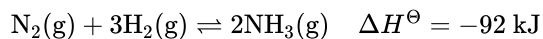

SL Paper 1

The reaction below represents the Haber process for the industrial production of ammonia.



The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important.

Which statement is correct?

- A. A higher temperature would ensure higher yield and a faster rate.
- B. A lower pressure would ensure a higher yield at a lower cost.
- C. A lower temperature would ensure a higher yield and a faster rate.
- D. A higher pressure would ensure a higher yield at a higher cost.

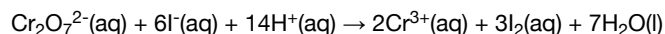
Markscheme

D

Examiners report

[N/A]

Which experimental methods could be used to observe the progress of the following reaction?



- I. Change in colour
- II. Change in mass
- III. Change in electrical conductivity

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Markscheme

B

Examiners report

[N/A]

Which statements describe the action of a catalyst?

- I. It does **not** alter the ΔH for a reaction.
 - II. It increases the E_a for the reaction.
 - III. It alters the mechanism (pathway) of a reaction.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

B

Examiners report

[N/A]

Consider the reaction between magnesium and hydrochloric acid. Which factors will affect the reaction rate?

- I. The collision frequency of the reactant particles
 - II. The number of reactant particles with $E \geq E_a$
 - III. The number of reactant particles that collide with the appropriate geometry
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

D

Examiners report

[N/A]

Which statements are correct?

- I. The activation energy of a reaction is not affected by temperature.
- II. A catalyst reduces the enthalpy change of a reaction.
- III. Catalysts provide alternative reaction pathways.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

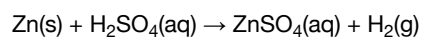
Markscheme

B

Examiners report

[N/A]

Copper catalyses the reaction between zinc and dilute sulfuric acid.



Why does copper affect the reaction?

- A. Decreases the activation energy
- B. Increases the activation energy
- C. Increases the enthalpy change
- D. Decreases the enthalpy change

Markscheme

A

Examiners report

[N/A]



Which methods can be used to monitor the progress of this reaction?

- I. Change in colour of this reaction mixture
- II. Change in mass of this reaction mixture
- III. Change in volume of gas evolved

- A. I and II only

- B. I and III only
- C. II and III only
- D. I, II and III

Markscheme

C

Examiners report

[N/A]

Which statement about the kinetic theory is **not** correct?

- A. The particles in ice vibrate about fixed points.
- B. The particles in steam have more energy than the particles in ice.
- C. All the particles in water have the same amount of energy at 298 K.
- D. Evaporation of water occurs at all temperatures between 273 K and 373 K when the atmospheric pressure is 101 kPa.

Markscheme

C

Examiners report

There were two G2 comments on this question both of which stated that this was a difficult question at SL. The question certainly was challenging and was found to be the third hardest question on the paper. However, 49% of candidates did manage to get the correct answer, C.

Hydrochloric acid is reacted with large pieces of calcium carbonate, the reaction is then repeated using calcium carbonate powder. How does this change affect the activation energy and the collision frequency?

	Activation energy	Collision frequency
A.	increases	increases
B.	stays constant	increases
C.	increases	stays constant
D.	stays constant	stays constant

Markscheme

B

Examiners report

[N/A]

Why does the rate of a reaction increase when the temperature is increased?

- I. The activation energy decreases.
 - II. There are more particles with energy equal to or greater than the activation energy.
 - III. The frequency of collisions between particles increases.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

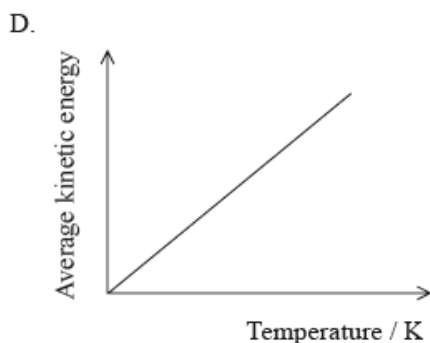
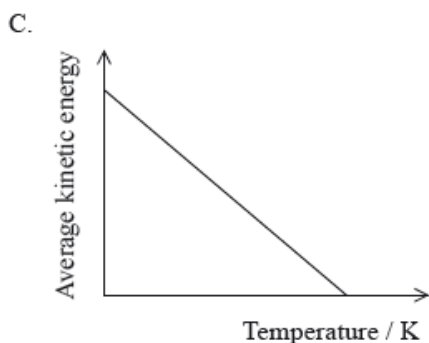
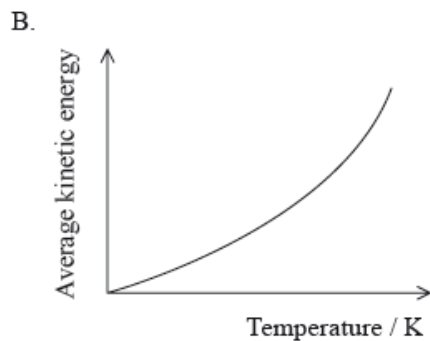
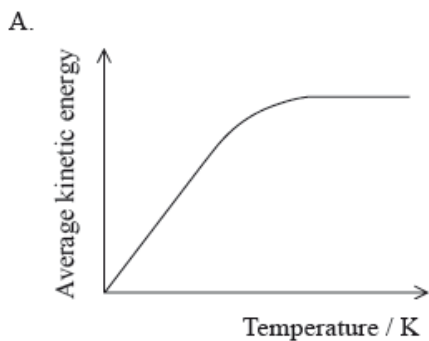
Markscheme

C

Examiners report

[N/A]

Which graph best represents the relationship between the average kinetic energy of molecules of a gas and temperature in K?



