Cambridge AS & A Level

# CHEMISTRY

# Paper 1

## Topical Past Paper Questions

+ Answer Scheme

## 2015 - 2021

PapaCambridge

# Chapter 8

# Reaction kinetics

## 8.1 Rate of reaction

410. 9701_m21_qp_12 Q: 10

A large excess of marble chips is reacted with 25 $cm^3$ of 1.0 mol $dm^{-3}$ hydrochloric acid at 40 °C.

How is the result different when the reaction is repeated with 60 $cm^3$ of 0.5 mol $dm^{-3}$ hydrochloric acid at 40 °C?

**A** The reaction is faster and more of the products are made when the reaction is complete.

**B** The reaction is faster and less of the products are made when the reaction is complete.

**C** The reaction is slower and more of the products are made when the reaction is complete.

**D** The reaction is slower and less of the products are made when the reaction is complete.

411. 9701_s21_qp_12 Q: 11

**1** Two chemicals, X and Y, react together in solution to give product Z.

The rate of formation of product Z at the start of the reaction was measured in five experiments, 1–5, using various concentrations of X and Y. The results are shown.

| experiment number | starting concentration of X / mol dm$^{-3}$ | starting concentration of Y / mol dm$^{-3}$ | rate of formation of Z at the start / mol dm$^{-3}$ s$^{-1}$ |
|---|---|---|---|
| 1 | 0.10 | 0.10 | 0.0001 |
| 2 | 0.10 | 0.20 | 0.0004 |
| 3 | 0.10 | 0.40 | 0.0016 |
| 4 | 0.20 | 0.10 | 0.0001 |
| 5 | 0.40 | 0.10 | 0.0001 |

Which statement is correct?

**A** The rate of the reaction is directly proportional to the concentration of reagent X.

**B** The rate of the reaction is directly proportional to the concentration of reagent Y.

**C** The rate of the reaction is **not** affected by the concentration of reagent X.

**D** The rate of the reaction is **not** affected by the concentration of reagent Y.

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412. 9701_s17_qp_11 Q: 11

When 4 g of powdered calcium carbonate, $M_r$ = 100, were added to 100 cm$^3$ of 0.10 mol dm$^{-3}$ hydrochloric acid the volume of carbon dioxide produced was recorded.

| time / s | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 |
|---|---|---|---|---|---|---|---|---|
| total volume of carbon dioxide given off / cm$^3$ | 40 | 70 | 88 | 101 | 110 | 116 | 120 | 120 |

Which row gives the correct explanations about these results?

| | why the rate of the reaction changes with time | why the reaction stops |
|---|---|---|
| **A** | fewer collisions between reacting molecules occur | the calcium carbonate is used up |
| **B** | fewer collisions between reacting molecules occur | the hydrochloric acid is used up |
| **C** | more collisions between reacting molecules occur | the calcium carbonate is used up |
| **D** | more collisions between reacting molecules occur | the hydrochloric acid is used up |

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413. 9701_w17_qp_11 Q: 7

Iodine and propanone react according to the following equation.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

If the concentration of propanone is increased, keeping the total reaction volume constant, the rate of the reaction also increases.

What could be the reason for this?

**A** A greater proportion of collisions is successful at the higher concentration.

**B** The particles are further apart at the higher concentration.

**C** The particles have more energy at the higher concentration.

**D** There are more collisions between reactant particles per second at the higher concentration.

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414. 9701_w17_qp_12 Q: 10

A large excess of marble chips was reacted with 25 $cm^3$ of 1.0 mol $dm^{-3}$ hydrochloric acid at 40 °C.

How will the result be different when the reaction is repeated with 60 $cm^3$ of 0.5 mol $dm^{-3}$ hydrochloric acid at 40 °C?

**A** The reaction is faster and less of the products are made.

**B** The reaction is faster and more of the products are made.

**C** The reaction is slower and less of the products are made.

**D** The reaction is slower and more of the products are made.

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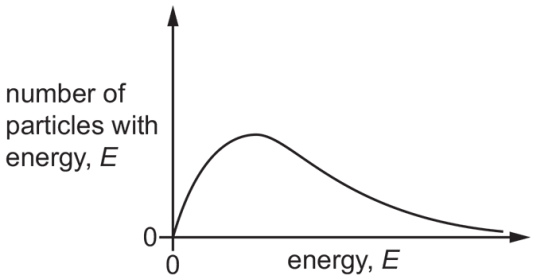
## 8.2 Effect of temperature on reaction rates and the concept of activation energy

415. 9701_m22_qp_12 Q: 15

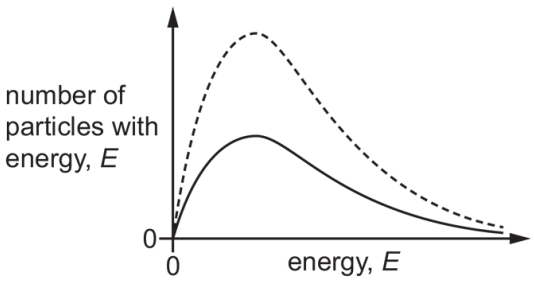
The Boltzmann distribution for one mole of a gas at temperature $T$ is shown.



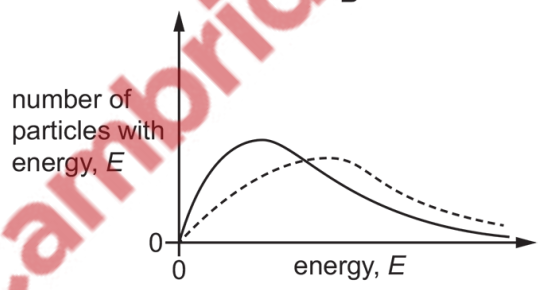

One mole of the same gas is added, and the gas remains at temperature $T$.

Which dotted curve shows the distribution with the added gas?

