SL Paper 1

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

$$\mathrm{N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)} \quad \Delta H^{\ominus} = -92\ \mathrm{kJ}$$

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.

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

$$Cr_2O_7^{2-}(aq) + 6I^-(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 7H_2O(l)$$

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

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

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 $E \geqslant E_{\mathrm{a}}$

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

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

Copper catalyses the reaction between zinc and dilute sulfuric acid.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

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

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

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

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.

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

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

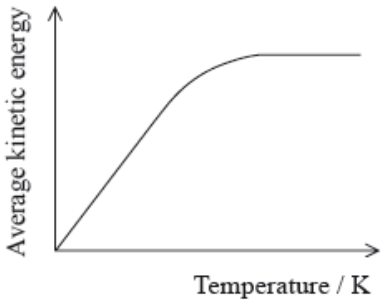
B. I and III only

C. II and III only

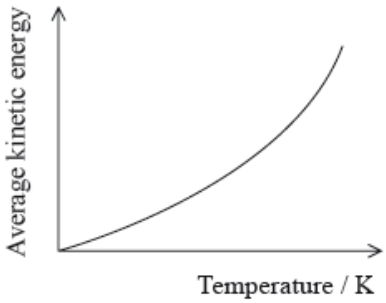
D. I, II and III

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

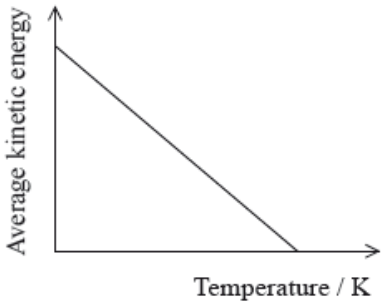
A.



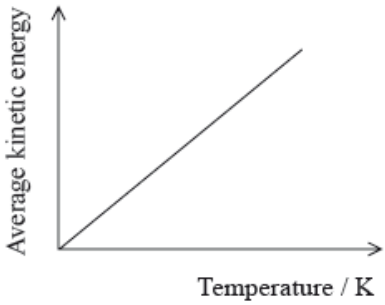
B.



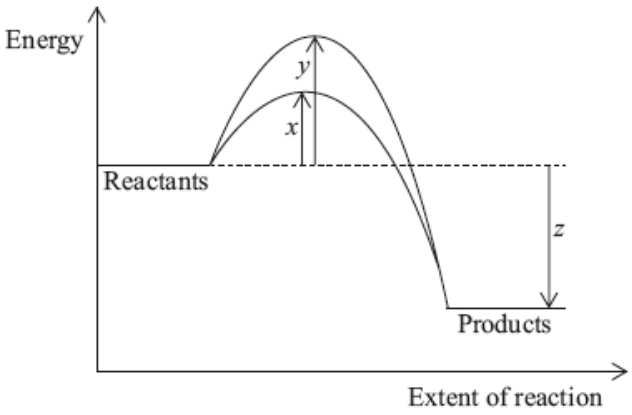
C.



D.



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

Which changes increase the rate of the reaction below?

$$C_4H_{10}(g) + Cl_2(g) \rightarrow C_4H_9Cl\ (l) + HCl(g)$$

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

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

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.

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

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

Which are appropriate units for the rate of a reaction?

A. $\mathrm{mol\,dm^{-3}s^{-1}}$

B. $\mathrm{mol\,dm^{-3}s}$

C. $\mathrm{mol\,dm^{-3}}$

D. s

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which change does **not** increase the initial rate of reaction when $CaCO_3(s)$ is added to excess HCl(aq)?

