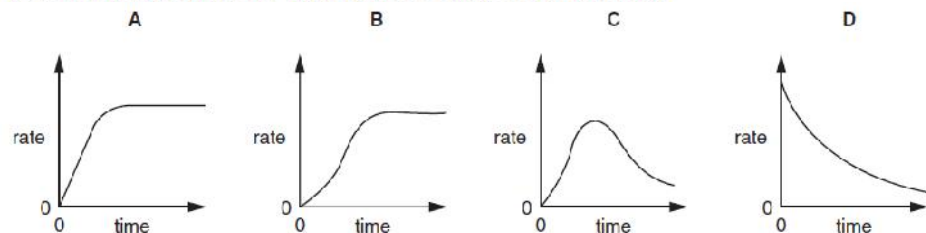# CHEMISTRY MULTIPLE CHOICE QUESTIONS

H. Reaction Kinetics

2002 -2014

1.

Which curve is obtained if the rate of reaction is plotted against time for an autocatalytic reaction (i.e. a reaction in which one of the products catalyses the reaction)?

[2002 M/J (11)]

2.

A piece of zinc foil dissolved completely in 20 cm^3 of a dilute sulphuric acid solution and the volume of hydrogen evolved was noted at equal, short time intervals. Another piece of zinc foil of the same surface area and mass was added to 40 cm^3 of the same solution of dilute sulphuric acid.

How will the initial rate of reaction and the total volume of hydrogen evolved in this second experiment compare to the first experiment?

|	initial rate of reaction	total volume of hydrogen evolved
A	no change	decrease
B	no change	no change
C	increase	no change
D	increase	increase

[2002 O/N (12)]

3.

It is often said that the rate of a typical reaction is roughly doubled by raising the temperature by 10 °C.

What explains this observation?

A   Raising the temperature by 10 °C doubles the average energy of each molecule.

B   Raising the temperature by 10 °C doubles the average velocity of the molecules.

C   Raising the temperature by 10 °C doubles the number of molecular collisions in a given time.

D   Raising the temperature by 10 °C doubles the number of molecules having more than a certain minimum energy.

[2003 M/J (12)]

4.

The diagram represents the Boltzmann distribution of molecular energies at a given temperature.
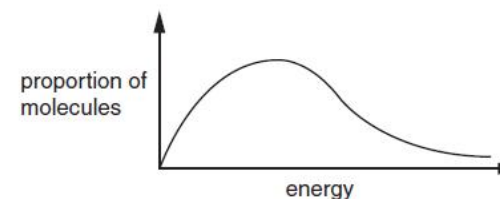
As temperature increases, which statements are correct?

1   The maximum of the curve is displaced to the right.

2   The proportion of molecules with energies **above** any given value increases.

3   The proportion of molecules **with** any given energy increases.

[2003 O/N (33)]

5.

Which statements about the properties of a catalyst are correct?