Markscheme

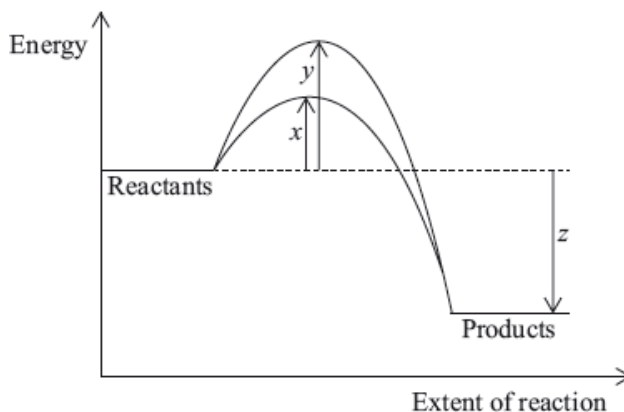
D

Examiners report

Some respondents mentioned in their G2 forms that the question was not appropriate as they could not find in the syllabus details where the specific relationship between temperature in K and average kinetic energy of molecules of gas is mentioned. In assessment statement 6.2.1 in the syllabus details it is clearly stated that “average kinetic energy is proportional to temperature in kelvins”. 48.33% of the candidates chose the correct answer D.

The discrimination index for this question was 0.42 which is reasonably good.

The diagram below shows the energy changes for a reaction with and without a catalyst. Which symbols represent the activation energy, E_a , and the enthalpy change, ΔH , for the reaction with a catalyst?



	E_a (with a catalyst)	ΔH
A.	x	z
B.	y	z
C.	z	x
D.	$y-x$	z

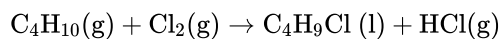
Markscheme

A

Examiners report

One respondent commented that it “is more difficult than it might be because of the use of algebra symbols”. This was the fourth easiest question with nearly 84% giving the correct answer.

Which changes increase the rate of the reaction below?



- I. Increase of pressure
- II. Increase of temperature
- III. Removal of HCl(g)

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Markscheme

A

Examiners report

It was suggested by one respondent that increase of pressure might be ambiguous. In the guide, the effect of pressure on the rate of a reaction is mentioned in AS 6.2.4. 59% of candidates got this question correct.

Which factors can increase the rate of a chemical reaction?

- I. Increasing the pressure in gaseous reactions
 - II. Increasing the temperature in gaseous reactions
 - III. Increasing the particle size of a solid in a reaction
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

A

Examiners report

There was a concern about the use of the word “can” in the question stem. The word was used to make the question about reactions in general. It does not seem to have troubled the candidates; it was the seventh easiest question, answered correctly by nearly 80% of the candidates.

Which statement best describes and explains the effect of a catalyst on the rate of a chemical reaction?

- A. The rate increases because the frequency of collisions between particles increases.
- B. The rate increases because more colliding particles have the energy needed to react.
- C. The rate increases because the activation energy increases.
- D. The rate increases because more molecules are present.

Markscheme

B

Examiners report

[N/A]

Which factors can affect the rate of reaction?

- I. Particle size of solid reactant
 - II. Concentration of reacting solution
 - III. Pressure of reacting gas
- A. I and II only

- B. I and III only
- C. II and III only
- D. I, II and III

Markscheme

D

Examiners report

[N/A]

Which factors can affect reaction rate?

- I. The state of the reactants
 - II. The frequency of the collisions between particles
 - III. The average kinetic energy of the particles
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

D

Examiners report

The fact that the state of the reactants is inevitably linked to the frequency of collisions between particles appeared to cause a degree of confusion as to whether they were separate factors and as a result the question also proved a poor discriminator, with a discrimination index of 0.04. A decision was therefore taken to omit it from the total mark.

Which are appropriate units for the rate of a reaction?

- A. $\text{mol dm}^{-3}\text{s}^{-1}$
- B. $\text{mol dm}^{-3}\text{s}$
- C. mol dm^{-3}
- D. s

Markscheme

A

Examiners report

[N/A]



Which change does **not** increase the initial rate of reaction when $\text{CaCO}_3(\text{s})$ is added to excess $\text{HCl}(\text{aq})$?

- A. Decrease in the size of the $\text{CaCO}_3(\text{s})$ particles
- B. Increase in the temperature of the reaction mixture
- C. Increase in the concentration of $\text{HCl}(\text{aq})$, keeping the same volume
- D. Increase in the volume of $\text{HCl}(\text{aq})$, keeping the same concentration

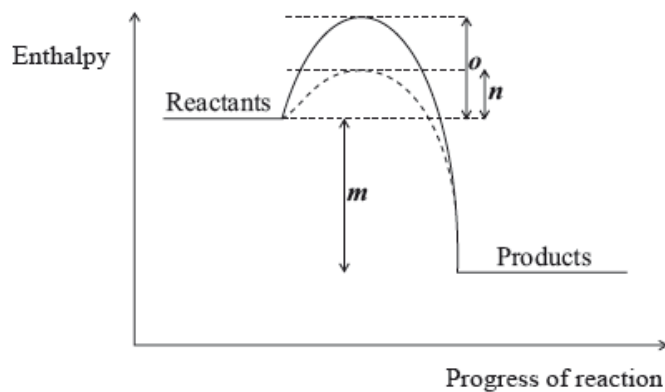
Markscheme

D

Examiners report

[N/A]

The following enthalpy level diagram shows the effect of the addition of a catalyst on a chemical reaction. What do *m*, *n* and *o* represent?