A. Decrease in the size of the $CaCO_3(s)$ particles

B. Increase in the temperature of the reaction mixture

C. Increase in the concentration of HCl(aq), keeping the same volume

D. Increase in the volume of HCl(aq), keeping the same concentration

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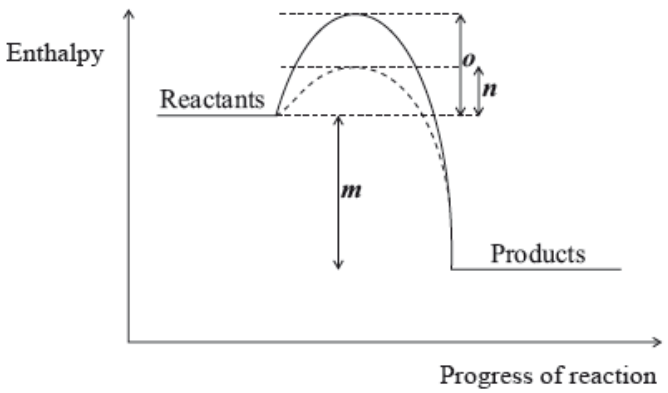
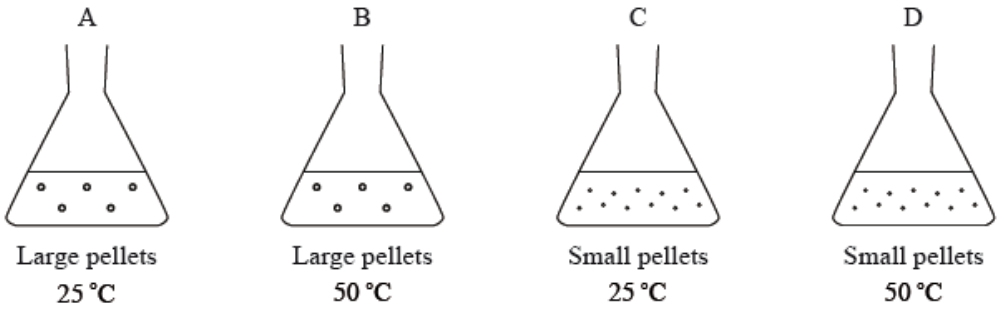
The following enthalpy level diagram shows the effect of the addition of a catalyst on a chemical reaction. What do ***m***, ***n*** and ***o*** represent?

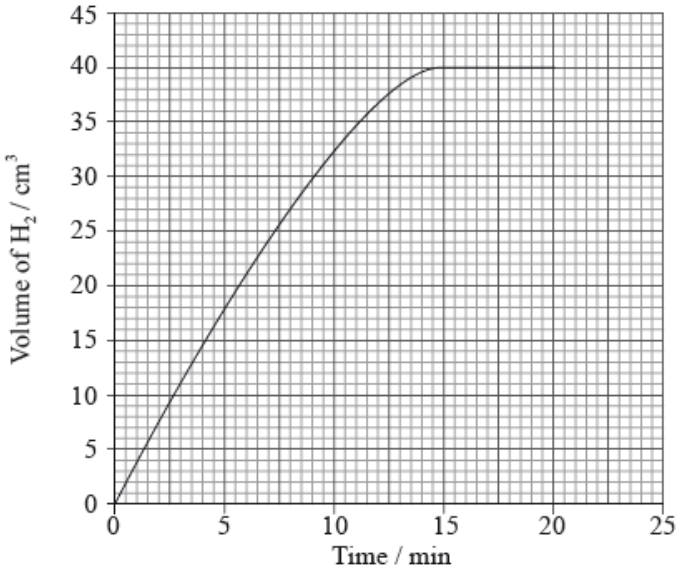


	m	*n*	*o*
A.	ΔH	E_a (without a catalyst)	E_a (with a catalyst)
B.	E_a (with a catalyst)	ΔH	E_a (without a catalyst)
C.	E_a (with a catalyst)	E_a (without a catalyst)	ΔH
D.	ΔH	E_a (with a catalyst)	E_a (without a catalyst)

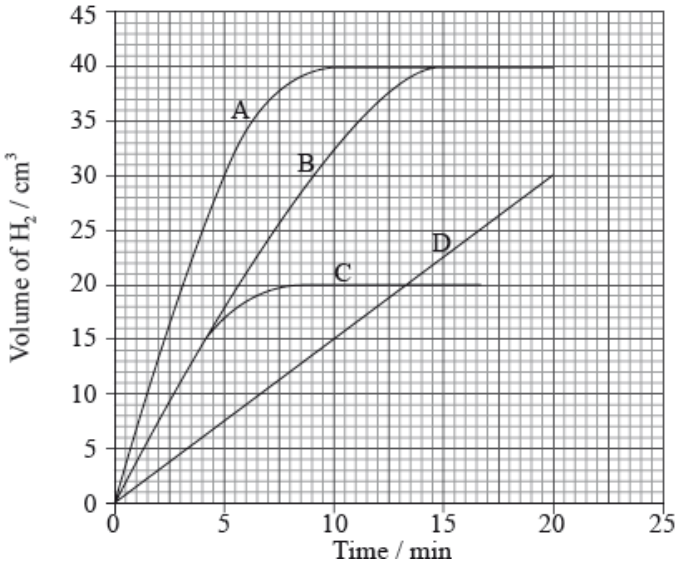
In which flask will the reaction between 2.0 g of magnesium carbonate and 25 cm^3 1.0 mol dm^{-3} hydrochloric acid occur most rapidly?



