

# Kinetics

9 questions · 26 marks

Answer all questions. The marks available are shown against each part. Every question is taken unaltered from a past paper; the source is noted beneath it. In Section A, choose the best answer and write its letter in the box.

## Section A · Multiple choice

7 questions · 7 marks

1. Which statement explains why the rate of a reaction increases when a catalyst is added at a constant temperature? 1 mark

[1 mark]

- A The collision frequency increases because there is a decrease in activation energy.
- B The collision frequency increases because there is an increase in the average energy of the particles.
- C The proportion of successful collisions increases because there is a decrease in activation energy.
- D The proportion of successful collisions increases because there is an increase in the average energy of the particles.

☐
☐
☐
☐

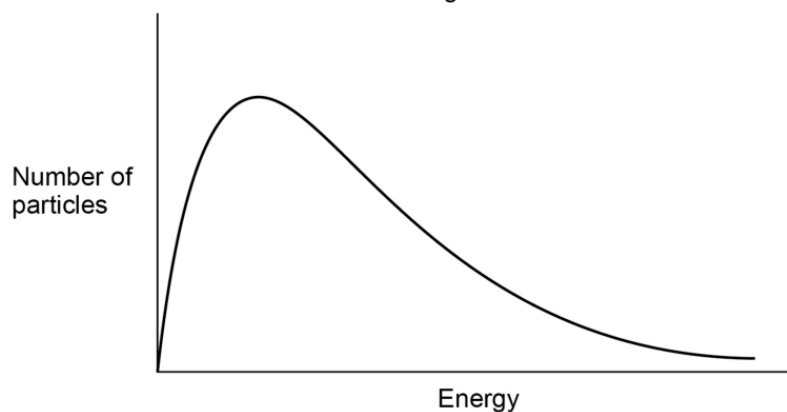
Answer

AQA 7405/3 Chemistry · June 2024 · Paper 3, Question 16

2.

This is a Maxwell–Boltzmann distribution for a gaseous reactant.

1 mark



What is represented by the total area under the curve?

[1 mark]

- A** total energy of the particles ☐
- B** activation energy for the reaction ☐
- C** total number of reacting particles ☐
- D** total number of particles present ☐

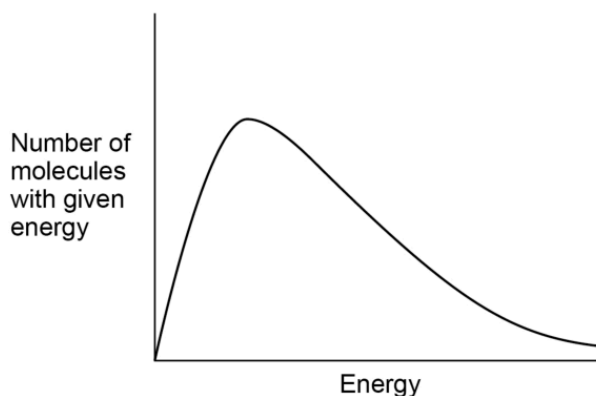
Answer

— AQA 7405/3 Chemistry · June 2023 · Paper 3, Question 11

3.

The Maxwell–Boltzmann distribution curve is shown for a gaseous reaction mixture.

1 mark



What is represented by the total area under the curve?

[1 mark]

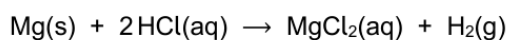
- A** The total energy of the molecules in the reaction mixture ☐
- B** The total energy of reacting molecules in the reaction mixture ☐
- C** The total number of molecules in the reaction mixture ☐
- D** The total number of reacting molecules in the reaction mixture ☐

