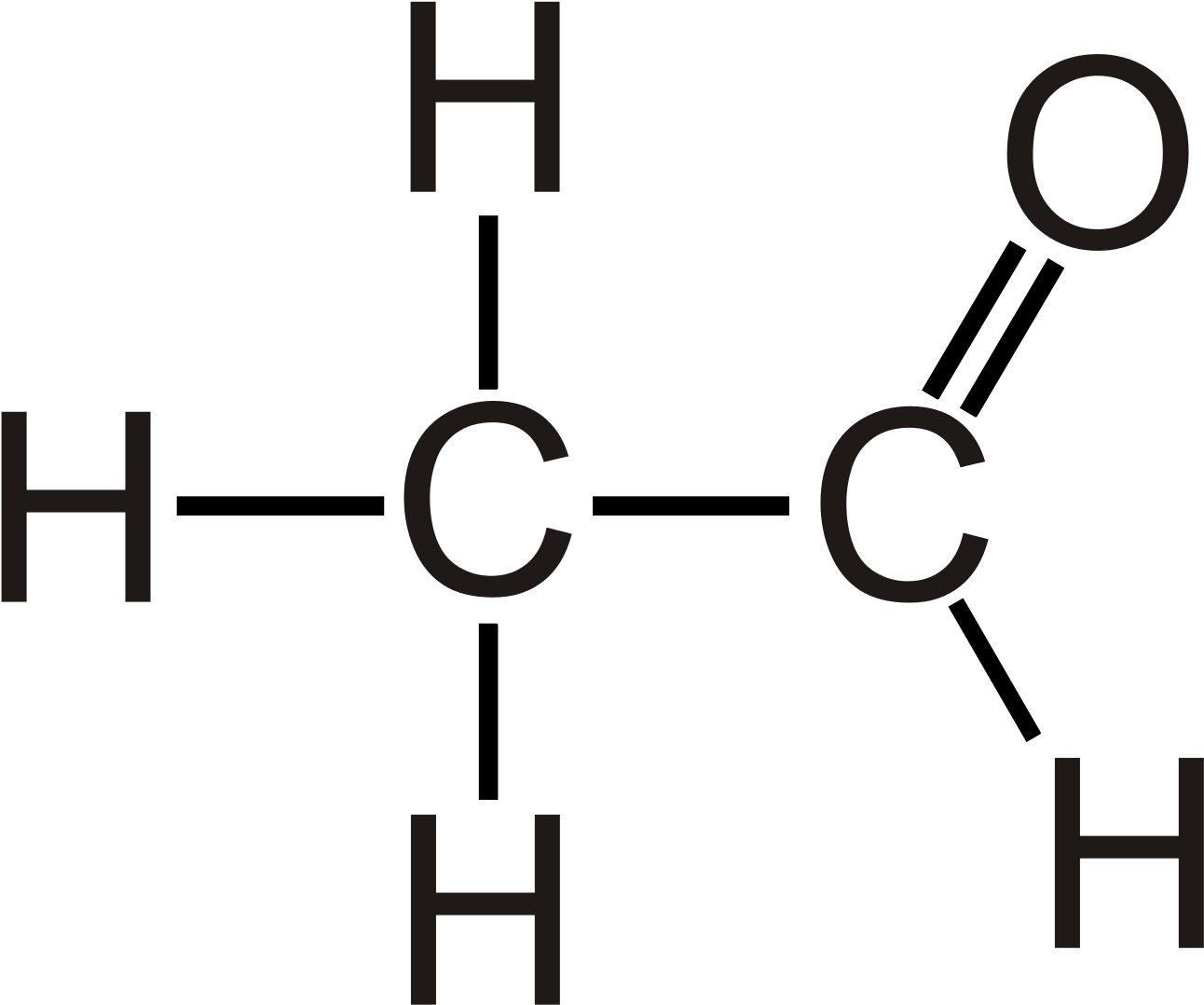
Step 6: If the answer is negative, the reaction is exothermic. The negative symbol indicates that energy is being given out to the surroundings. A positive answer means the reaction is endothermic, and that energy is being taken in from the surroundings.

