Rates of Reaction

Question Paper 1

<table>
<thead>
<tr>
<th>Level</th>
<th>Edexcel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Exam Board</td>
<td>GCSE(9-1)</td>
</tr>
<tr>
<td>Topic</td>
<td>Rates of Reaction &amp; Energy Changes</td>
</tr>
<tr>
<td>Sub Topic</td>
<td>Rates of Reaction</td>
</tr>
<tr>
<td>Booklet</td>
<td>Question Paper 1</td>
</tr>
</tbody>
</table>

Time Allowed: 58 minutes
Score: /48
Percentage: /100
1. (a) Catalytic converters in the exhaust systems of cars contain catalysts.

   (i) Explain what is meant by the term **catalyst**.

   (ii) This reaction takes place in a catalytic converter

   \[
   \text{carbon monoxide} + \text{oxygen} \rightarrow \text{carbon dioxide}
   \]

   This reaction is exothermic.

   On the axes below, draw labelled lines to show the relative energies of the reactants and products in this reaction.
(iii) Another reaction in a catalytic converter is the reaction of hydrocarbons with excess oxygen to form carbon dioxide and water.

Write the balanced equation for the reaction of the hydrocarbon heptane, \( C_7H_{16} \), with excess oxygen.

(b) When reactions take place in a solution, the rate of reaction is affected by the concentration in the solution.

Explain, in terms of particles and collisions, why the rate of a reaction increases when the concentration of one of the reactants is increased.

(Total for Question 1 = 9 marks)
2 (a) Marble chips react with hydrochloric acid to produce carbon dioxide.

The equation for the reaction is

$$\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$$

Which one of these changes would **decrease** the rate of this reaction?
Put a cross (X) in the box next to your answer.

- [ ] A  use hydrochloric acid which is more dilute
- [ ] B  use smaller sized marble chips
- [ ] C  use marble chips which have a larger surface area
- [ ] D  use a larger volume of the hydrochloric acid

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

.......................................................................................................................... ... ......................
.......................................................................................................................... ... ......................
.......................................................................................................................... ... ......................
.......................................................................................................................... ... ......................
.......................................................................................................................... ... ......................
.......................................................................................................................... ... ......................
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

Which of these graphs shows the mass of the catalyst during the reaction?

Put a cross (\(\square\)) in the box next to your answer.

\(\square\) A

\(\square\) B

\(\square\) C

\(\square\) D
(ii) The decomposition of hydrogen peroxide, $\text{H}_2\text{O}_2$, produces oxygen and water.

Give the balanced equation for this reaction.

\[(2)\]

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

\[(2)\]

(Total for Question 2 = 8 marks)
3 (a) A student investigated the rate of a reaction.
   The student investigated the reaction between zinc and dilute sulfuric acid.
   The products are zinc sulfate, ZnSO₄, and hydrogen.

   (i) Write the balanced equation for this reaction.

   

(ii) The student carried out two experiments.

   The same mass of zinc and the same sized pieces of zinc were used in each experiment.

   The results are shown in the table.

<table>
<thead>
<tr>
<th></th>
<th>experiment 1</th>
<th>experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>concentration of sulfuric acid / mol dm⁻³</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>temperature / °C</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>rate of reaction</td>
<td>slow</td>
<td>fast</td>
</tr>
</tbody>
</table>

   Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
   In your answer you should refer to the frequency and energy of collisions between particles.
(b) Zinc is reacted with copper sulfate solution. The equation for the reaction is

\[ \text{Zn(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu(s)} \]

(i) What type of reaction is this?

Put a cross (✓) in the box next to your answer.

☐ A decomposing
☐ B displacement
☐ C dissolving
☐ D neutralisation

(ii) This reaction is exothermic.

On the diagram below draw labelled lines to show the relative energies of the reactants and products in this reaction.

(Total for Question 3 = 11 marks)
4 A student investigated the rate of reaction between dilute hydrochloric acid and marble chips (calcium carbonate).

Calcium chloride, carbon dioxide and water are formed.

(a) Complete and balance the equation for the reaction.

\[
\text{CaCO}_3 + \text{HCl} \rightarrow \text{.............................................................} + \text{.............................................................} + \text{.............................................................}
\]
(b) The student investigated the rate by using different sizes of marble chips. In their investigation, the same mass of marble chips was used in each experiment.

The volume of gas given off was measured.

The graph in Figure 8 shows the results.

![Graph showing rate of reaction](image)

**Figure 8**

(i) State how the graph shows that line B gives the results for the larger marble chips.

(ii) A tangent has been drawn on line A.

Calculate the rate of reaction at this point.

rate of reaction = \( \text{cm}^3 \text{s}^{-1} \)
(c) During any reaction, reactants are used up and the rate of reaction decreases.

Explain, in terms of particles, why the rate of reaction decreases.  

(2)

(d) The decomposition of hydrogen peroxide is catalysed by adding a small amount of manganese(IV) oxide.

Which of these graphs shows the mass of the catalyst as the reaction takes place?  