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?



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

$$\mathrm{N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)} \quad \Delta H = -92\ \mathrm{kJ}$$

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.

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

$$\mathrm{CH_3–CO–CH_3(aq) + I_2(aq) \xrightarrow{H^+(aq)} CH_3–CO–CH_2–I(aq) + HI(aq)}$$

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

Consider the reaction between gaseous iodine and gaseous hydrogen.

$$\mathrm{I_2(g) + H_2(g) \rightleftharpoons 2HI(g)} \quad \Delta H^\ominus = -9\ \mathrm{kJ}$$

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.

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

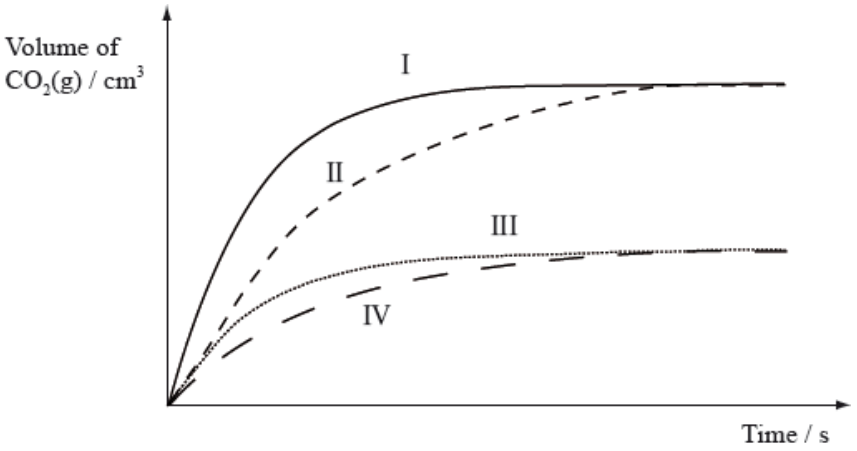
D. I, II and III

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

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

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

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

A. Rate of reaction

B. Collision frequency

C. Collision geometry

D. % of molecules with $E \geq E_a$

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

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

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

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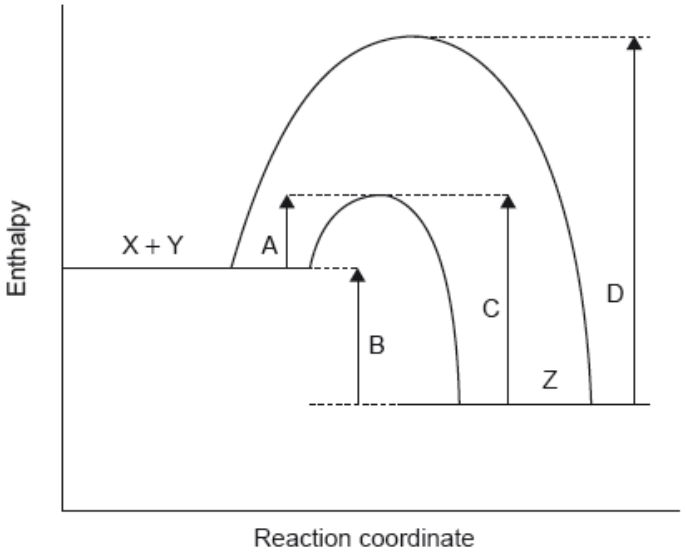
The potential energy profile for the reversible reaction, X + Y $\rightleftharpoons$ Z is shown.