	<i>m</i>	<i>n</i>	<i>o</i>
A.	ΔH	E_a (without a catalyst)	E_a (with a catalyst)
B.	E_a (with a catalyst)	ΔH	E_a (without a catalyst)
C.	E_a (with a catalyst)	E_a (without a catalyst)	ΔH
D.	ΔH	E_a (with a catalyst)	E_a (without a catalyst)

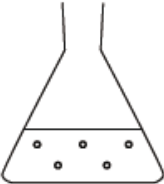
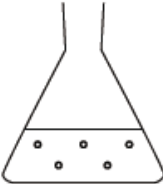
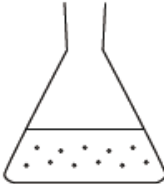
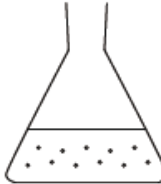
Markscheme

D

Examiners report

[N/A]

In which flask will the reaction between 2.0 g of magnesium carbonate and 25 cm³ 1.0 mol dm⁻³ hydrochloric acid occur most rapidly?

<p>A</p>  <p>Large pellets 25 °C</p>	<p>B</p>  <p>Large pellets 50 °C</p>	<p>C</p>  <p>Small pellets 25 °C</p>	<p>D</p>  <p>Small pellets 50 °C</p>
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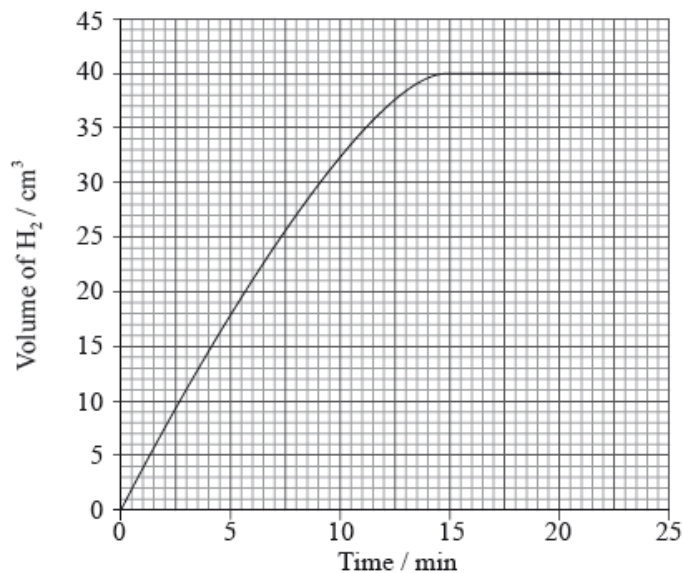
Markscheme

D

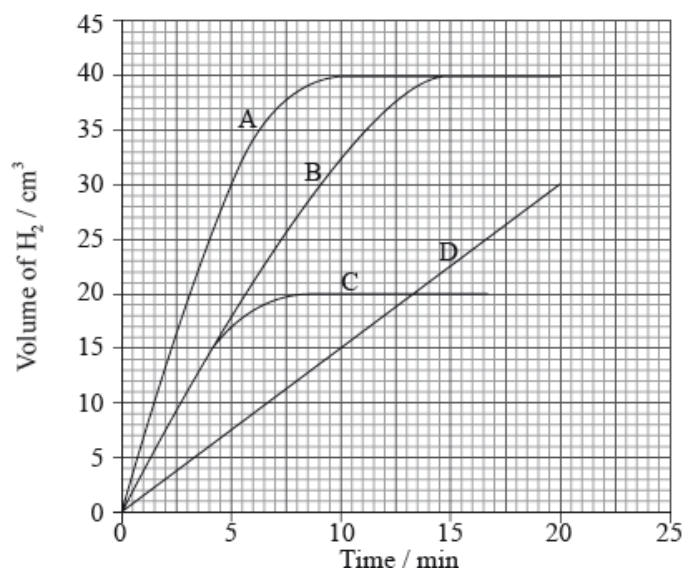
Examiners report

Although one respondent was concerned about the circles being confused with bubbles and the use of the word “pellet”, this turned out to be the easiest question on the paper. “Pellet” is a word that the examiners would expect candidates to understand.

A piece of zinc was added to aqueous nitric acid and the volume of hydrogen gas produced was measured every minute. The results are plotted on the graph below.



Which graph would you expect if the same mass of powdered zinc was added to nitric acid with the same concentration?



Markscheme

A

Examiners report

[N/A]

Nitrogen gas reacts with hydrogen gas according to the following equation.



Why is the rate of reaction slow at room temperature?

- A. The activation energy of the forward reaction is high.
- B. The activation energy of the forward reaction is low.
- C. The equilibrium constant is very small.