1   A catalyst increases the average kinetic energy of the reacting particles.

2   A catalyst increases the rate of the reverse reaction.

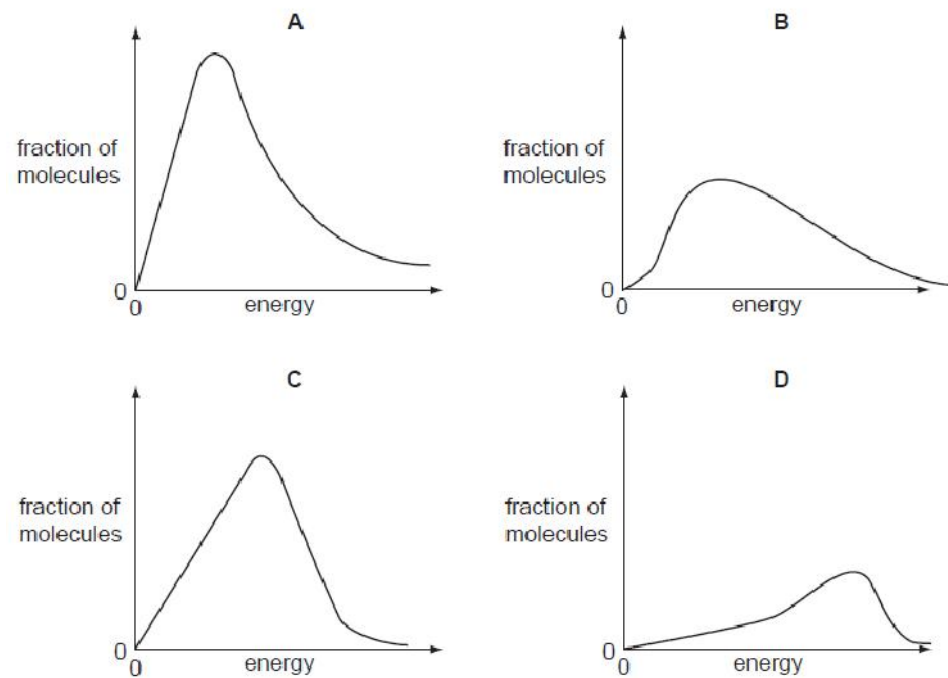3   A catalyst has no effect on the enthalpy change $\Delta H^{\ominus}$ of the reaction.

[2004 M/J (33)]

6.

The diagram shows the Boltzmann distribution for air at room temperature.
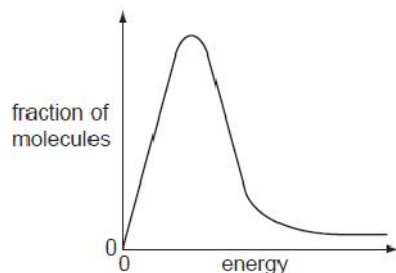
Air inside a car engine can reach a temperature of about $500\,^\circ C$, enabling nitrogen to react with oxygen to form nitrogen oxides.

What would be the Boltzmann distribution for the air inside this car engine?

[2004 O/N (12)]

7.

What factors can affect the value of the activation energy of a reaction?

1 the presence of a catalyst

2 changes in temperature

3 changes in concentration of the reactants

[2004 O/N (33)]

8.

The reaction represented by the following equation was carried out.

$$HCO_2CH_3(aq) + NaOH(aq) \rightarrow HCO_2Na(aq) + CH_3OH(aq)$$
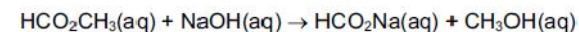
Which graph best shows the relationship between $[CH_3OH(aq)]$ and t, the time from mixing of the reactants?
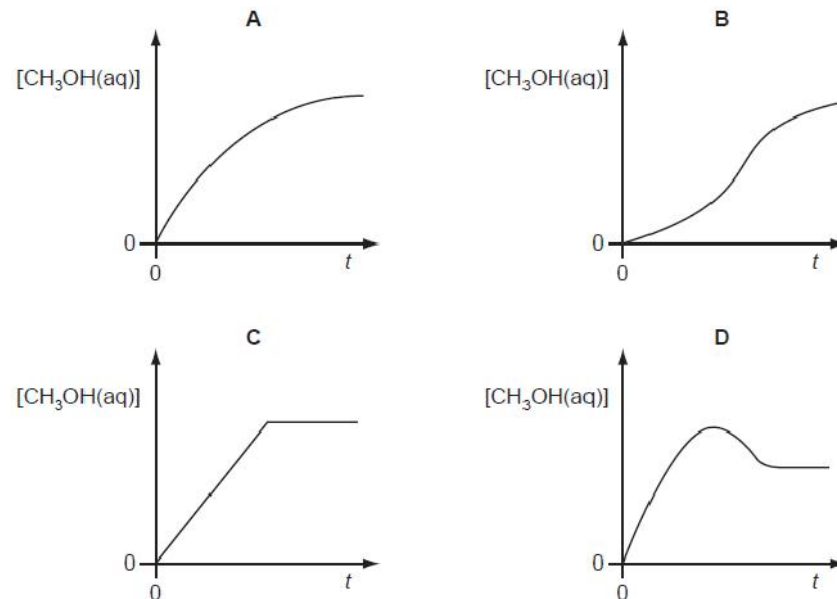
[2005 M/J (11)]

9.