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

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

$$\mathrm{CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I\,(aq) + H^+(aq) + I^-(aq)}$$

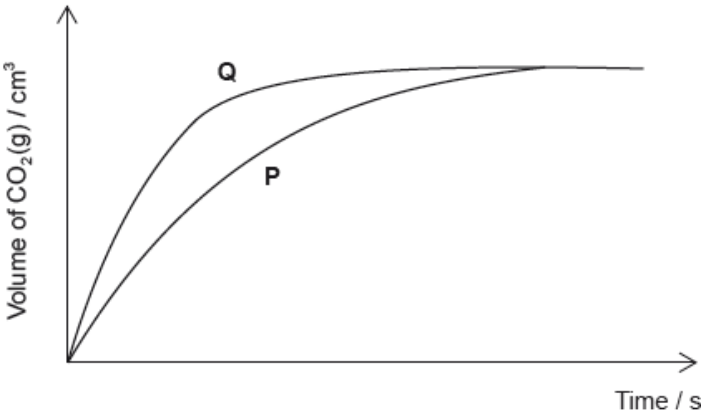
A. A colorimeter

B. A gas syringe

C. A stopwatch

D. A pH meter

$100\ \mathrm{cm^3}$ of a $1.00\ \mathrm{mol\,dm^{-3}}$ 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 $200\ \mathrm{cm}^3$

B. Increasing the mass of calcium carbonate to 4.00 g

C. Increasing the concentration of the hydrochloric acid to $2.00\ \mathrm{mol\,dm}^{-3}$

D. Replacing the 2.00 g of small pieces of calcium carbonate with 2.00 g of larger pieces of calcium carbonate

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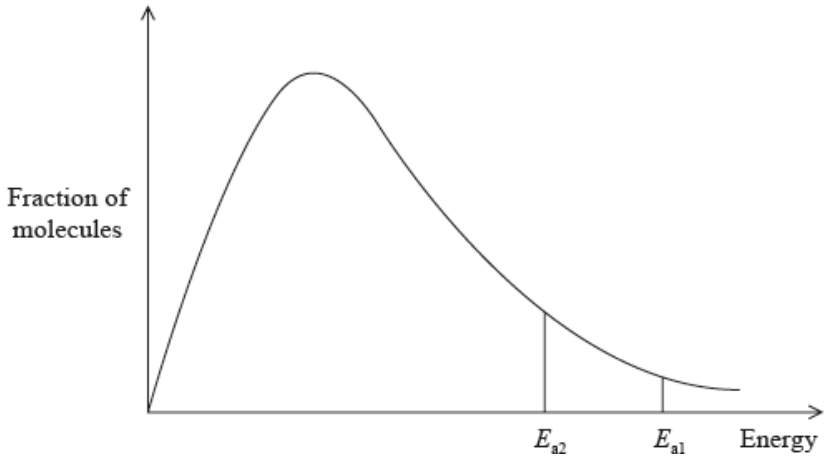
The diagram represents the Maxwell-Boltzmann energy distribution curve of the reactants for a chemical reaction with different activation energies, E_{a1} and E_{a2}.



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.

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

A. mol

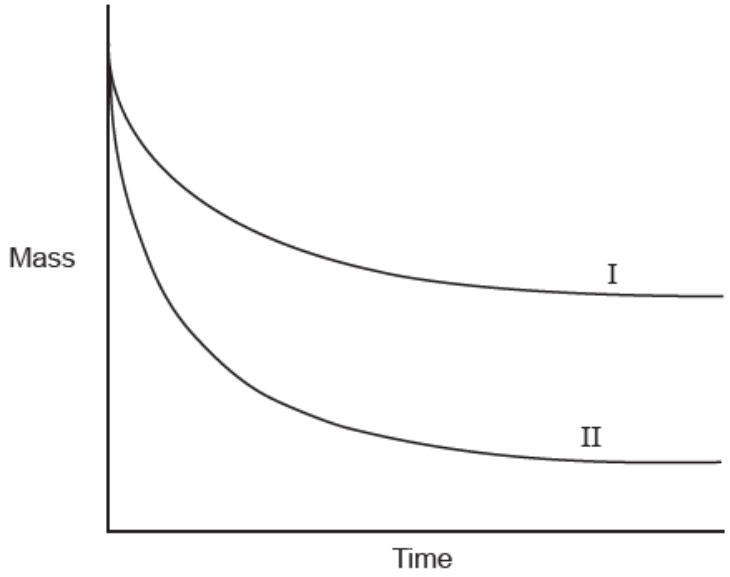
B. $\mathrm{mol\,dm}^{-3}$

C. $\mathrm{mol\,dm}^{-3}\mathrm{s}^{-1}$

D. dm^3

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?