D. The rate of the reverse reaction is greater than the rate of the forward reaction.

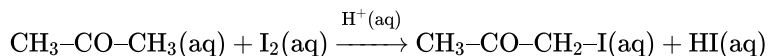
Markscheme

A

Examiners report

[N/A]

Which statement is true about using sulfuric acid as a catalyst in the following reaction?



- I. The catalyst increases the rate of reaction.
- II. The catalyst lowers the activation energy for the reaction.
- III. The catalyst has been consumed at the end of the chemical reaction.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

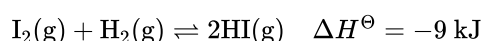
Markscheme

A

Examiners report

Five respondents alluded to the fact that the three options were listed as I, II and II, instead of I, II and III. The question overall was well answered by candidates (Difficulty Index was 76%). Another respondent stated that statement II, the fact the catalyst lowers the activation energy for the reaction is in fact misleading, as a catalyst provides in fact an alternative reaction pathway with a lower activation energy requirement. This is a valid interpretation, but it was felt that the wording did not have an impact on student performance.

Consider the reaction between gaseous iodine and gaseous hydrogen.



Why do some collisions between iodine and hydrogen **not** result in the formation of the product?

- A. The I_2 and H_2 molecules do not have sufficient energy.

- B. The system is in equilibrium.
- C. The temperature of the system is too high.
- D. The activation energy for this reaction is very low.

Markscheme

A

Examiners report

[N/A]

Which of the following can **increase** the rate of a chemical reaction?

- I. Increasing the temperature
 - II. Adding a catalyst
 - III. Increasing the concentration of reactants
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

D

Examiners report

[N/A]

Which conditions must be met for a reaction to take place?

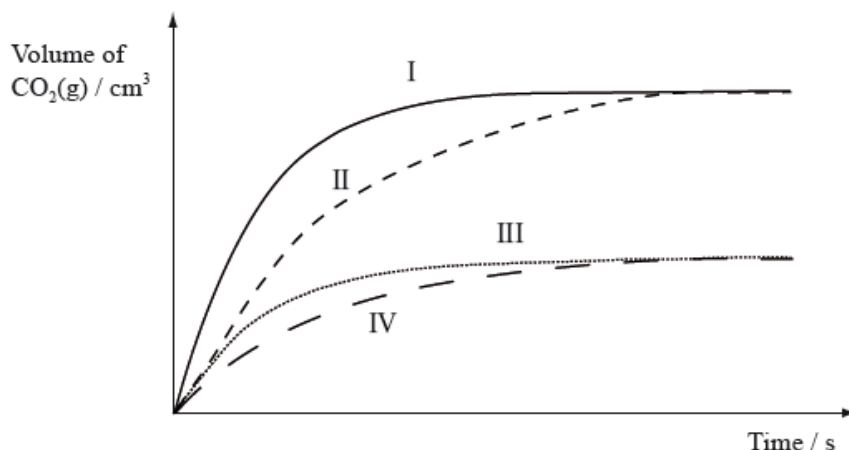
- I. Reactants collide with sufficient energy.
 - II. Reactants collide with correct orientation.
 - III. Reactants must be in the same state.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

Examiners report

[N/A]

Equal masses of powdered calcium carbonate were added to separate solutions of hydrochloric acid. The calcium carbonate was in excess. The volume of carbon dioxide produced was measured at regular intervals. Which curves best represent the evolution of carbon dioxide against time for the acid solutions shown in the table below.



	25 cm ³ of 2 mol dm ⁻³ HCl	50 cm ³ of 1 mol dm ⁻³ HCl	25 cm ³ of 1 mol dm ⁻³ HCl
A.	I	III	IV
B.	I	IV	III
C.	I	II	III
D.	II	I	III

Markscheme

C

Examiners report

Opinion expressed through the G2 forms was divided with some commenting that this was a good question, whilst others felt it was too time consuming. Though a significant number of blank responses would seem to indicate that some candidates found the format of the question confusing, those that answered it performed quite well as indicated by a difficulty index of 44%. The question also proved to be quite a good discriminator, with a discrimination index of 0.33.

Which change increases the rate of a chemical reaction?

- A. Increasing the size of solid reactant particles
- B. Decreasing the concentration of aqueous reactants
- C. Increasing the surface area of a solid reactant
- D. Decreasing the pressure of gaseous reactants

Markscheme

C

Examiners report

[N/A]

Which is **not** affected by an increase in temperature?

- A. Rate of reaction
- B. Collision frequency
- C. Collision geometry
- D. % of molecules with $E \geq E_a$

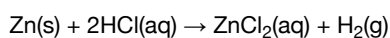
Markscheme

C

Examiners report

[N/A]

Which change increases the rate of formation of hydrogen when zinc reacts with excess hydrochloric acid, assuming all other conditions remain the same?