The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(g)$$

Two experiments were carried out in which the production of R was measured against time. The results are shown in the diagram below.
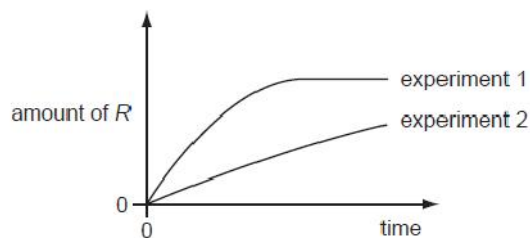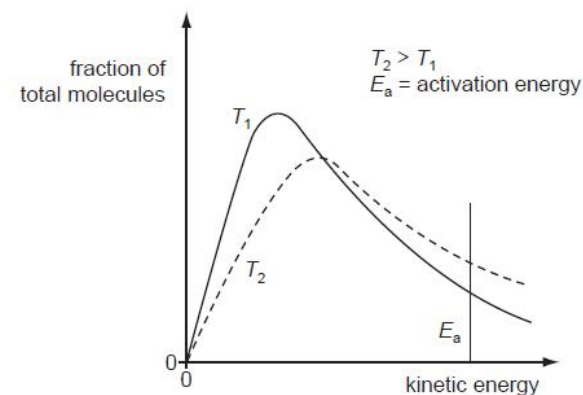

Which changes in the conditions from experiment 1 to experiment 2 might explain the results shown?

1   Less of P was used.

2   A different catalyst was used.

3   Product S was continuously removed from the reaction vessel.

[2005 M/J (34)]

10.

The distribution of molecular kinetic energies within a gas at temperature T_1 and T_2 are shown in the diagram.


Which statement correctly explains why a small increase in temperature leads to a significant increase in the rate of a gaseous reaction?

A   The frequency of collisions between molecules is greater at a higher temperature.

B   The activation energy of the reaction is less when the gases are at a higher temperature.

C   The frequency of collisions between molecules with kinetic energy greater than the activation energy is greater at higher temperature.

D   The proportion of molecules with more kinetic energy than the activation energy is lower at a higher temperature.
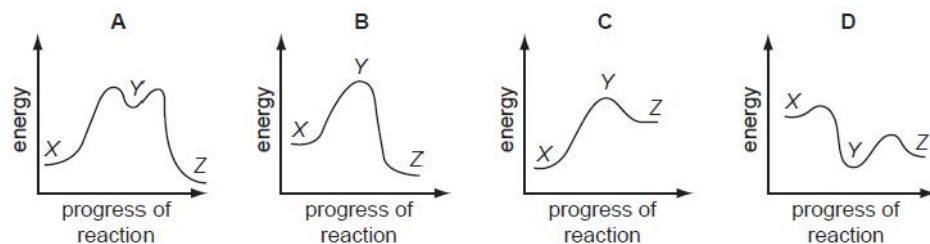
[2005 O/N (11)]

11.

In the conversion of compound X into compound Z, it was found that the reaction proceeded by way of compound Y, which could be isolated. The following steps were involved.

$$X \rightarrow Y \; ; \Delta H, \text{ positive}$$
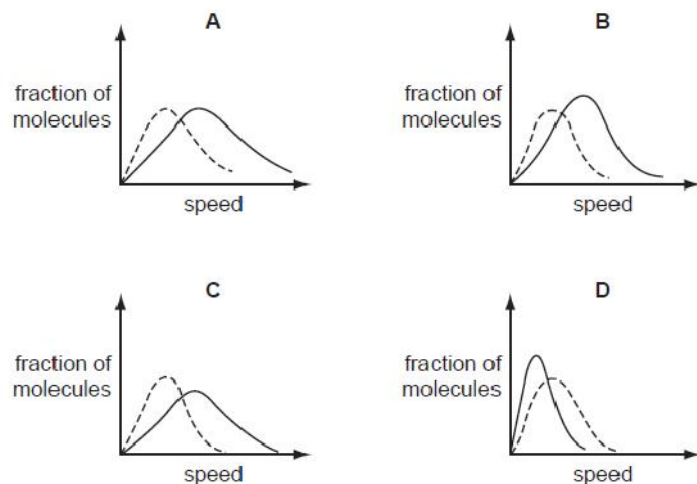$$Y \rightarrow Z \; ; \Delta H, \text{ negative}$$
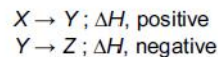
Which reaction profile fits these data?