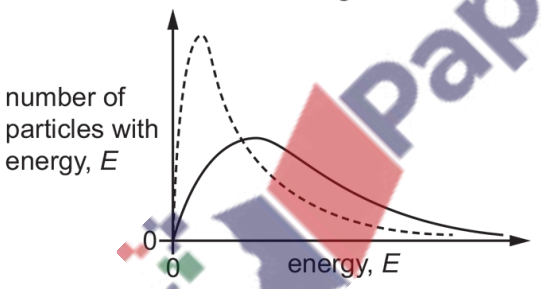
A



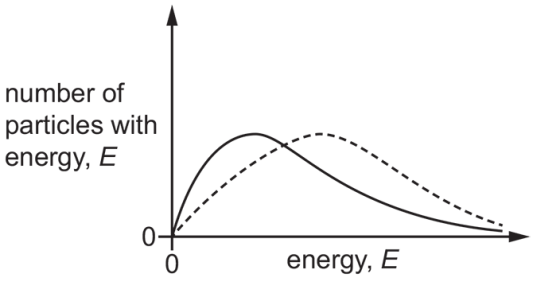

B




C




D



416. 9701_m22_qp_12 Q: 16

In the reaction shown, the concentrations of both X and Y are reduced to half of their original values whilst keeping the total volume of the solution constant.

$$X(aq) + Y(aq) \rightarrow XY(aq)$$

Simultaneously the temperature is increased from 298 K to 348 K.

Which prediction is definitely true?

**A** A smaller proportion of collisions between particles of X and particles of Y will be successful.

**B** The average kinetic energy of particles of X and particles of Y will increase.

**C** The rate of the reaction will be unaffected.

**D** The frequency of collisions between particles of X and particles of Y will halve.

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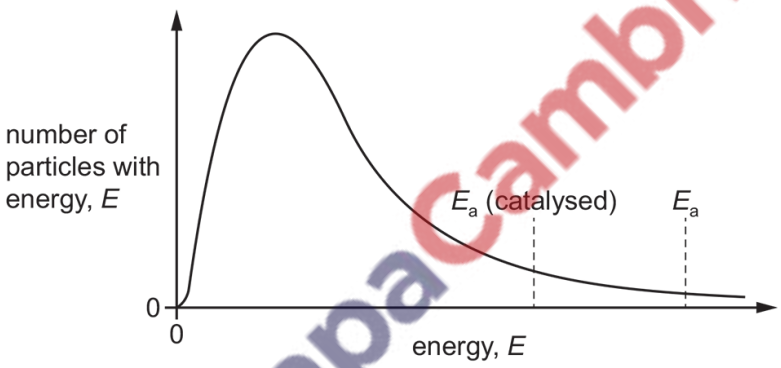
417. 9701_m21_qp_12 Q: 11

The Boltzmann distribution curve for a gaseous mixture of ethene and hydrogen is shown. Nickel is an effective catalyst for the reaction that occurs.




How does the diagram appear if the same reaction mixture is at a higher temperature?

**A** The curve is unchanged.

**B** The values of both $E_a$ (catalysed) and $E_a$ decrease.

**C** The values of both $E_a$ (catalysed) and $E_a$ increase.

**D** The values of both $E_a$ (catalysed) and $E_a$ remain the same.

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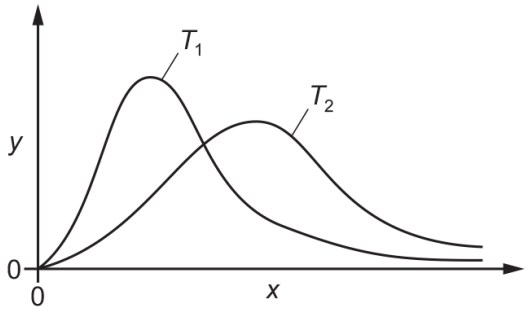
418. 9701_s21_qp_11 Q: 5

The diagram shows the Boltzmann distribution for the same gas at two different temperatures, $T_1$ and $T_2$.




What is plotted on the *y*-axis and which line represents the higher temperature?

| | plotted on *y*-axis | higher temperature |
|---|---|---|
| **A** | number of molecules | $T_1$ |
| **B** | number of molecules | $T_2$ |
| **C** | molecular energy | $T_1$ |
| **D** | molecular energy | $T_2$ |

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419. 9701_s21_qp_13 Q: 12

The height of the peak of the curve in a Boltzmann distribution represents the number of molecules that have the most probable energy.

A sample of gas has its temperature decreased without changing the number of molecules present.

Which statement correctly describes a feature of the Boltzmann distribution for the gas when the temperature decreases?

**A** The value of the most probable energy would stay the same.

**B** The number of molecules with the most probable energy would increase.

**C** The area under the molecular energy distribution curve would decrease.

**D** The number of molecules at the very high energy end of the distribution would stay the same.

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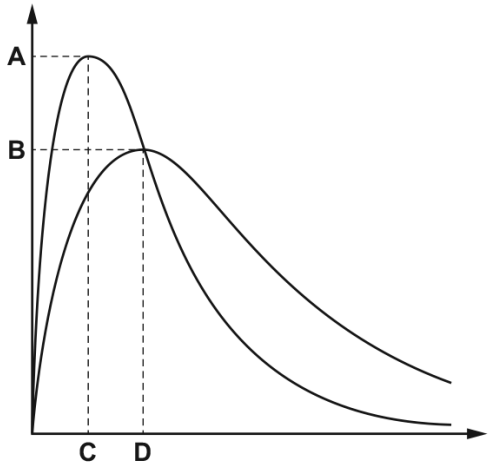
420. 9701_s20_qp_11 Q: 6

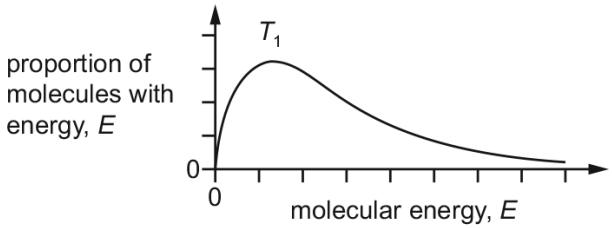
The diagram shows the Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy for molecules of the same sample of gas at the **lower** temperature?



421. 9701_m19_qp_12 Q: 1

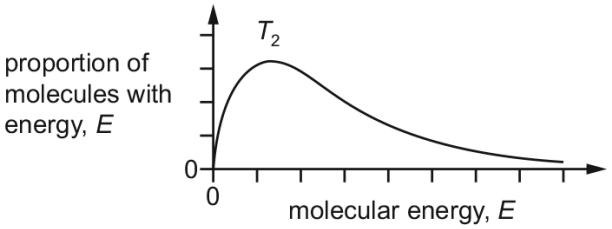
The Boltzmann distribution is shown for a sample of gas at an initial temperature, $T_1$.