(1)
(e) Two gases, X and Y, react to give a gaseous product Z.  

The reaction is carried out under two different sets of conditions in experiments 1 and 2 as shown in Figure 9.

<table>
<thead>
<tr>
<th>condition</th>
<th>experiment 1</th>
<th>experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature / °C</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>pressure / atm</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Figure 9**

Explain why it is not possible to predict what the rate of Experiment 2 will be compared with Experiment 1.

(Total for Question 4 = 11 marks)
5 (a) Zinc is a metal.

Zinc reacts with dilute hydrochloric acid to produce zinc chloride and hydrogen.

Edward used this apparatus to investigate the speed of the reaction between zinc and dilute hydrochloric acid.

(i) Edward’s results for 50 °C are shown on the graph.

Sketch a line on the graph to show the results that Edward should expect to obtain if he carried out the experiment to completion at 30 °C.
(ii) When zinc powder is used, instead of larger pieces of zinc, the reaction is faster.

Explain, using ideas about particles, why the reaction is faster when zinc powder is used.

.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...

(iii) Balance the equation for the reaction of zinc with dilute hydrochloric acid by putting a number in the space provided.

Zn  +  ...............  HCl  →  ZnCl₂  +  H₂

(iv) The reaction between zinc and dilute hydrochloric acid is exothermic.

Explain, in terms of breaking and forming bonds, why this reaction is exothermic.

.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...

(b) Catalysts are added to some reactions.

State the effect of catalysts on reactions.

.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...
.................................................................................................................................. ...

(Total for Question 5 = 9 marks)
## Rates of Reaction

### Question Paper 2

<table>
<thead>
<tr>
<th>Level</th>
<th>Edexcel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Exam Board</td>
<td>GCSE(9-1)</td>
</tr>
<tr>
<td>Topic</td>
<td>Rates of Reaction &amp; Energy Changes</td>
</tr>
<tr>
<td>Sub Topic</td>
<td>Rates of Reaction</td>
</tr>
<tr>
<td>Booklet</td>
<td>Question Paper 2</td>
</tr>
</tbody>
</table>

**Time Allowed:** 26 minutes

**Score:** /21

**Percentage:** /100
The diagram shows a catalytic converter used in car exhaust systems. Gases from the car engine pass into the catalytic converter. In the catalytic converter, carbon monoxide and unburnt hydrocarbons are changed into carbon dioxide and water vapour.

1  The diagram shows a catalytic converter used in car exhaust systems. Gases from the car engine pass into the catalytic converter. In the catalytic converter, carbon monoxide and unburnt hydrocarbons are changed into carbon dioxide and water vapour.

(a) What type of reaction occurs in the catalytic converter?

Put a cross (✓) in the box next to your answer.

☐ A cracking
☐ B displacement
☐ C oxidation
☐ D precipitation

(b) It is important that the reactions in the catalytic converter happen quickly.

(i) Explain why the catalyst is spread onto the honeycomb structure rather than used as large pieces.
(ii) Hot gases from the engine pass over the catalyst.

   Explain why the catalyst is more effective when the engine has been running for a short time rather than when the engine is first started.

   (2)

(c) Carbon monoxide reacts with oxygen, $O_2$, to form carbon dioxide in the catalytic converter.

   Write the balanced equation for this reaction.

   (3)

(d) In the catalytic converter, a hydrocarbon is converted to carbon dioxide and water.

   The diagram shows the heat energies of the reactants and products in this reaction.

   Explain what the diagram shows about the type of reaction occurring.

   (2)

(Total for Question 1 = 10 marks)
2 (a) An experiment is carried out to measure the temperature change when solid ammonium chloride is dissolved in water.

- initial temperature of water = 19 °C
- final temperature of solution = 15 °C

Explain what the temperature readings show about the type of heat change occurring when ammonium chloride dissolves in water.

(b) When zinc reacts with copper sulfate solution, copper and zinc sulfate solution are formed.

\[ \text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4 \]

This reaction is exothermic.

Use this information to complete the diagram.

[Diagram of heat energy and progress of reaction]
Reactions are accompanied by heat changes. The heat changes are the results of bonds being broken and bonds being formed.

Which row of the table shows the heat energy changes that occur when bonds are broken and when bonds are formed?

Put a cross (✓) in the box next to your answer.

<table>
<thead>
<tr>
<th>bonds broken</th>
<th>bonds formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ A</td>
<td>heat energy is released</td>
</tr>
<tr>
<td>□ B</td>
<td>heat energy is required</td>
</tr>
<tr>
<td>□ C</td>
<td>heat energy is released</td>
</tr>
<tr>
<td>□ D</td>
<td>heat energy is required</td>
</tr>
</tbody>
</table>
*(d) Reactions can occur when particles collide. Rates of reactions can be altered by changing conditions.

Explain how the rate of reaction between a solid and a liquid is altered by changing the size of the pieces of solid and by changing the temperature of the liquid.

(Total for Question 2 = 11 marks)
1 (a) Each of these substances forms ions in solution.

One mole of the following substances is dissolved in 1 dm³ of water.