[2006 M/J (8)]

12.

Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?
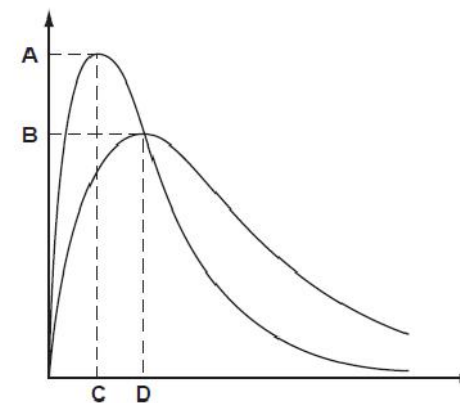

[2006 M/J (12)]

13.

The diagram shows the Maxwell-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 of the molecules at the lower temperature?

[2006 O/N (12)]

14.

A reversible reaction is catalysed.

Which statements about the effects of the catalyst on this system are correct?

1   The catalyst alters the mechanism of the reaction.

2   The catalyst reduces the energy of activation (the energy barrier) for both the forward and the backward reaction.

3   The catalyst alters the composition of the equilibrium mixture.

[2006 O/N (33)]

15.

The Boltzmann distribution shows the number of molecules having a particular kinetic energy at constant temperature.
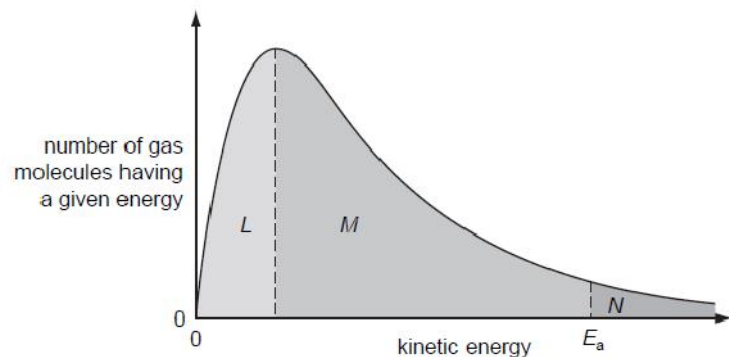

If the temperature is decreased by $10\,°C$, what happens to the size of the areas labelled L, M and N?

	L	M	N
A	decreases	decreases	decreases
B	decreases	increases	decreases
C	increases	decreases	decreases
D	increases	decreases	increases

[2007 M/J (10)]

16.

In the diagram, curve **X** was obtained by observing the decomposition of $100\,cm^3$ of $1.0\,mol\,dm^{-3}$ hydrogen peroxide, catalysed by manganese(IV) oxide.
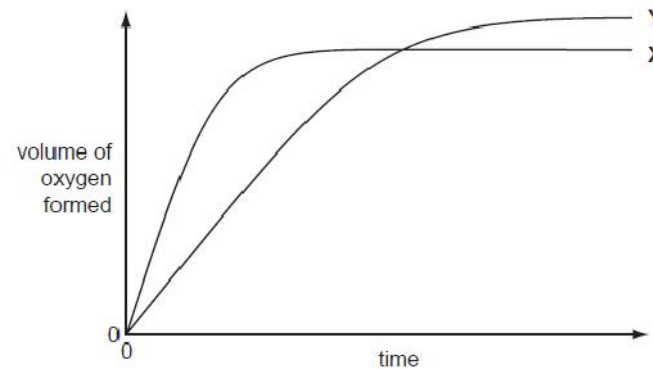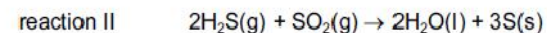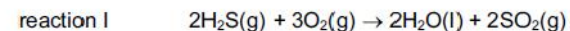

Which alteration to the original experimental conditions would produce curve **Y**?