1.  C2H6, ethane (C-H = 413kJ/mol, C-C = 347kJ/mol)

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1.  C2H4O, acetaldehyde (C-H = 413kJ/mol, C-C = 347kJ/mol, C=O = 799kJ/mol)

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I do:

Hydrogen and chlorine react together to form hydrogen chloride gas:

H2 + Cl2 → 2HCl

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Description automatically generated with low confidence

(H-H = 432kJ/mol, Cl-Cl = 239kJ/mol, H-Cl = 427kJ/mol)

Step 1: Determine what bonds are present in the reactants: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 2: Calculate the bond energies of the reactants: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 3: Determine what bonds are present in the products: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 4: Calculate the bond energies of the products: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 5: Reactant bond energy – Product bond energy: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 6: Positive or negative? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

We do:

Hydrogen reacts with Iodine to form Hydrogen Iodide

H2 + I2 → 2HI

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(H-H – 432kJ/mol, I-I = 149kJ/mol, H-I = 295kJ/mol)

Step 1: Determine what bonds are present in the reactants: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 2: Calculate the bond energies of the reactants: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 3: Determine what bonds are present in the products: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 4: Calculate the bond energies of the products: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 5: Reactant bond energy – Product bond energy: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 6: Positive or negative? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Task 2:

You do:

Hydrogen bromide decomposes to form hydrogen and bromine

2HBr → H2 + Br2

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(H-Br = 363kJ/mol, H-H = 432kJ/mol, Br-Br = 193kJ/mol)

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ME Time:

The following questions show you how these calculations are presented in an exam situation

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**1.**

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**5.**

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**6.**

**Lesson 6: (Chemistry only). Fuel cells.**

**Objective:** How does different combinations of metal electrodes affect the potential difference of a cell?

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there but I still care:** Support – AQA Chemistry pages 120 -121

1. Describe what a battery is.

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1. What factors affect the voltage a battery can produce?

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1. Explain the difference between rechargeable & non- rechargeable batteries.

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A logo with a puzzle piece in the middle

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In previous KS3 lessons you learnt the relative reactivity of different metals.

1. Using your knowledge of the reactivity of different metals, complete the ‘reactivity series cup’ to determine the overall most reactive metal (winner)

A student investigated the reactivity of three different metals.

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(b)     Use the results shown in table above to place zinc, copper and magnesium in order of reactivity.

Most reactive         \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

                       \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Least reactive        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     Suggest **one** reason why the student should **not** use sodium in this investigation.

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**(1)**

**Notes**

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Usually, a battery is made up of cells. The cell is what converts the chemical energy into electrical energy.

A simple cell contains two different metals (electrodes) separated by a liquid or paste called an electrolyte. When the metals are connected by wires an electrical circuit is completed.

One metal is more reactive than the other. Negatively charged electrons flow from the more reactive metal through the wires to the less reactive metal. In the diagram below, electrons flow from the magnesium to the copper. So, magnesium acts as the negative terminal of the cell, providing electrons and forms a positive ion.

Electricity will continue to flow until there is no more magnesium left to react.

**A picture containing text, screenshot, cartoon

Description automatically generated**

**What affects the voltage of a cell?**

**A blue arrow pointing up

Description automatically generated with medium confidence**

If we connect different combinations of these metals to make a cell, we find that the voltage changes.

**Practical**

A close-up of a logo

Description automatically generated with low confidence**Equipment:**

* Voltmeter
* Beakers (250cm**3**)
* Measuring cylinder
* Connecting wires with clips
* Sodium chloride (1M)
* Copper strip
* Iron strip
* Magnesium strip
* Zinc strip

**Method**

1. Measure out 100cm3of sodium chloride solution, using a measuring cylinder, in one beaker.
2. Place a strip of copper metal & and a strip of zinc in the sodium chloride solution.
3. Connect the copper strip to the anode, positive electrode, and the zinc strip to the cathode, negative electrode, of the voltmeter using the connecting wires and clips.
4. Switch on the voltmeter and record the reading.
5. Replace the zinc strip with the iron strip and magnesium & repeat.
6. Record the readings in a results table.