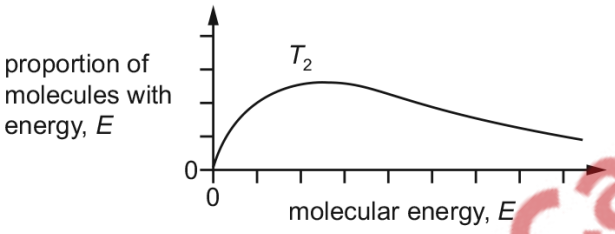

The sample of gas was heated to temperature, $T_2$.

What is the correct distribution for the higher temperature, $T_2$?

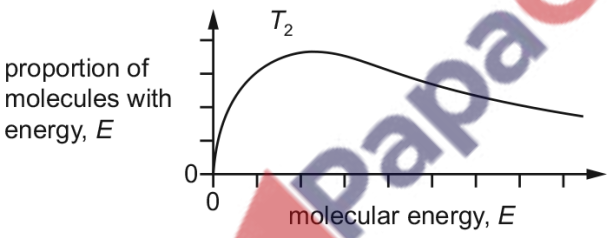
**A**



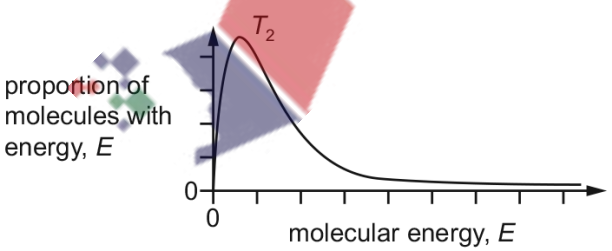

**B**




**C**




**D**



422. 9701_s19_qp_11 Q: 1

The temperature of a sample of an inert gas is increased.

What effect does this have on the number of molecules with the most probable energy and on the number of molecules with high energy?

| | number of molecules with the most probable energy | number of molecules with high energy |
|---|---|---|
| **A** | decreases | decreases |
| **B** | decreases | increases |
| **C** | increases | decreases |
| **D** | increases | increases |

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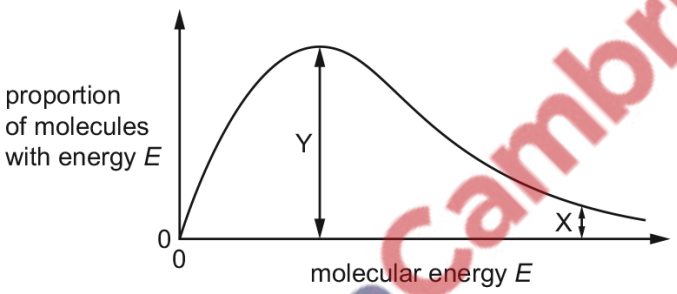
423. 9701_s17_qp_13 Q: 11

The diagram shows the Boltzmann distribution of the energy of gaseous molecules at a particular temperature.




Which statement is correct?

**A** If the temperature of the gas is raised, the height of the maximum of the curve increases.

**B** If the temperature of the gas is raised, the maximum of the curve moves to the right.

**C** The length of the line labelled X shows the activation energy for the reaction.

**D** The length of the line labelled Y shows the enthalpy change of the reaction.

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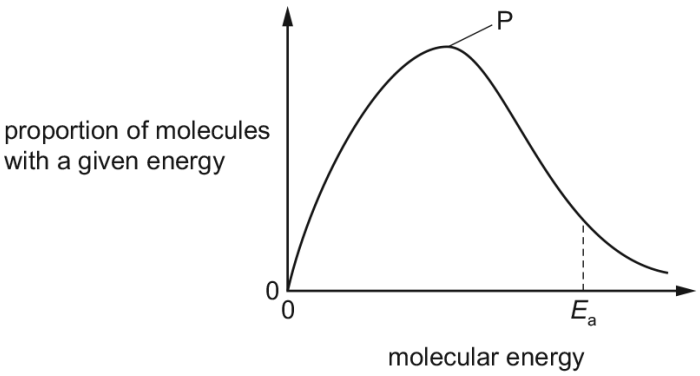
424. 9701_s16_qp_12 Q: 1

The diagram shows the Boltzmann distribution of energies in 1 mole of a gas. The gas can take part in a reaction with an activation energy, $E_a$.




Which statement correctly describes the effect of an increase in temperature?

**A** Peak P will be higher and fewer molecules will have energy > $E_a$.

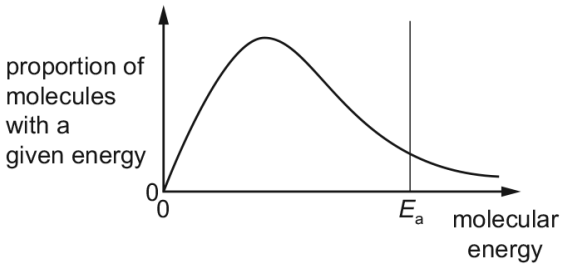
**B** Peak P will be higher and more molecules will have energy > $E_a$.

**C** Peak P will be lower and fewer molecules will have energy > $E_a$.

**D** Peak P will be lower and more molecules will have energy > $E_a$.

425. 9701_w16_qp_11 Q: 1

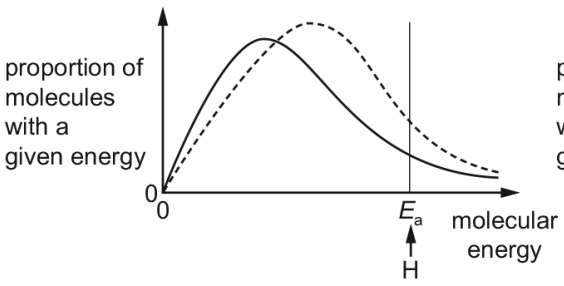
The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, $E_a$, is marked.