A adding water

B adding some $0.1\,mol\,dm^{-3}$ hydrogen peroxide

C using less manganese(IV) oxide

D lowering the temperature

[2007 M/J (11)]

17.

Many crude oils contain sulphur as H_2S. During refining, by the Claus process, the H_2S is converted into solid sulphur, which is then removed.

$$\text{reaction I} \qquad 2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$

$$\text{reaction II} \qquad 2H_2S(g) + SO_2(g) \rightarrow 2H_2O(l) + 3S(s)$$

Which statements about the Claus process are correct?

1 H_2S is oxidised in reaction I.

2 SO_2 oxidises H_2S in reaction II.

3 SO_2 behaves as a catalyst.

[2007 M/J (33)]

18.

It is often said that the rate of a typical reaction is roughly doubled by raising the temperature by 10 °C.

What explains this observation?

A   Raising the temperature by 10 °C doubles the average kinetic energy of each molecule.

B   Raising the temperature by 10 °C doubles the average velocity of the molecules.

C   Raising the temperature by 10 °C doubles the number of molecular collisions in a given time.

D   Raising the temperature by 10 °C doubles the number of molecules having more than a certain minimum energy.

[2007 O/N (11)]

19.

Which statements are correct about the activation energy of a reaction?

1   It is different for the forward and back reactions in an exothermic process.

2   It is low for a reaction that takes place slowly.
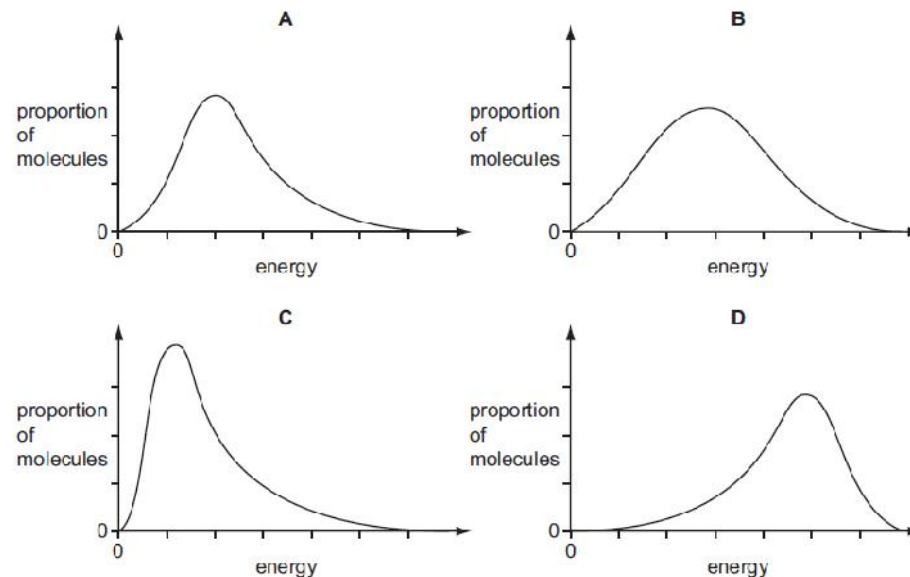
3   It is unaffected by the presence of a catalyst.

[2007 O/N (34)]

20.

The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.
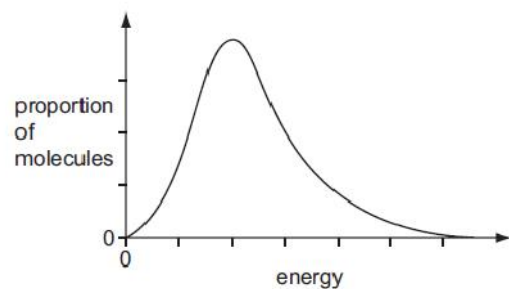
Which curve applies for the same gas at a lower temperature?


[2008 M/J (12)]

21.

Which statements about the properties of a catalyst are correct?