- A. Adding water to the hydrochloric acid
- B. Decreasing the temperature
- C. Increasing the volume of hydrochloric acid
- D. Decreasing the size of the zinc particles while keeping the total mass of zinc the same

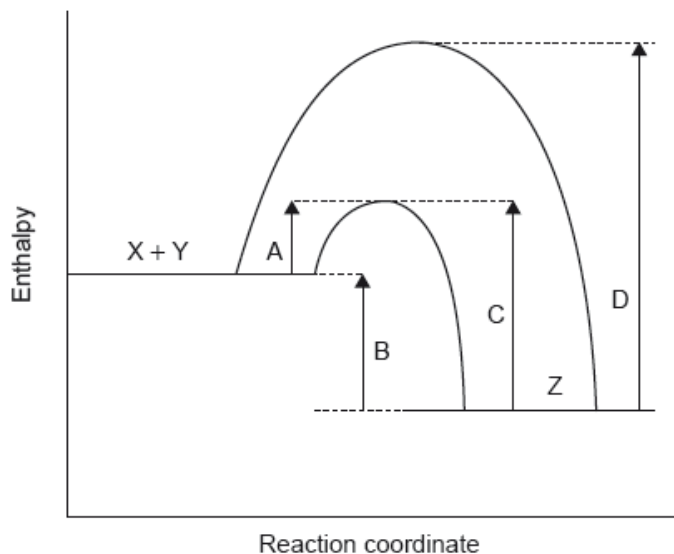
Markscheme

D

Examiners report

[N/A]

The potential energy profile for the reversible reaction, $X + Y \rightleftharpoons Z$ is shown.



Which arrow represents the activation energy for the reverse reaction, $Z \rightarrow X + Y$, with a catalyst?

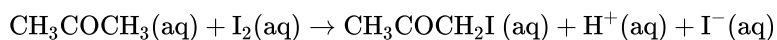
Markscheme

C

Examiners report

[N/A]

Which piece of equipment could **not** be used in an experiment to measure the rate of this reaction?



- A. A colorimeter
- B. A gas syringe
- C. A stopwatch
- D. A pH meter

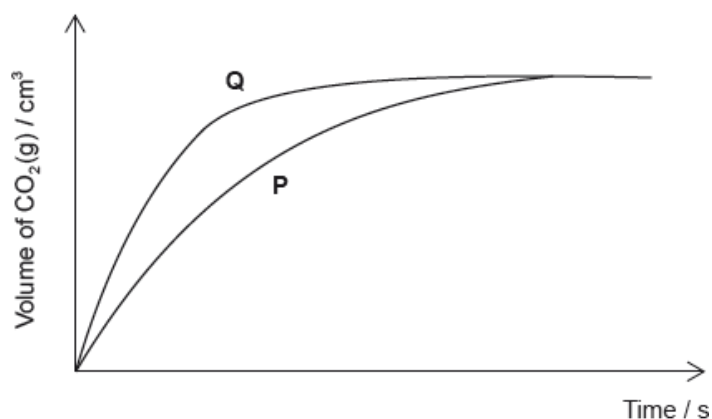
Markscheme

B

Examiners report

[N/A]

100 cm³ of a 1.00 mol dm⁻³ solution of hydrochloric acid is added to 2.00 g of small pieces of calcium carbonate at 20 °C. The volume of carbon dioxide produced against time is plotted to give curve **P**.



Which change will produce curve **Q**, given that calcium carbonate is always the limiting reagent?

- A. Increasing the volume of the hydrochloric acid to 200 cm³
- B. Increasing the mass of calcium carbonate to 4.00 g
- C. Increasing the concentration of the hydrochloric acid to 2.00 mol dm⁻³
- D. Replacing the 2.00 g of small pieces of calcium carbonate with 2.00 g of larger pieces of calcium carbonate

Markscheme

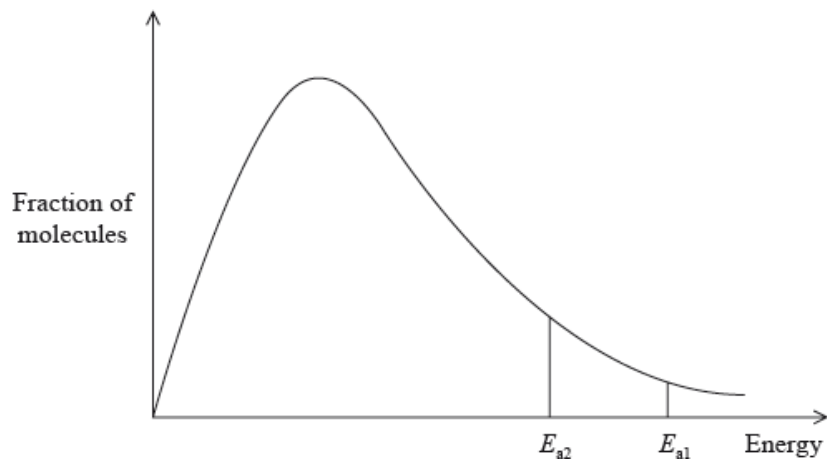
C

Examiners report

[N/A]

The diagram represents the Maxwell-Boltzmann energy distribution curve of the reactants for a chemical reaction with different activation energies,

E_{a1} and E_{a2} .



What is the reason why the rate of the reaction with activation energy E_{a2} is greater?

- A. More frequent collisions between the particles occur.
- B. More energetic collisions between the particles occur.
- C. A catalyst has been added.
- D. The temperature is higher.

Markscheme

C

Examiners report

The initial wording of the question was thought to be complicated, though it was clear that a catalyst had been added (only possible answer here).

Which unit could be used for the rate of a chemical reaction?