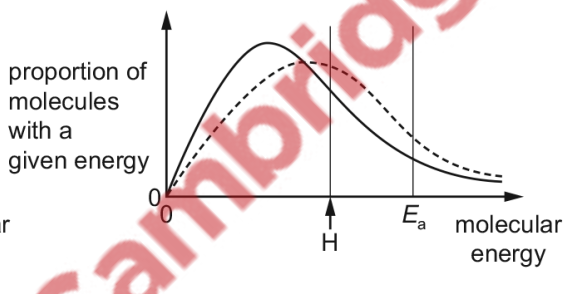

The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?

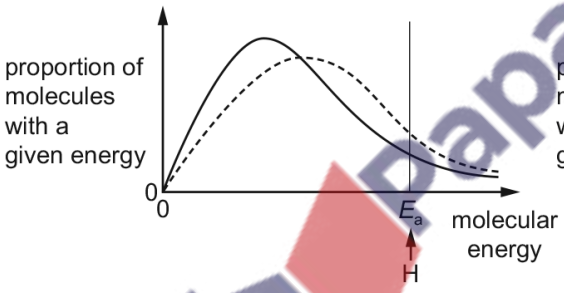
A



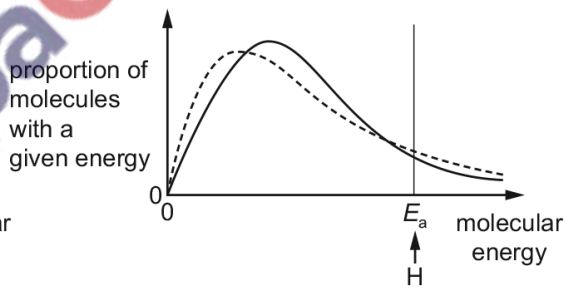

B




C

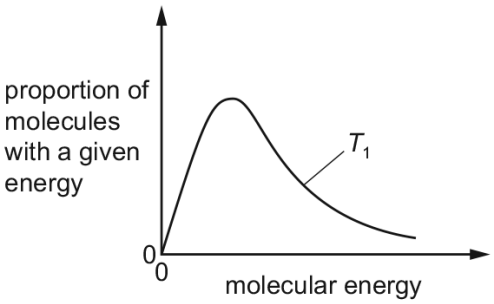



D



426. 9701_w16_qp_12 Q: 1

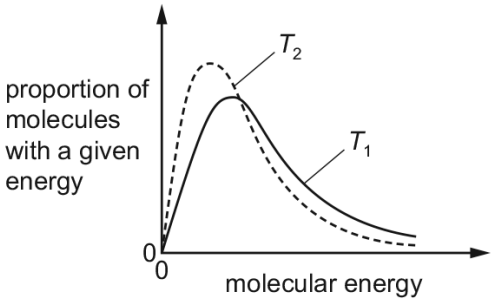
The molecules of a gas at a constant temperature, $T_1$, have the distribution of molecular energies shown in the diagram.



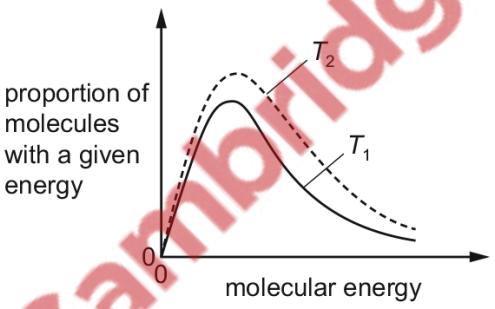

When the temperature is **increased** to $T_2$, the distribution of molecular energies changes.

Which diagram correctly shows this change?

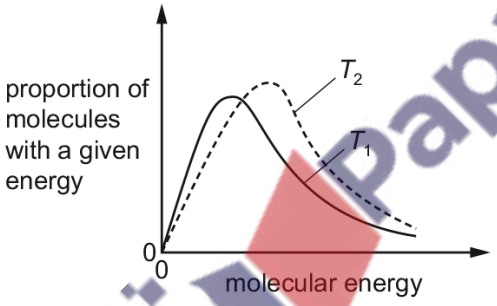
A



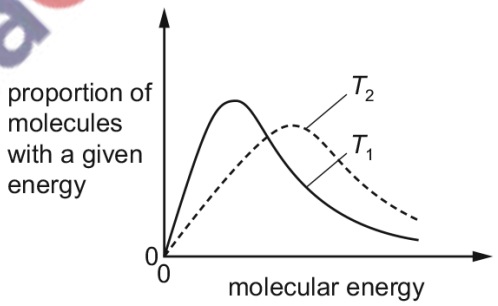

B




C

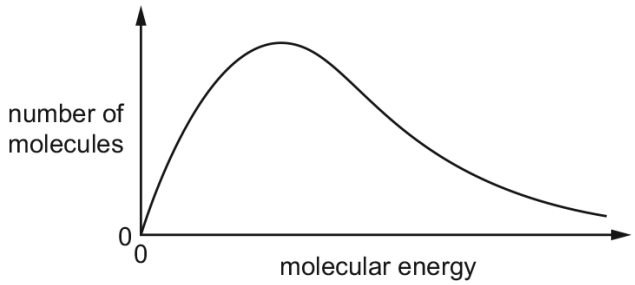



D



427. 9701_s15_qp_12 Q: 11

The Boltzmann distribution below shows the distribution of molecular energies in a sample of a gas at a given temperature.




Which statement correctly describes the change in such a distribution if the temperature is increased?

**A** Fewer molecules possess the most probable energy value and this value shifts to the left.

**B** Fewer molecules possess the most probable energy value and this value shifts to the right.

**C** More molecules possess the most probable energy value and this value shifts to the left.

**D** The area under the curve of the distribution increases.

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428. 9701_w15_qp_12 Q: 11

Which row correctly describes what happens when the temperature of a chemical reaction is **decreased**?

| | activation energy ($E_a$) | number of successful collisions |
|---|---|---|
| **A** | decreases | decreases |
| **B** | decreases | increases |
| **C** | remains the same | decreases |
| **D** | remains the same | increases |

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## 8.3 Homogeneous and heterogeneous catalysts

429. 9701_s21_qp_11 Q: 11

Which statement about catalysts is correct?