1   A catalyst increases the average kinetic energy of the reacting particles.

2   A catalyst increases the rate of the reverse reaction.

3   A catalyst has no effect on the enthalpy change of the reaction.

[2008 M/J (33)]

22.

The diagram represents the reaction pathway for the following reaction.

$$W(g) + X(g) \rightarrow Y(g) + Z(g)$$
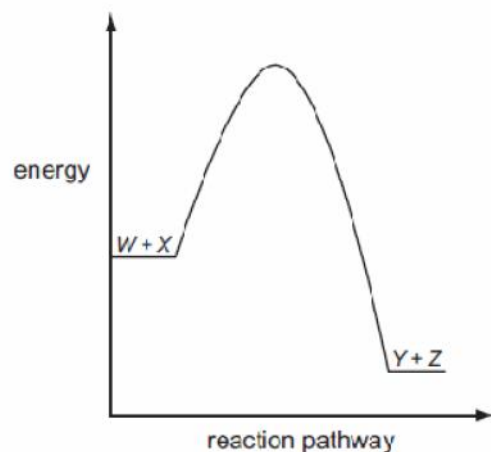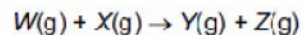
What statement can be made about the reverse reaction, $Y(g) + Z(g) \rightarrow W(g) + X(g)$?

A   It will have a larger activation energy and a positive ΔH.

B   It will have a larger activation energy and a negative ΔH.

C   It will have a smaller activation energy and a positive ΔH.

D   It will have a smaller activation energy and a negative ΔH.

[2008 O/N (9)]

23.

The diagram shows the Maxwell-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.
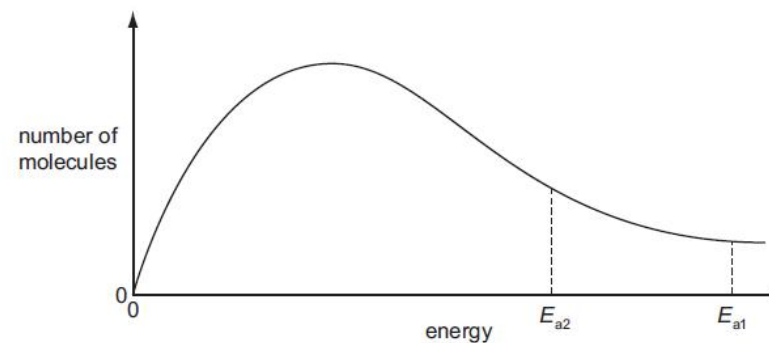
E_a is the activation energy for the reaction between the gases. Of the two values shown, one is for a catalysed reaction, the other for an uncatalysed one.

Which pair of statements is correct when a catalyst is used?

| A	E_{a1}	catalysed reaction fewer effective collisions	E_{a2}	uncatalysed reaction more effective collisions
B	E_{a1}	uncatalysed reaction fewer effective collisions	E_{a2}	catalysed reaction more effective collisions
C	E_{a1}	catalysed reaction more effective collisions	E_{a2}	uncatalysed reaction fewer effective collisions
D	E_{a1}	uncatalysed reaction more effective collisions	E_{a2}	catalysed reaction fewer effective collisions

[2009 M/J (10)]

24.

Four reactions of the type shown are studied at the same temperature.

$$X(g) + Y(g) \rightarrow Z(g)$$
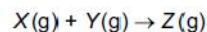
Which is the correct reaction pathway diagram for the reaction that would proceed **most** rapidly and with the **highest** yield?