Answer

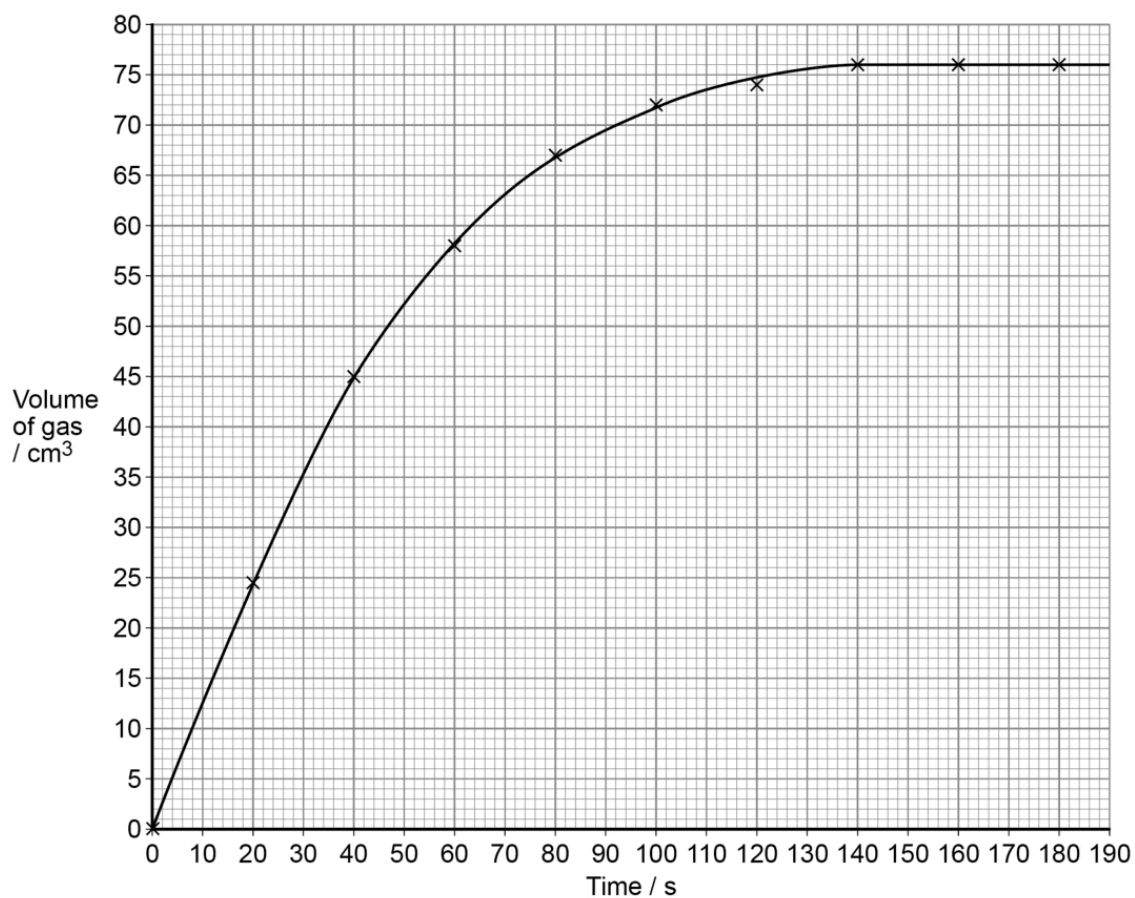
4.

A student investigated the reaction between magnesium and hydrochloric acid.

1 mark



The results are plotted on this graph.

Which value is closest to the rate of reaction, in  $\text{cm}^3 \text{s}^{-1}$ , at 70 s?

[1 mark]

A 0.4

☐

B 0.9

☐

C 1.1

☐

D 2.5

☐

Answer

5. A mixture of 2 dm<sup>3</sup> of hydrogen and 1 dm<sup>3</sup> of oxygen is at room temperature. 1 mark

Which statement is correct?

[1 mark]

- A** There is no reaction to form water because the molecules do not collide with sufficient energy.
- B** There is no reaction to form water because the molecules do not collide with sufficient frequency.
- C** The mean velocity of the hydrogen molecules is less than that of the oxygen molecules.
- D** The partial pressure of each gas is the same.