**A** They change the reaction pathway by increasing the activation energy.

**B** They increase the rate of reaction by lowering the enthalpy change of the reaction.

**C** They increase the number of particles that have sufficient energy to react.

**D** Heterogeneous catalysts are in the same state as the reactant.

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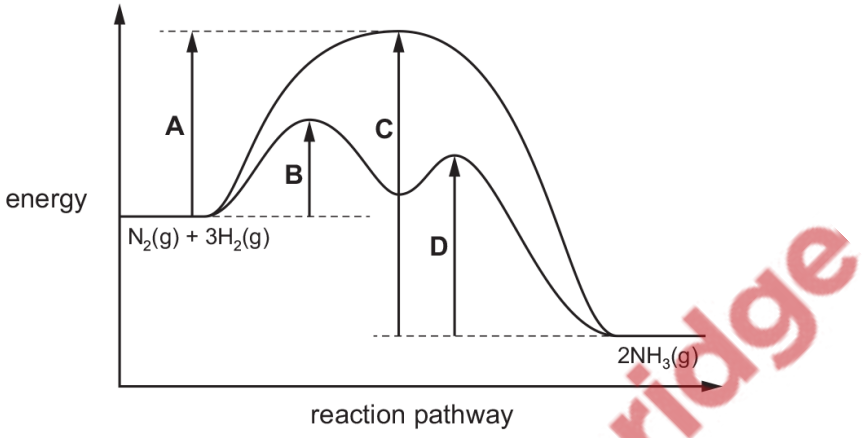
430. 9701_s21_qp_12 Q: 7

The reaction pathway diagram for the catalysed reaction and the uncatalysed reaction between $N_2$ and $H_2$ is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which letter represents the activation energy for the first step in the decomposition of $NH_3$ in the presence of a catalyst?

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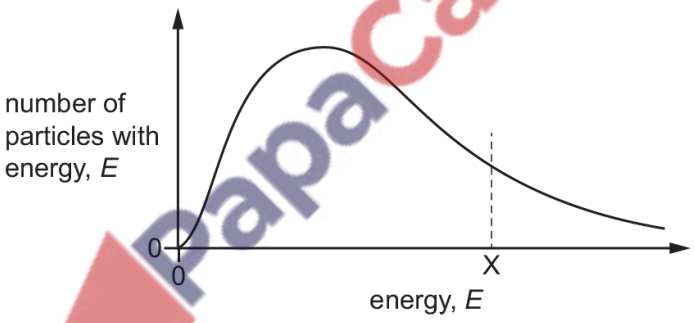
431. 9701_w21_qp_11 Q: 11

The diagram shows the Boltzmann distribution of energies for a reactant gas. For a particular reaction, the activation energy is X.




Which change to the diagram occurs if an effective catalyst is added at the same temperature?

**A** More particles will possess higher values of *E*.

**B** The peak will move to the left.

**C** The peak will move to the right.

**D** The value of the activation energy decreases.

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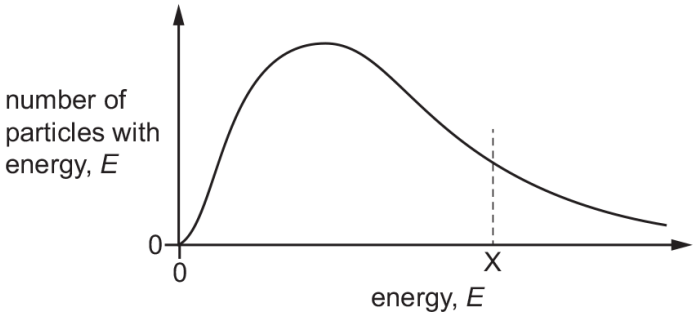
432. 9701_w21_qp_13 Q: 11

The diagram shows the Boltzmann distribution of energies for a reactant gas. For a particular reaction, the activation energy is X.




Which change to the diagram occurs if an effective catalyst is added at the same temperature?

**A** More particles will possess higher values of *E*.

**B** The peak will move to the left.

**C** The peak will move to the right.

**D** The value of the activation energy decreases.

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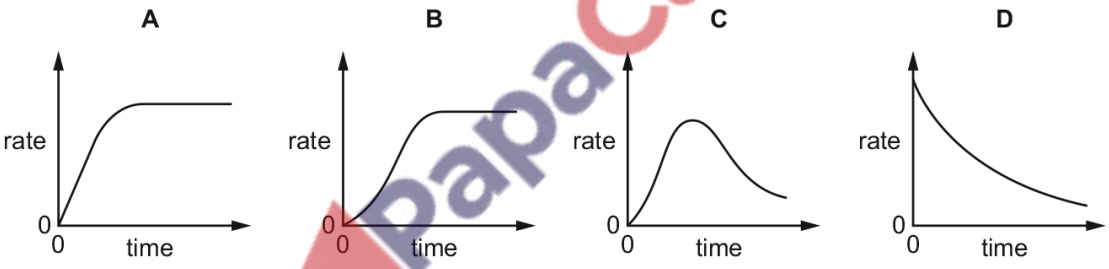
433. 9701_w20_qp_11 Q: 11

An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

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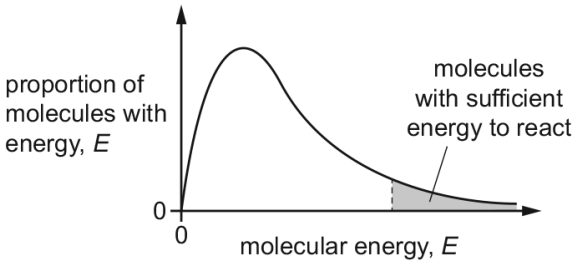
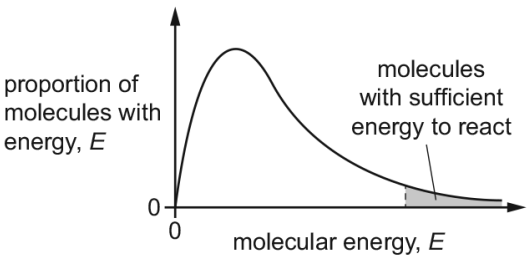
434. 9701_s19_qp_12 Q: 1

The Boltzmann distribution of molecular energies in a sample of aqueous hydrogen peroxide at room temperature is shown.