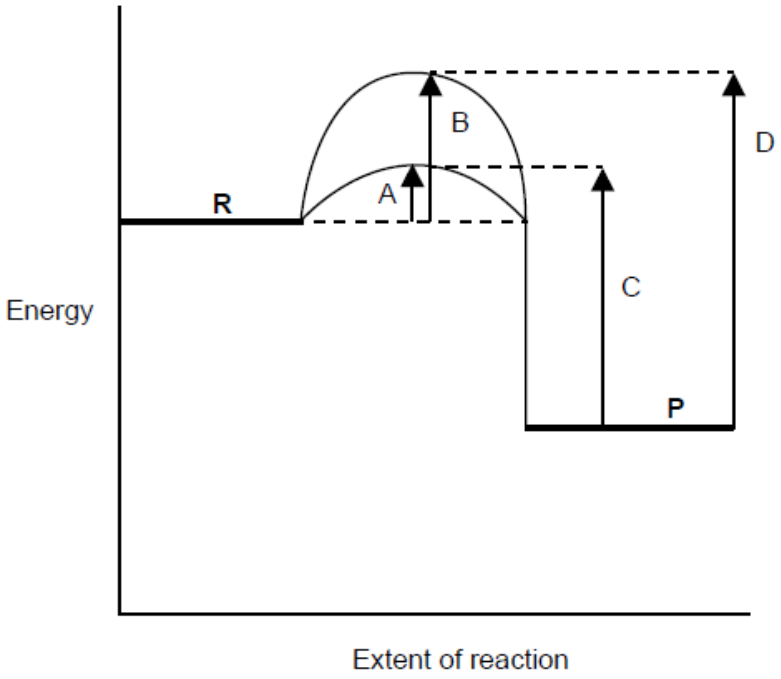
A. Doubling the mass of powdered Mg

B. Using the same mass of Mg ribbon

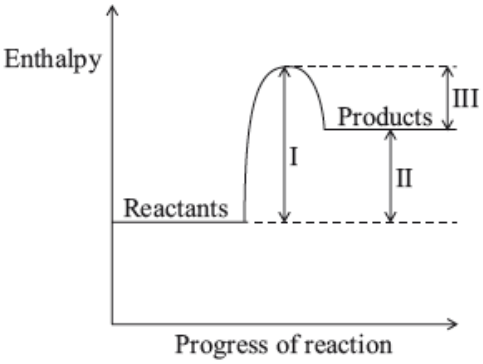
C. Increasing the temperature

D. Using the same volume of more concentrated HCl

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



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

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

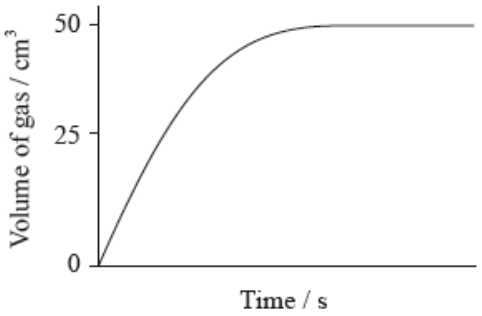
A. The time it takes to use up all the reactants

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

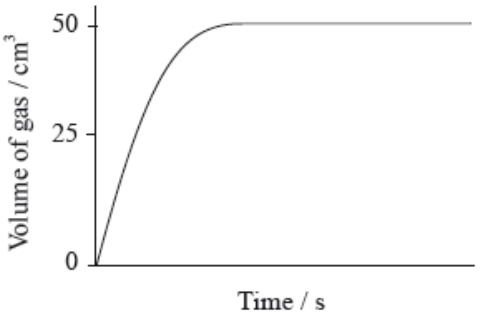
D. The increase in concentration of a product per unit time

A student added 0.20 g of calcium carbonate powder to $100\ \mathrm{cm^3}$ of $1.0\ \mathrm{mol\,dm^{-3}}$ hydrochloric acid (an excess) and measured the volume of the gas that was evolved. The graph of the results is shown below.