- A. mol
- B. mol dm^{-3}
- C. $\text{mol dm}^{-3}\text{s}^{-1}$
- D. dm^3

Markscheme

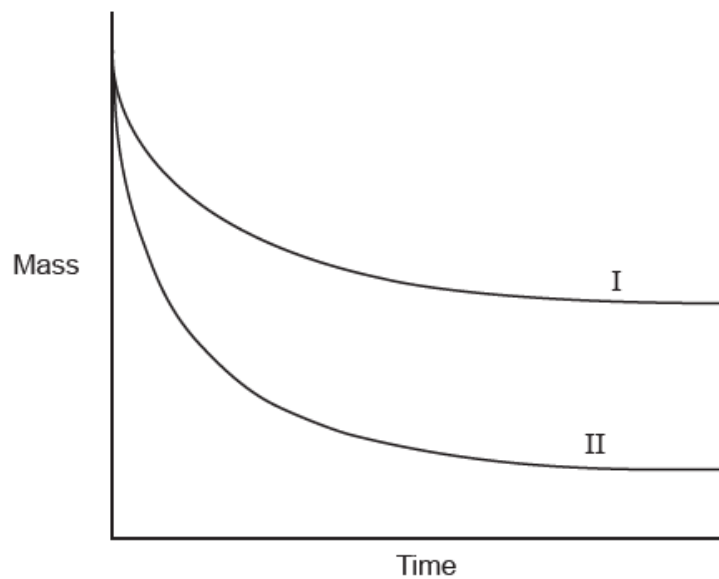
C

Examiners report

[N/A]

Excess magnesium powder was added to a beaker containing hydrochloric acid, HCl (aq).

The mass of the beaker and its contents was recorded and plotted against time (line I).



Which change could give line II?

- A. Doubling the mass of powdered Mg
- B. Using the same mass of Mg ribbon
- C. Increasing the temperature
- D. Using the same volume of more concentrated HCl

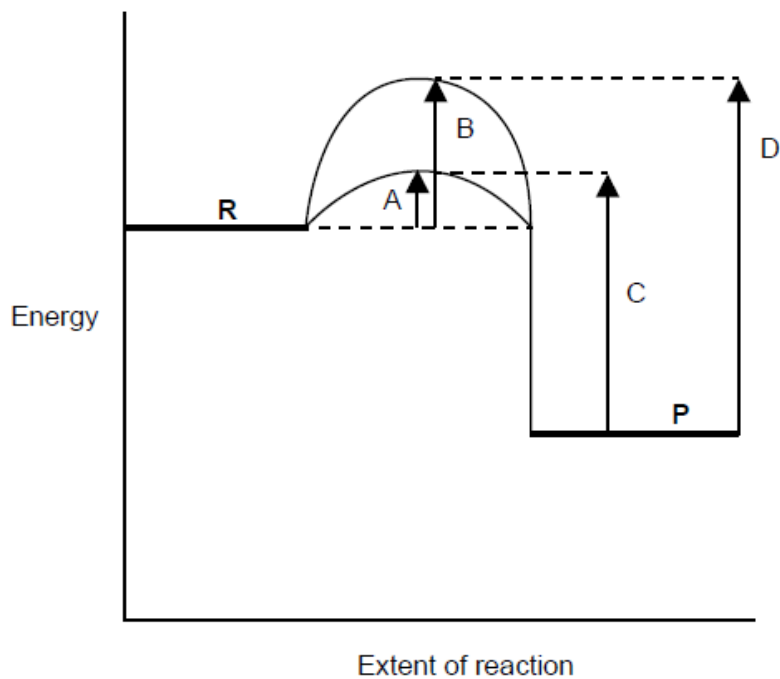
Markscheme

D

Examiners report

[N/A]

For the reaction $R \rightarrow P$, which letter represents the activation energy for the catalysed **reverse** reaction?



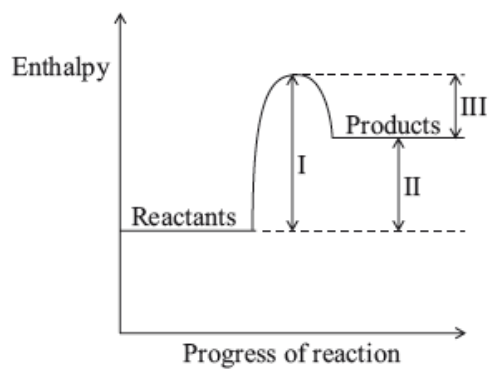
Markscheme

C

Examiners report

[N/A]

Which quantity can be changed by the use of a catalyst?



- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Markscheme

B

Examiners report

[N/A]

What is the best definition of *rate of reaction*?

- A. The time it takes to use up all the reactants
- B. The rate at which all the reactants are used up
- C. The time it takes for one of the reactants to be used up
- D. The increase in concentration of a product per unit time