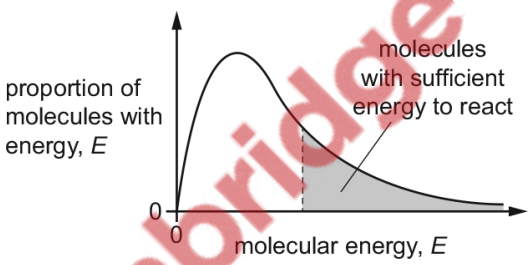



Which diagram shows the Boltzmann distribution of molecular energies of aqueous hydrogen peroxide maintained at room temperature when a catalyst, manganese(IV) oxide, is added?

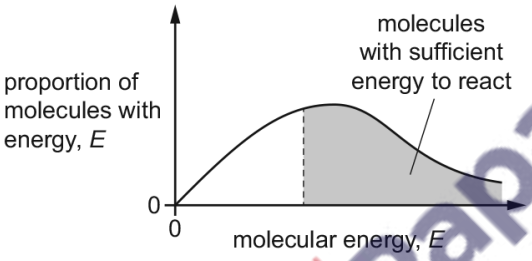
A



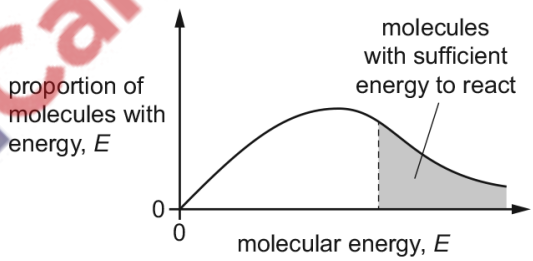

B




C




D

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435. 9701_s19_qp_12 Q: 11

Which row is an example of heterogeneous catalysis?

| | reaction | catalyst |
|---|---|---|
| **A** | esterification | sulfuric acid |
| **B** | the Contact process | divanadium pentoxide |
| **C** | destruction of the ozone layer | chlorine radicals |
| **D** | atmospheric formation of sulfur trioxide | nitrogen dioxide |

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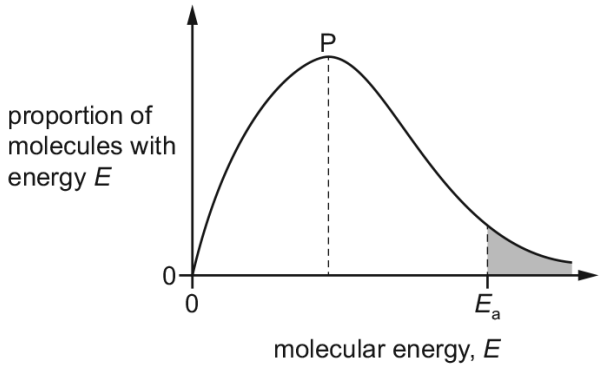
436. 9701_w19_qp_11 Q: 1

The diagram shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, $E_a$. The peak of the distribution is labelled P.




If the same reaction is carried out in the presence of a catalyst, which statement is correct?

**A** The peak P is at a lower height and the position of $E_a$ moves to the left.

**B** The peak P is at a lower height and the position of $E_a$ moves to the right.

**C** The peak P remains at the same height and the position of $E_a$ moves to the left.

**D** The peak P remains at the same height and the position of $E_a$ moves to the right.

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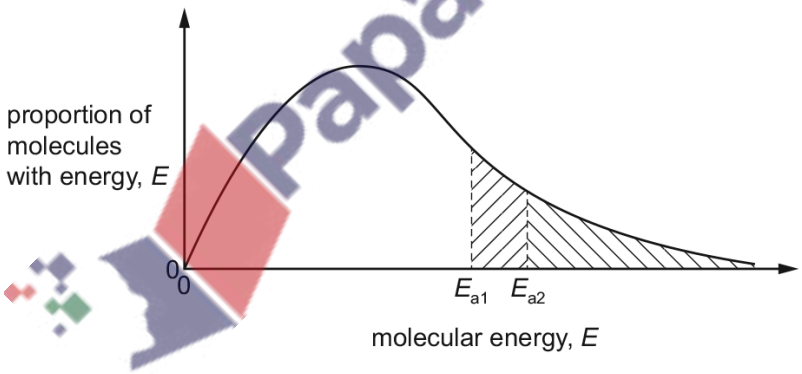
437. 9701_w19_qp_12 Q: 1

The diagram shows a Boltzmann distribution of the energies of gaseous molecules and the activation energies, $E_a$, of a reaction with and without a catalyst.




Which statement about this distribution curve is correct?

**A** If the temperature of the gas is increased, the maximum of the curve becomes higher.

**B** If the temperature of the gas is increased, the maximum of the curve moves to the left.

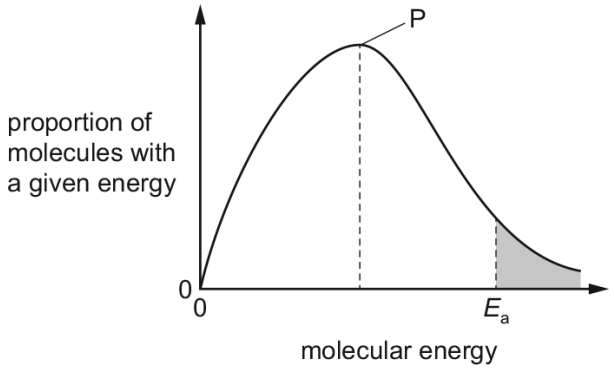
**C** The fraction of molecules that react in the presence of a catalyst is shown by ▨.

**D** The fraction of molecules that react in the absence of a catalyst is shown by ▨.

---

438. 9701_s18_qp_11 Q: 4

The diagram shows the Boltzmann distribution of energies in a gas. The gas can take part in a reaction with an activation energy, $E_a$. The gas is maintained at a constant temperature.




Which statement is correct?

**A** If a catalyst is added, peak P will be lower and $E_a$ will move to the left.

**B** If a catalyst is added, peak P will be lower and $E_a$ will move to the right.

**C** If a catalyst is added, peak P will be the same and $E_a$ will move to the left.

**D** If a catalyst is added, peak P will be the same and $E_a$ will move to the right.

---

439. 9701_s18_qp_12 Q: 11

A chemical company used a catalyst in a chemical process. The company has now decided not to use the catalyst but to increase the temperature so that the rate of the reaction is the same as it was when the catalyst was used.