Which solution contains the greatest number of ions?

☐ A ammonium sulfate, \((\text{NH}_4)_2\text{SO}_4\)

☐ B iron(III) chloride, \(\text{FeCl}_3\)

☐ C magnesium nitrate, \(\text{Mg(NO}_3)_2\)

☐ D potassium bromide, \(\text{KBr}\)

(b) When sodium hydroxide solution is neutralised with an acid there is a temperature change.

A student is given dilute hydrochloric acid and dilute ethanoic acid of the same concentration in mol dm⁻³.

Devise a plan to compare the temperature changes produced when sodium hydroxide solution is neutralised with each of these two acids.
(c) Hydrogen reacts with chlorine to form hydrogen chloride.

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \]

The reaction is exothermic.

Draw and label the reaction profile diagram for this reaction, identifying the activation energy.
(d) The energies of some bonds are shown in Figure 13.

<table>
<thead>
<tr>
<th>bond</th>
<th>energy of bond / kJ mol⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>H—H</td>
<td>436</td>
</tr>
<tr>
<td>Cl—Cl</td>
<td>243</td>
</tr>
<tr>
<td>H—Cl</td>
<td>432</td>
</tr>
</tbody>
</table>

**Figure 13**

Hydrogen reacts with chlorine to form hydrogen chloride.

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl(}\text{g)} \]

Calculate the energy change, in kJ mol⁻¹, for the reaction of 1 mol of hydrogen gas, H₂, with 1 mol of chlorine gas, Cl₂, to form 2 mol of hydrogen chloride gas, HCl.

\[ \text{energy change} = \quad \ldots \quad \text{kJ mol}^{-1} \]

(Total for Question 1 = 12 marks)
2 (a) An experiment is carried out to measure the temperature change when solid ammonium chloride is dissolved in water.

- initial temperature of water = 19 °C
- final temperature of solution = 15 °C

Explain what the temperature readings show about the type of heat change occurring when ammonium chloride dissolves in water.

(b) When zinc reacts with copper sulfate solution, copper and zinc sulfate solution are formed.

\[ \text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4 \]

This reaction is exothermic.

Use this information to complete the diagram.
(c) Reactions are accompanied by heat changes.

The heat changes are the results of bonds being broken and bonds being formed.

Which row of the table shows the heat energy changes that occur when bonds are broken and when bonds are formed?

Put a cross (\(\square\)) in the box next to your answer.

<table>
<thead>
<tr>
<th>bonds broken</th>
<th>bonds formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>heat energy is released</td>
</tr>
<tr>
<td>B</td>
<td>heat energy is required</td>
</tr>
<tr>
<td>C</td>
<td>heat energy is released</td>
</tr>
<tr>
<td>D</td>
<td>heat energy is required</td>
</tr>
</tbody>
</table>
*(d) Reactions can occur when particles collide. Rates of reactions can be altered by changing conditions.

Explain how the rate of reaction between a solid and a liquid is altered by changing the size of the pieces of solid and by changing the temperature of the liquid.

(Total for Question 2 = 11 marks)
3  (a) Marble chips react with hydrochloric acid to produce carbon dioxide.

The equation for the reaction is

$$\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$$

Which one of these changes would decrease the rate of this reaction?

Put a cross (√) in the box next to your answer.

(1) □  A  use hydrochloric acid which is more dilute

□  B  use smaller sized marble chips

□  C  use marble chips which have a larger surface area

□  D  use a larger volume of the hydrochloric acid

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

..........................................................................................................................
.........................................................................................................................
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

Which of these graphs shows the mass of the catalyst during the reaction?

Put a cross (✓) in the box next to your answer.

(1)
(ii) The decomposition of hydrogen peroxide, H$_2$O$_2$, produces oxygen and water.

Give the balanced equation for this reaction.

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(Total for Question 3 = 8 marks)
4  (a) A student investigated the rate of a reaction.
The student investigated the reaction between zinc and dilute sulfuric acid.
The products are zinc sulfate, \( \text{ZnSO}_4 \), and hydrogen.

(i) Write the balanced equation for this reaction.

(ii) The student carried out two experiments.
The same mass of zinc and the same sized pieces of zinc were used in each experiment.
The results are shown in the table.

<table>
<thead>
<tr>
<th></th>
<th>experiment 1</th>
<th>experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>concentration of sulfuric acid / mol dm(^{-3})</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>temperature / °C</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>rate of reaction</td>
<td>slow</td>
<td>fast</td>
</tr>
</tbody>
</table>

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)
(b) Zinc is reacted with copper sulfate solution. The equation for the reaction is

\[ \text{Zn}(s) + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu}(s) \]

(i) What type of reaction is this?

Put a cross (\(\square\)) in the box next to your answer.

\(\square\) A decomposition
\(\square\) B displacement
\(\square\) C dissolving
\(\square\) D neutralisation

(ii) This reaction is exothermic.

On the diagram below draw labelled lines to show the relative energies of the reactants and products in this reaction.

(Total for Question 4 = 11 marks)