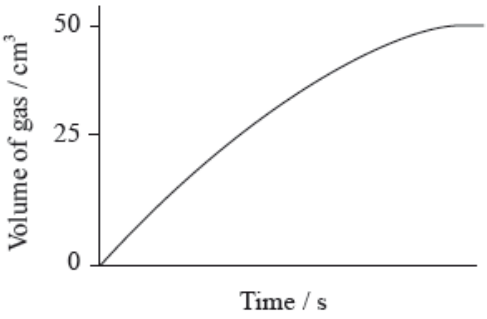


Which graph would be obtained if 0.20 g of calcium carbonate powder is added to $100\ \mathrm{cm^3}$ of $0.5\ \mathrm{mol\,dm^{-3}}$ hydrochloric acid (an excess)?

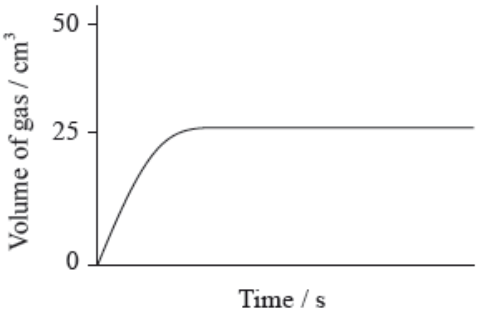
A.



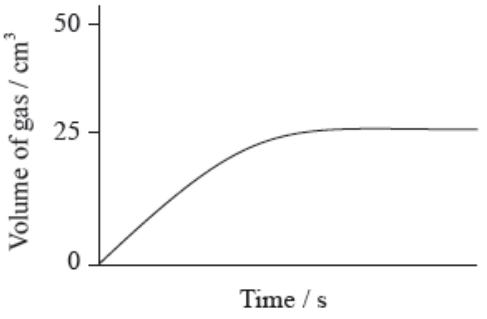
B.



C.



D.



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

A. $\mathrm{mol\,dm^{-3}s^{-1}}$

B. $\mathrm{mol\,dm^{-3}s}$

C. $\mathrm{mol\,s}$

D. $\mathrm{mol^{-1}\,dm^3s^{-1}}$

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

$$2\mathrm{H_2O_2(l)} \rightarrow 2\mathrm{H_2O(l)} + \mathrm{O_2(g)}$$

A. Volume of solution

B. Volume of gas

C. pH of solution

D. Conductivity of solution

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

$$\mathrm{H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)}$$

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

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

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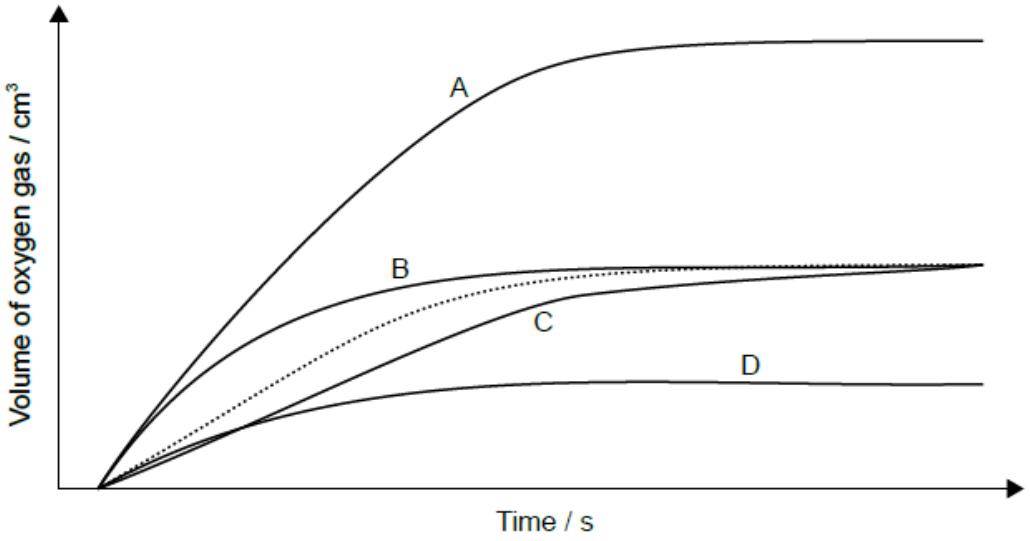
100 cm^3 of 10% hydrogen peroxide solution decomposes at 298 K to form water and oxygen.