Which statement about the new conditions compared to the original conditions is correct?

**A** The activation energy has been decreased.

**B** The activation energy has been increased.

**C** There are fewer successful collisions per unit time.

**D** There are more successful collisions per unit time.

---

440. 9701_s18_qp_13 Q: 11

The enzyme maltase speeds up the reaction between maltose and water.

$$\text{maltose + water} \xrightarrow{\text{maltase}} \text{glucose}$$

Maltase shows **specificity**.

Which statement describes the **specificity** of maltase?

**A** Maltase is a biological catalyst and it is a type of protein.

**B** Maltase is most effective between pH 6.1 and pH 6.8.

**C** Maltase lowers the activation energies of the reactions it catalyses.

**D** Maltase only speeds up a small number of chemical reactions.

---

441. 9701_w18_qp_11 Q: 11

Two reactions are shown.

reaction 1 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

reaction 2 $2O_3(g) \rightleftharpoons 3O_2(g)$

In reaction 1, a finely powdered iron catalyst is used.

In reaction 2, a vaporised tetrachloromethane catalyst in ultraviolet light is used.

Which statement about the catalysts used is correct?

**A** Both reaction 1 and reaction 2 use a heterogeneous catalyst.

**B** Both reaction 1 and reaction 2 use a homogeneous catalyst.

**C** Reaction 1 uses a heterogeneous catalyst and reaction 2 uses a homogeneous catalyst.

**D** Reaction 1 uses a homogeneous catalyst and reaction 2 uses a heterogeneous catalyst.

---

442. 9701_w18_qp_12 Q: 10

In a chemical system the particles involved have a range of energies. This can be shown on a graph called the Boltzmann distribution.

Which statement correctly explains the effect of a catalyst on the particles in a chemical system?

**A** A catalyst enables particles with a lower energy to collide successfully.

**B** A catalyst increases the number of particles with higher energies.

**C** A catalyst increases the number of particles with the most probable energy value.

**D** A catalyst increases the value of the most probable particle energy.

---

443. 9701_w18_qp_12 Q: 11

Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture **and** increasing the temperature?

| | adding iron | increasing the temperature |
|---|---|---|
| **A** | has no effect on the equilibrium yield | reduces the equilibrium yield |
| **B** | increases the equilibrium yield | increases the equilibrium yield |
| **C** | increases the equilibrium yield | increases the rate |
| **D** | increases the rate | has no effect on the equilibrium yield |

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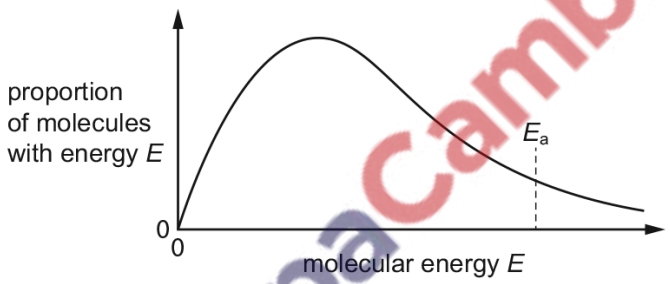
444. 9701_s17_qp_12 Q: 11

The Boltzmann distribution for the hydrogenation of an alkene at a particular temperature in the absence of a catalyst is shown.



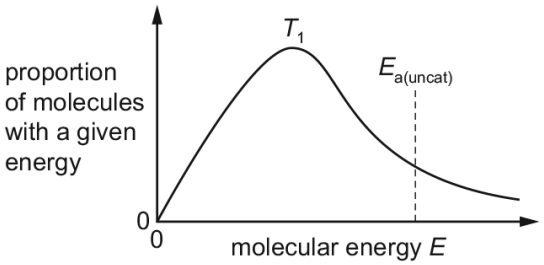

Which row correctly describes the effects of adding nickel to the reaction vessel?

| | the shape of the Boltzmann distribution | activation energy, $E_a$ |
|---|---|---|
| **A** | changes | decreases |
| **B** | changes | increases |
| **C** | does not change | decreases |
| **D** | does not change | increases |

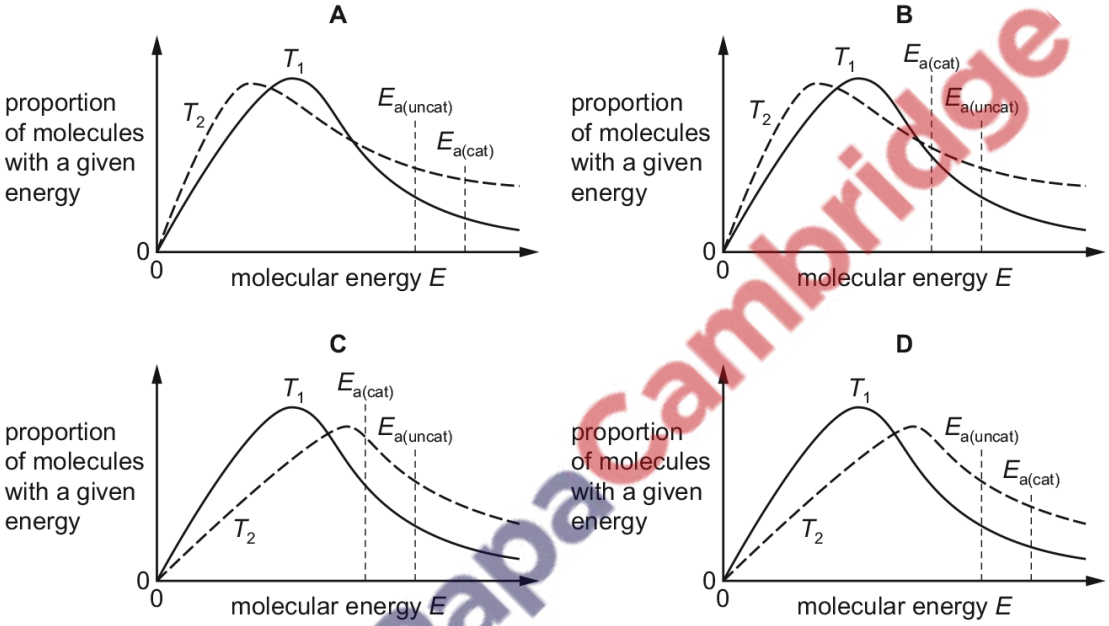
---

445. 9701_w17_qp_11 Q: 10

The diagram shows the distribution of molecular energies in a sample of gas at a temperature $T_1$. The activation energy for an uncatalysed reaction of this gas, $E_{a(uncat)}$, is shown.