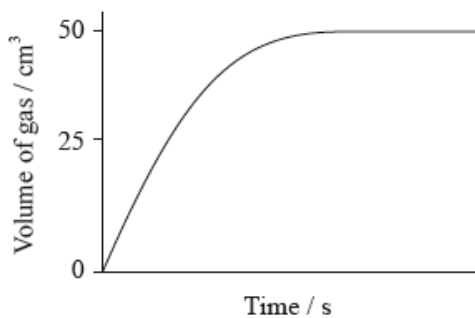
Markscheme

D

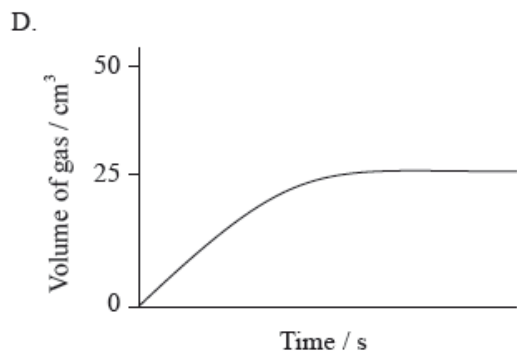
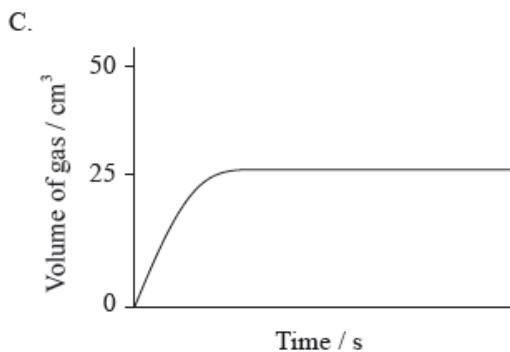
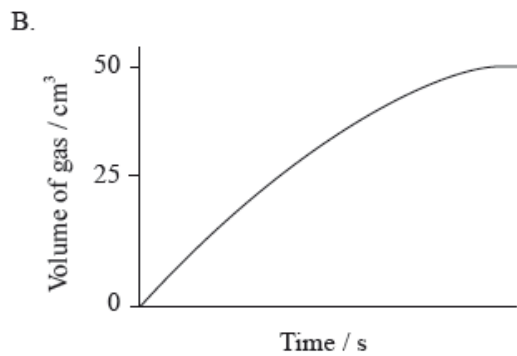
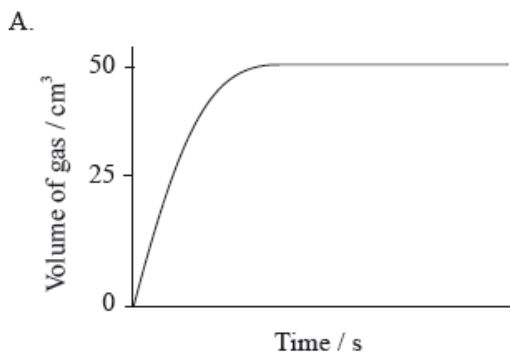
Examiners report

[N/A]

A student added 0.20 g of calcium carbonate powder to 100 cm³ of 1.0 mol dm⁻³ hydrochloric acid (an excess) and measured the volume of the gas that was evolved. The graph of the results is shown below.



Which graph would be obtained if 0.20 g of calcium carbonate powder is added to 100 cm³ of 0.5 mol dm⁻³ hydrochloric acid (an excess)?



Markscheme

B

Examiners report

[N/A]

Which is a correct unit for expressing the rate of a reaction?

- A. mol dm⁻³s⁻¹
- B. mol dm⁻³s
- C. mol s
- D. mol⁻¹ dm³s⁻¹

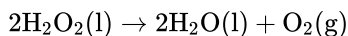
Markscheme

A

Examiners report

[N/A]

Which variable is best to use when determining the rate of decomposition of hydrogen peroxide?



- A. Volume of solution
- B. Volume of gas
- C. pH of solution
- D. Conductivity of solution

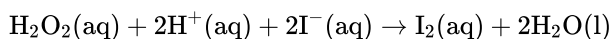
Markscheme

B

Examiners report

[N/A]

Consider the following reaction between hydrogen peroxide, hydrogen ions and iodide ions.



Which changes could be used to investigate the rate of this reaction?

- I. Electrical conductivity
 - II. Mass of solution
 - III. Colour intensity
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

Markscheme

B

Examiners report

[N/A]

Which statements explain the increase in the rate of a reaction when the temperature is increased?

- I. More particles have energy greater than the activation energy.
- II. The frequency of collisions increases.

III. The activation energy decreases.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

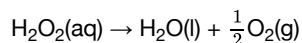
Markscheme

A

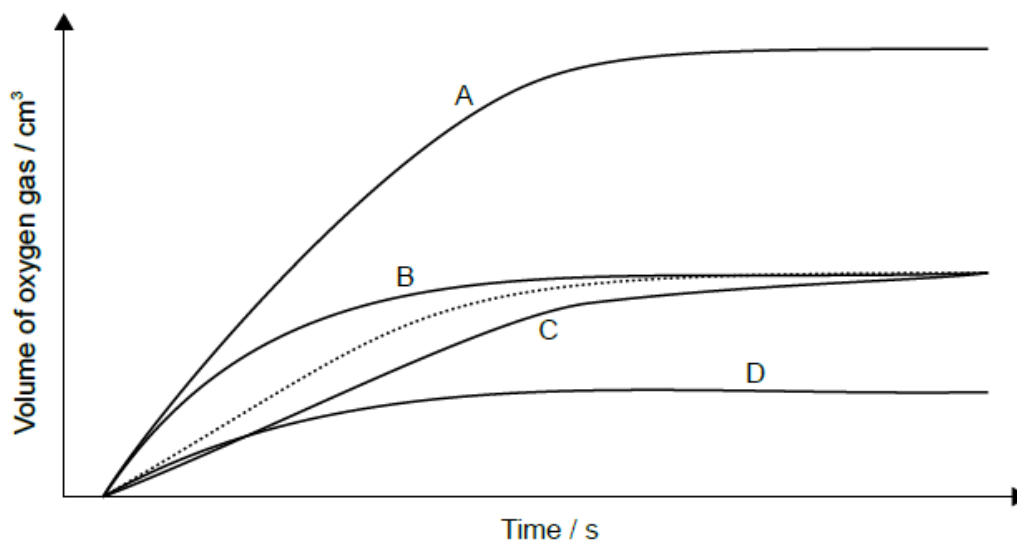
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[N/A]

100 cm³ of 10% hydrogen peroxide solution decomposes at 298 K to form water and oxygen.