☐
☐
☐
☐

Answer

— AQA 7405/3 Chemistry · 2021 · Paper 3, Question 18

6. The rate of reaction is greater when a catalyst is used, without changing the temperature. 1 mark

Which statement explains why the rate of reaction is greater with a catalyst?

[1 mark]

- A** The collision frequency increases because the catalysed reaction has a lower activation energy.
- B** The collision frequency increases because there is an increase in the average energy of the particles.
- C** The proportion of successful collisions increases because the catalysed reaction has a lower activation energy.
- D** The proportion of successful collisions increases because there is an increase in the average energy of the particles.

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☐

Answer

— AQA 7405/3 Chemistry · June 2023 · Paper 3, Question 12

7. Which statement about the addition of a catalyst to an equilibrium mixture is correct? 1 mark

[1 mark]

- A** The activation energy for the reverse reaction increases.
- B** The equilibrium constant for the forward reaction increases.
- C** The rate of the reverse reaction increases.
- D** The enthalpy change for the forward reaction decreases.

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Answer

— AQA 7405/3 Chemistry · 2021 · Paper 3, Question 20

## Section B · Structured questions

2 questions · 19 marks

8. This question is about rates of reaction.

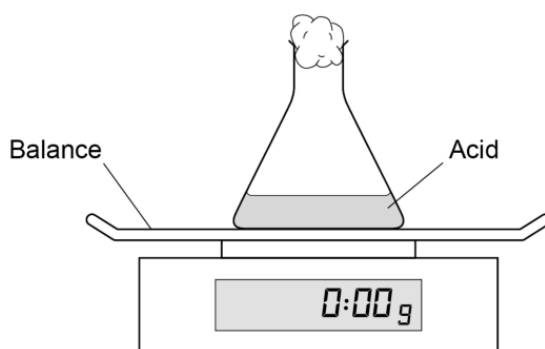
7 marks

**Figure 1** shows apparatus used to measure the rate of reaction when an acid reacts with an excess of solid sodium hydrogencarbonate,  $\text{NaHCO}_3$

When different monoprotic organic acids are used, the rates at which gas escapes can be used to compare the strengths of the acids.

A timer is started when the  $\text{NaHCO}_3$  is added to the acid and the mass of  $\text{CO}_2$  gas lost is recorded at regular intervals. (It is assumed that any change in mass is due to the loss of  $\text{CO}_2$ )

Figure 1



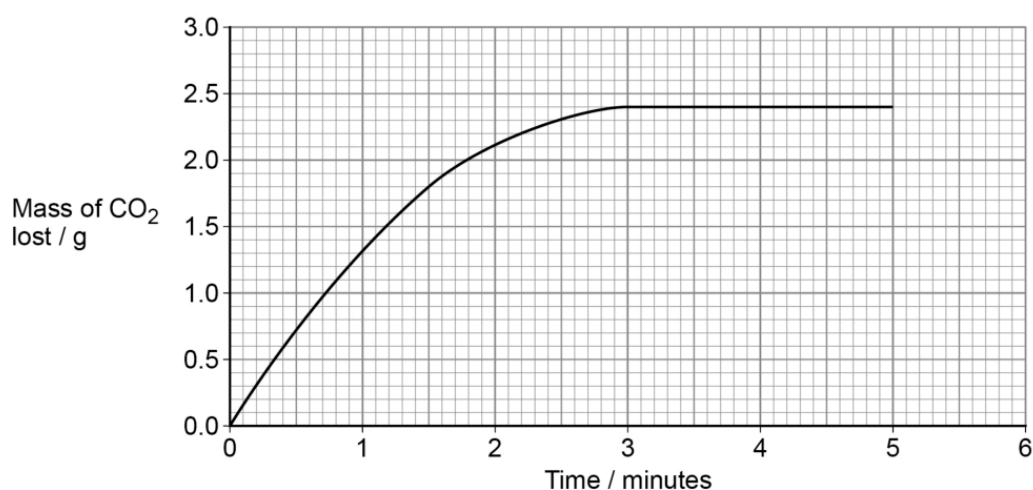
1

Suggest a reason why using a conical flask instead of a beaker would give more accurate results in this experiment.