Which diagram correctly shows the new distribution and new activation energy, $E_{a(cat)}$, when the temperature is increased to $T_2$, and a catalyst is used that increases the rate of the reaction?

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446. 9701_w17_qp_12 Q: 11

Which change alters the activation energy of a given reaction?

**A** adding a suitable catalyst

**B** changing the particle size of the reactants

**C** changing the pressure at which the reaction is carried out

**D** changing the temperature at which the reaction is carried out

---

447. 9701_s16_qp_11 Q: 11

Enzymes are biological catalysts. Many enzymes show specificity. An example of an enzyme which shows specificity is glucokinase. Glucokinase is involved in the metabolism of glucose.

What does specificity mean in this context?

**A** Glucokinase is most effective as a catalyst over a narrow pH range.

**B** Glucokinase is most effective as a catalyst over a narrow range of temperatures.

**C** Glucokinase only operates on a narrow range of substrate molecules.

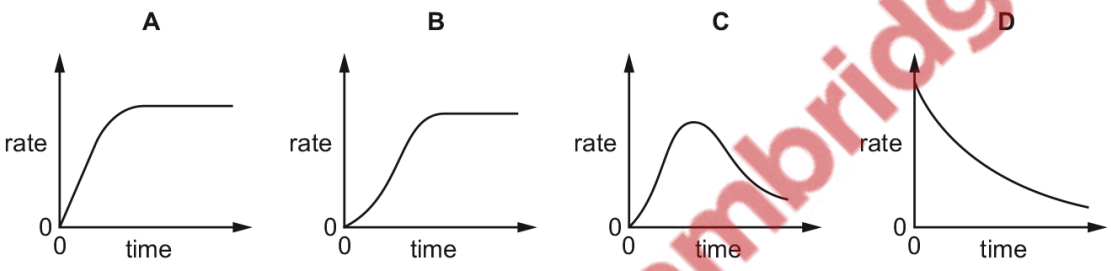
**D** Glucokinase provides an alternative route for the reactions it catalyses.

---

448. 9701_w16_qp_11 Q: 11

An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

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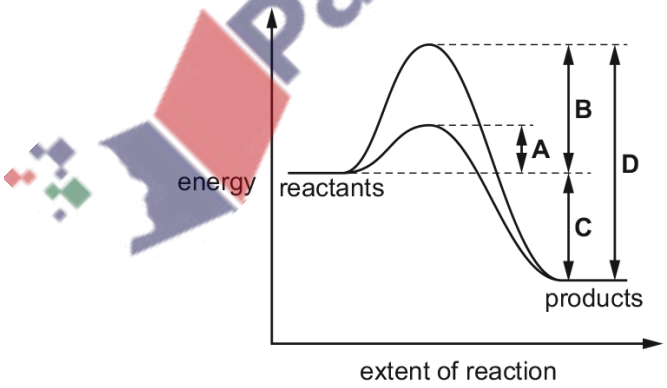
449. 9701_w16_qp_12 Q: 2

The diagram shows the pathways of a reaction, with and without a catalyst.

Which letter represents the overall energy change for the reaction?

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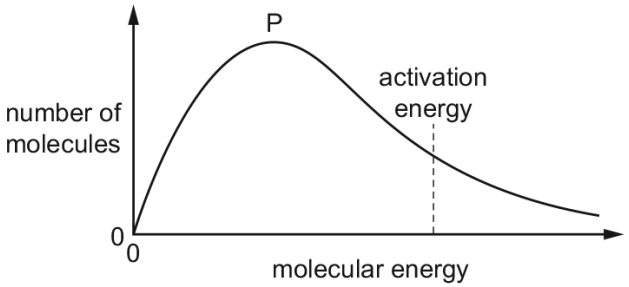
450. 9701_s15_qp_11 Q: 1

The diagram shows a Boltzmann distribution of molecular energies for a gaseous mixture. The distribution has a peak, labelled P on the diagram.




What happens when an effective catalyst is added to the mixture?

**A** The height of the peak decreases and the activation energy moves to the right.

**B** The height of the peak decreases and the activation energy moves to the left.

**C** The height of the peak remains the same and the activation energy moves to the right.

**D** The height of the peak remains the same and the activation energy moves to the left.

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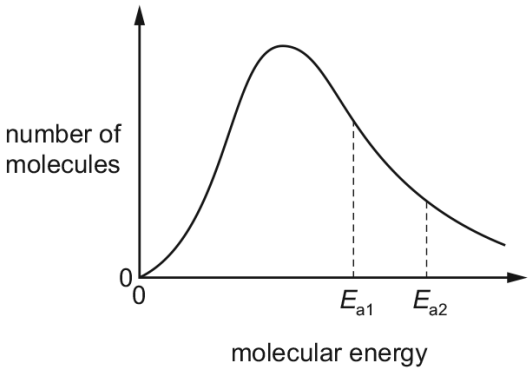
451. 9701_s15_qp_13 Q: 1

The diagram shows the Boltzmann energy distribution curve for molecules of a mixture of two gases at a given temperature. For a reaction to occur the molecules must collide together with sufficient energy.




$E_a$ is used to represent the activation energy for the reaction between the gases. Of the two values shown, one is the activation energy for a catalysed reaction, the other for an uncatalysed reaction.

Which statement about $\boldsymbol{E_{a1}}$ is correct?

**A** $E_{a1}$ corresponds to a catalysed reaction with fewer effective collisions than the uncatalysed reaction.

**B** $E_{a1}$ corresponds to an uncatalysed reaction with fewer effective collisions than the catalysed reaction.

**C** $E_{a1}$ corresponds to a catalysed reaction with a greater number of effective collisions than the uncatalysed reaction.

**D** $E_{a1}$ corresponds to an uncatalysed reaction with a greater number of effective collisions than the catalysed reaction.