A screenshot of a computer

Description automatically generated

**Results**

|  |  |  |
| --- | --- | --- |
| **Anode (+ve)** | **Cathode (-ve)** | **Potential Difference (V)** |
| **Copper** | **Zinc** |  |
| **Copper** | **Iron** |  |
| **Copper** | **Magnesium** |  |
| **Copper** | **Copper** |  |
| **Iron** | **Zinc** |  |
| **Iron** | **Magnesium** |  |
| **Iron** | **Iron** |  |
| **Zinc** | **Magnesium** |  |
| **Zinc** | **Zinc** |  |
| **Magnesium** | **Magnesium** |  |

A green and white logo

Description automatically generated with low confidenceA picture containing logo, graphics, clipart, font

Description automatically generated

A picture containing text, screenshot, font, number

Description automatically generated

**Analysis & Conclusion**

1. You did four experiments where **copper** was used as the anode and different metals were used as the cathode.

Put the metals used for the cathode in order of reactivity.

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1. Compare the difference in reactivity of the metals used, to the potential difference induced.

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1. Write a conclusion that links the difference in reactivity of the electrodes to the potential difference induced.

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1. You did four experiments where **iron** was used as the anode and different metals were used as the cathode.

Put the metals used for the cathode in order of reactivity.

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1. Compare the difference in reactivity of the metals used, to the potential difference induced.

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1. Write a conclusion that links the difference in reactivity of the electrodes to the potential difference induced.

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**Synoptic**

The voltage of an electrochemical cell is related to the reactivity of the metals that it contains.

Explain why a potential is induced when electrodes are made of two different metals.

You should try to include ideas about:

1. Electronic structure of atoms.
2. Why some metals are more reactive than others.
3. Oxidation and reduction (OILRIG).

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In the below table, the positive electrodes and what they are made from are listed along the top and the negative electrodes down the side.

A screenshot of a graph

Description automatically generated with low confidence

Use the results above to explain the size of the potential between different combinations of metals.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Suggest, with reasoning, the voltage of a cell made using magnesium and silver.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Why is it not possible to make an electrical cell using two electrodes made of the same metal?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name the metal that is reduced in a cell using copper & zinc electrodes.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 7: Hydrogen Fuel Cells**

**Objective: You are learning to evaluate the use of hydrogen fuel cells in comparison with rechargeable cells and batteries.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there but I still care:**

**Figure 1** shows a chemical cell.

The voltage produced by the cell in **Figure 1** depends on the difference in reactivity between the type of electrodes, and the type of electrolyte.

**Figure 1**

**A picture containing sketch, diagram, line, white

Description automatically generated**

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 |  |

The order of reactivity of three metals is shown below.

|  |  |
| --- | --- |
| Iron | (Most reactive) |
|  |  |
| Tin |  |
| Copper | (Least reactive) |

Connect

At Key Stage 3, and in the KS4 Chemical Changes topic, you were introduced to the concept of different metals having different reactivities: reactive metals reacting with substances more rapidly than less reactive metals. You should have also observed the Group I metals (Alkali Metals) reacting with water and seen that although the reactions were similar, the rate of reaction was different.

**A close-up of a test tube

Description automatically generated with low confidence**

What can you see from the above image?

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Place the images in order from most reactive to least reactive, explain your choice.

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**Notes**

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Fuel Cell Video

<https://www.youtube.com/watch?v=MQG87a8EwzY>

Foundation Tier Questions

There are a lot of questions to answer here, see how many you can get whilst watching the video!

1. Rechargeable batteries will always be able to hold the same amount of energy

(circle the correct answer)

True / False

1. The chemicals in a battery are toxic (circle the correct answer)

True / False

1. Fuel cells need to be recharged (circle the correct answer)

True / False

1. Which fuel is normally used in fuel cells? (circle the correct answer)

Hydrogen Petrol LPG

1. What is a disadvantage of this fuel?
2. What is the advantage of using this fuel in fuel cells?
3. The reaction between hydrogen and oxygen controlled in a fuel cell is often explosive

(circle the correct answer)

True / False

1. Fill in the blank:

\_\_\_\_\_\_\_\_\_\_\_\_\_ is the name of the process for splitting hydrogen into protons and electrons.