The dotted line graph represents the volume of oxygen produced.



Which graph represents the decomposition of an equal volume of a 20% solution under the same conditions?

Markscheme

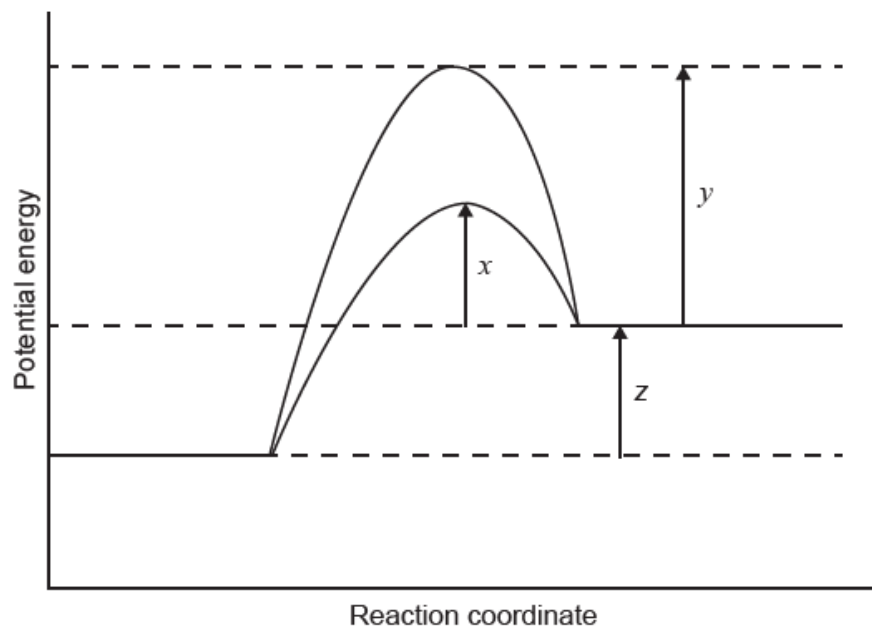
A

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[N/A]

The diagram shows the energy profile for a catalysed and uncatalysed reaction.

Which represents the enthalpy change, ΔH , and the activation energy, E_a , for the **catalysed** reaction?



	ΔH	E_a (catalysed reaction)
A.	z	$x + z$
B.	z	$z + y$
C.	$-z$	x
D.	$z + x$	x

Markscheme

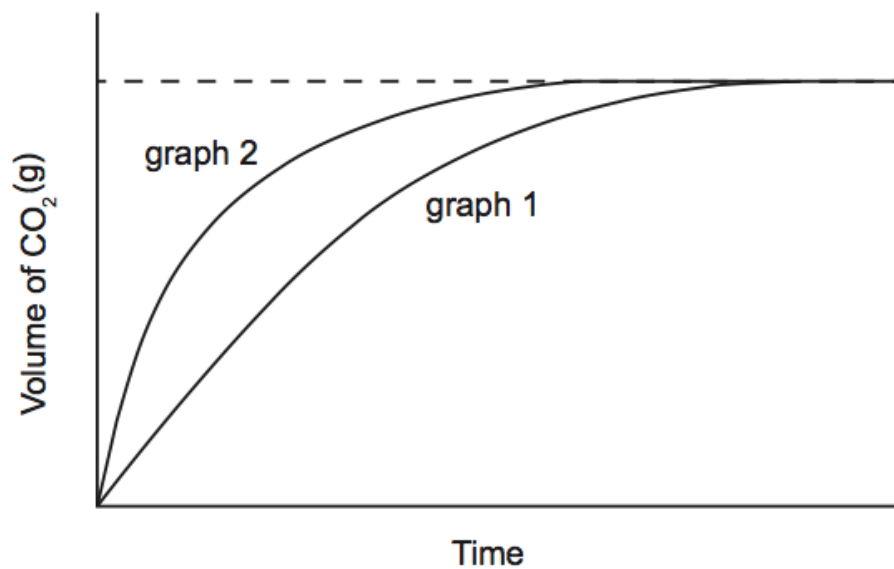
A

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[N/A]

Graph 1 shows a plot of volume of $\text{CO}_2(\text{g})$ against time for the reaction of $\text{CaCO}_3(\text{s})$ with $1.00 \text{ mol dm}^{-3} \text{HCl}(\text{aq})$. The acid is the limiting reagent and entirely covers the lumps of $\text{CaCO}_3(\text{s})$.

Which set of conditions is most likely to give the data plotted in graph 2 when the same mass of $\text{CaCO}_3(\text{s})$ is reacted with the same volume of $\text{HCl}(\text{aq})$ at the same temperature?



	Size of lumps	Concentration of acid / mol dm ⁻³
A.	larger	1.00
B.	smaller	0.05
C.	smaller	1.00
D.	larger	0.05

Markscheme

C

Examiners report

[N/A]