[1 mark]

**Figure 2** shows the results of this experiment when  $25.0 \text{ cm}^3$  of a  $2.23 \text{ mol dm}^{-3}$  solution of ethanoic acid reacts with an excess of  $\text{NaHCO}_3$

Figure 2



2

Use **Figure 2** to calculate the rate of reaction at 2 minutes.

Deduce the units of your calculated rate.

[3 marks]

Units

Chloroethanoic acid is a stronger acid than ethanoic acid.

Suggest why chloroethanoic acid is a stronger acid than ethanoic acid.

**[3 marks]**

[illegible]

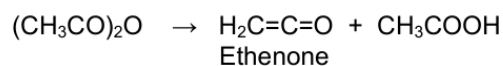
— AQA 7405/2 Chemistry · June 2023 · Paper 2, Question 1

This question is about ethanoic anhydride.

12 marks

In the gas phase, ethanoic anhydride  $(\text{CH}_3\text{CO})_2\text{O}$  decomposes to form ethenone.

The equation is



Ethenone is the simplest member of the ketene homologous series. Ketenes all contain one C=C double bond and one C=O double bond.

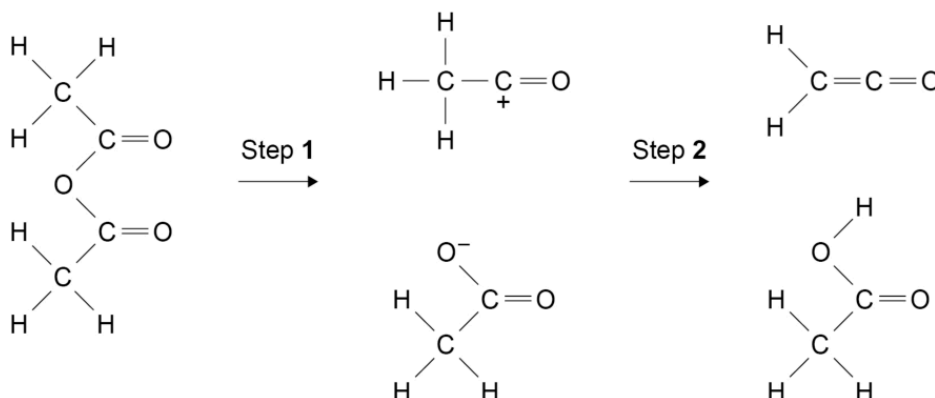
Deduce the general formula for the ketene homologous series.

**[1 mark]**

2

**Figure 11** shows an incomplete suggested mechanism for the decomposition of ethanoic anhydride.

Figure 11



Complete the mechanism in **Figure 11** by adding three curly arrows and any relevant lone pairs of electrons.

[3 marks]

3

For a chemical reaction the relationship between the rate constant,  $k$ , and the temperature,  $T$ , is shown by the Arrhenius equation.

$$k = Ae^{\frac{-E_a}{RT}}$$

For the decomposition of gaseous ethanoic anhydride

the activation energy,  $E_a = 34.5 \text{ kJ mol}^{-1}$

the Arrhenius constant,  $A = 1.00 \times 10^{12} \text{ s}^{-1}$

At temperature  $T_1$  the rate constant,  $k = 2.48 \times 10^8 \text{ s}^{-1}$

Calculate  $T_1$

The gas constant,  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[3 marks]

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$T_1$ 

K

4

Sketch the Maxwell–Boltzmann distribution of molecular energies for gaseous ethanoic anhydride at temperature  $T_1$  and at a higher temperature  $T_2$

Include a label for each axis, and mark on the appropriate axis a typical position for the activation energy.

Explain why the rate of reaction is faster at  $T_2$

**[5 marks]**

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Explanation

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— AQA 7405/2 Chemistry · June 2023 · Paper 2, Question 9