1. What is the word equation for the overall reaction in a fuel cell?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 🡪 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Balance the chemical equation for the reaction in a fuel cell

\_\_\_H2 + O2 🡪 \_\_\_H20

1. What types of energy are produced by a fuel cell? (circle the correct answers)

Electrical Kinetic Heat Light Gravitational

1. Fuel cells are an inefficient way of converting energy

True/False

1. List the advantages of hydrogen fuel cell cars
2. List the disadvantages of hydrogen fuel cell cars
3. What are the other uses for fuel cells? (circle the correct answers)

Rockets Chairs Computers

Heating homes Busses Trains

Fuel Cell Video

<https://www.youtube.com/watch?v=MQG87a8EwzY>

Higher Tier Questions

There are a lot of questions to answer here, see how many you can get whilst watching the video!

1. What happens to batteries over time?
2. What can be a problem with the chemicals in a battery?
3. Fuel cells need to be recharged (circle the correct answer)

True/False

1. What fuel is normally used in fuel cells?
2. What is a disadvantage of this fuel?
3. What is the advantage of using this fuel in fuel cells?
4. How is the reaction between hydrogen and oxygen controlled in a fuel cell?
5. (AQA HT Only) What is the half equation for the reaction at the anode?
6. What is the name of the process for splitting hydrogen into protons and electrons?
7. (AQA HT Only) What is the half equation for the reaction at the cathode?
8. What is the word equation for the overall reaction in a fuel cell?
9. What is the balanced chemical equation for the reaction in a fuel cell?
10. What types of energy are produced by a fuel cell?
11. Fuel cells are an inefficient way of converting energy

True/False

1. List the advantages of hydrogen fuel cell cars
2. List the disadvantages of hydrogen fuel cell cars
3. What are the other uses for fuel cells?

Knowledge Check In

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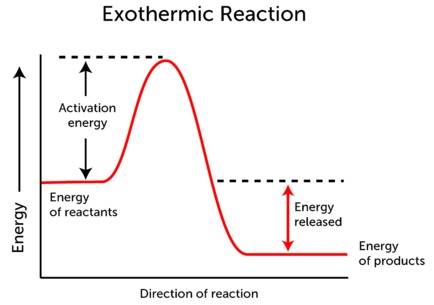
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Exothermic and endothermic reactions

When a chemical reaction occurs, energy is transferred to or from the surroundings. There is usually a temperature change. For example, when a bonfire burns it transfers heat energy to the surroundings. Objects near a bonfire become warmer. The temperature rise can be measured with a thermometer.

Exothermic reactions

These are reactions that transfer energy to the surroundings (ie the energy exits from the reaction, hence the name exothermic). The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to become hotter. A thermometer is used to detect the temperature increase.

Some examples of exothermic reactions are:

combustion (burning)

neutralisation reactions between acids and alkalis

the reaction between water and calcium oxide

Endothermic reactions

These are reactions that take in energy from the surroundings (ie energy enters the reaction, which will help you to remember the name endothermic). The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to become colder. A thermometer is used to detect the temperature decrease.

Some examples of endothermic reactions are:

electrolysis

the reaction between ethanoic acid and sodium carbonate

the thermal decomposition of calcium carbonate in a blast furnace

**Hydrogen Fuel Cells**

Diagram of a fuel cell

Description automatically generated with medium confidence

 At the cathode, oxygen gains electrons and reacts with water to make hydroxide ions:​

O2 + 4e + 2H2O  🡪  4OH​

Then, at the anode, hydrogen combines with the hydroxide ions to make water and electrons:​

2H2 + 4OH   🡪   4H2O + 4e​

Overall: 2H2 + O2  🡪  2H2O

**Q2.**

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**

**A picture containing text, line, diagram, plot

Description automatically generated**

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

Describe the **two** errors.

1  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**Q3.**

Chemical reactions can produce electricity.

(a)  The diagram below shows a simple cell.

A picture containing diagram, line, sketch, white

Description automatically generated

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?

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**(1)**

(c)  Why can alkaline batteries **not** be recharged?

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**(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.

\_\_\_\_\_\_\_\_ H2 + \_\_\_\_\_\_\_\_ ⟶ \_\_\_\_\_\_\_\_ H2O

**(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)**