$$H_2O_2(aq) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$$

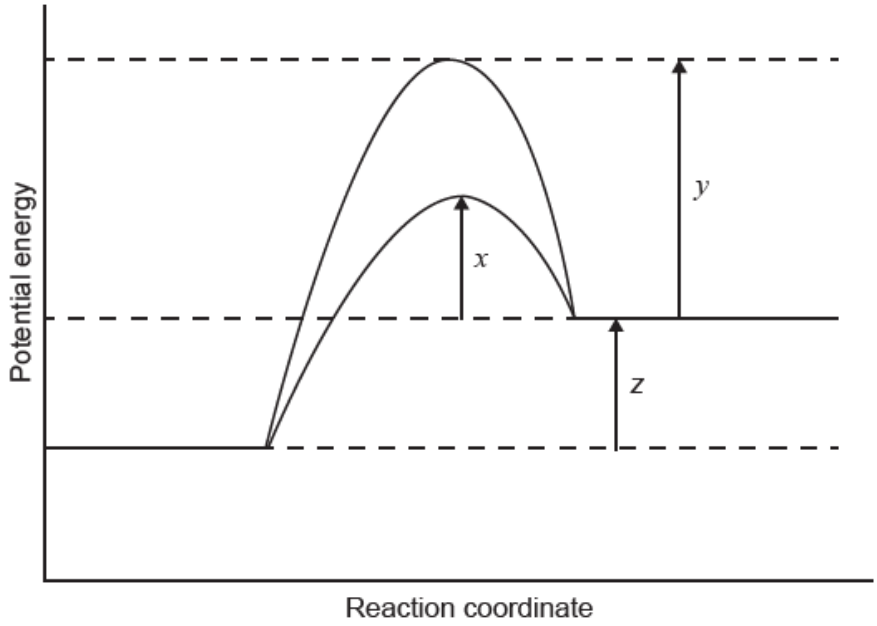
The dotted line graph represents the volume of oxygen produced.



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

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

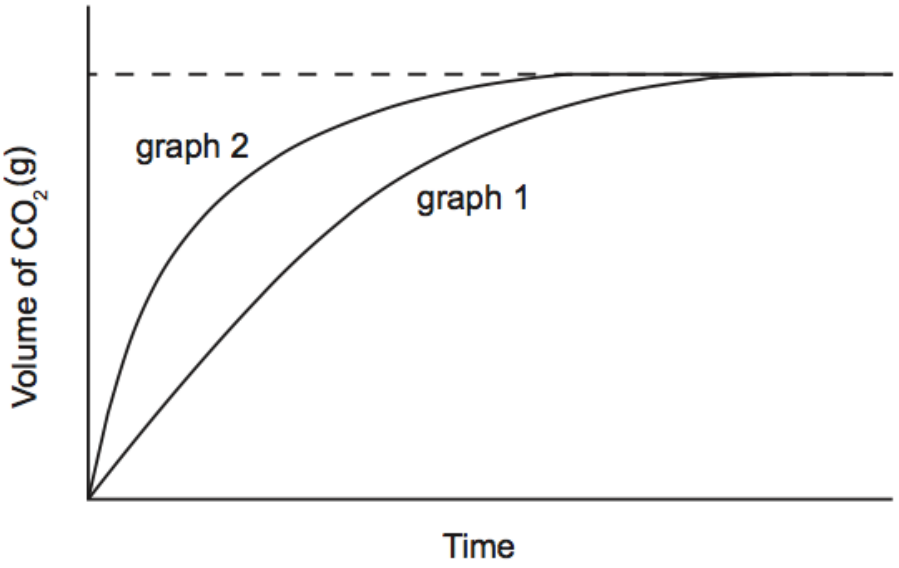
Which represents the enthalpy change, ΔH, and the activation energy, E_a, for the **catalysed** reaction?



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

Graph 1 shows a plot of volume of $CO_2(g)$ against time for the reaction of $CaCO_3(s)$ with 1.00 $moldm^{-3}HCl$ (aq). The acid is the limiting reagent and entirely covers the lumps of $CaCO_3(s)$.

Which set of conditions is most likely to give the data plotted in graph 2 when the same mass of $CaCO_3(s)$ is reacted with the same volume of HCl(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