A

B

C

D
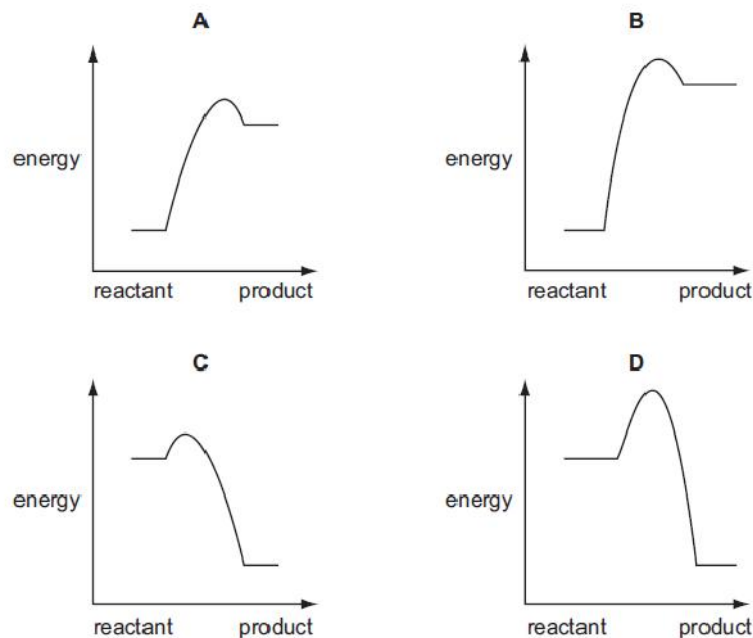
[2009 O/N-11 (10)]

25.

Why does a mixture of hydrogen gas and bromine gas react together faster at a temperature of 500K than it does at a temperature of 400K?

1   A higher proportion of effective collisions occurs at 500K.

2   Hydrogen molecules and bromine molecules collide more frequently at 500K.

3   The activation energy of the reaction is lower at 500K.

[2009 O/N-11 (34)]

26.

$Na_2S_2O_3$ reacts with dilute HCl to give a pale yellow precipitate. If $1 cm^3$ of $0.1 mol dm^{-3}$ HCl is added to $10 cm^3$ of $0.02 mol dm^{-3}$ $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with $1 cm^3$ of $0.1 mol dm^{-3}$ HCl and $10 cm^3$ of $0.05 mol dm^{-3}$ $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

A   The activation energy of the reaction is lower when $0.05 mol dm^{-3}$ $Na_2S_2O_3$ is used.

B   The reaction proceeds by a different pathway when $0.05 mol dm^{-3}$ $Na_2S_2O_3$ is used.

C   The collisions between reactant particles are more violent when $0.05 mol dm^{-3}$ $Na_2S_2O_3$ is used.

D   The reactant particles collide more frequently when $0.05 mol dm^{-3}$ $Na_2S_2O_3$ is used.

[2010 M/J-11 (12)]

27.

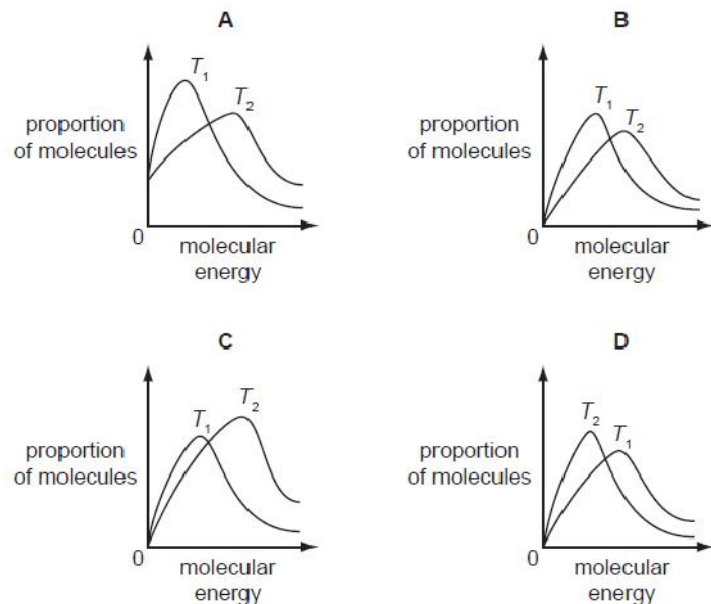The diagram represents the Boltzmann distribution of molecular energies at a given temperature.
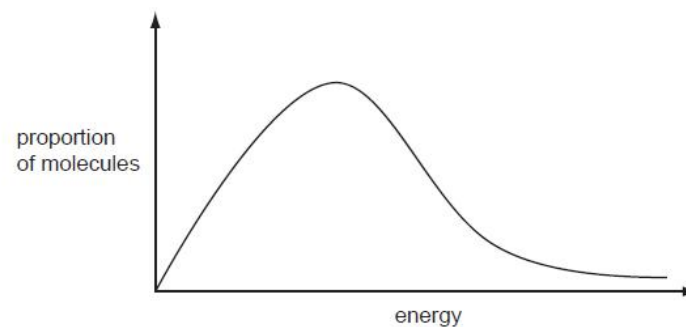
Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1   increasing the concentration of reactants

2   increasing the temperature

3   the addition of a catalyst

[2010 O/N-11 (32)]

28.

Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2, where $T_1 = 300\,K$ and $T_2 = 310\,K$?

A

proportion of molecules

T_1 T_2

0 molecular energy

B

proportion of molecules

T_1 T_2

0 molecular energy

C

proportion of molecules

T_2 T_1

0 molecular energy

D

proportion of molecules

T_2 T_1

0 molecular energy

[2010 O/N-12 (2)]

29.

The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.

energy

E_1 ----- transition state

E_2 reactants

E_3 ----- products

reaction coordinate
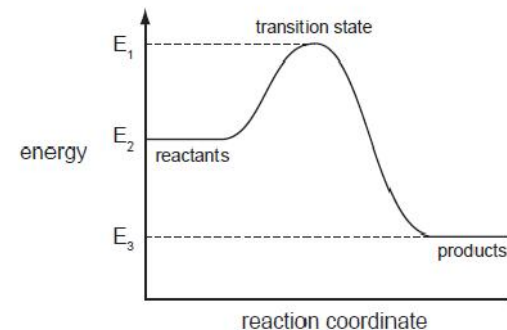
Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

[2010 O/N-12 (6)]

30.

A student puts 10 cm^3 of 0.100 mol dm^{-3} sulfuric acid into one test-tube and 10 cm^3 of 0.100 mol dm^{-3} ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.

Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.

Which statements are correct?

1 After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.

2 After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

3 After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

[2010 O/N-12 (34)]

31.

Different Boltzmann distributions are shown in the diagrams.
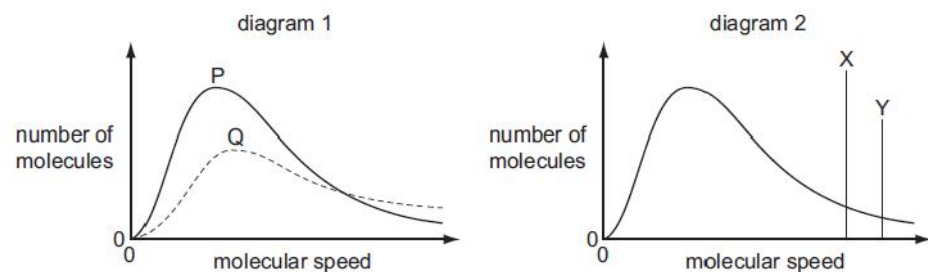
diagram 1

diagram 2

In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.
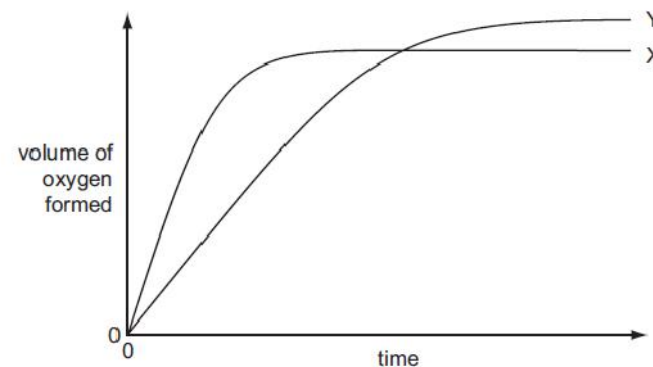
Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

[2011 M/J-11 (4)]

32.

In the diagram, curve X was obtained by observing the decomposition of $100\,cm^3$ of $1.0\,mol\,dm^{-3}$ hydrogen peroxide, catalysed by manganese(IV) oxide.
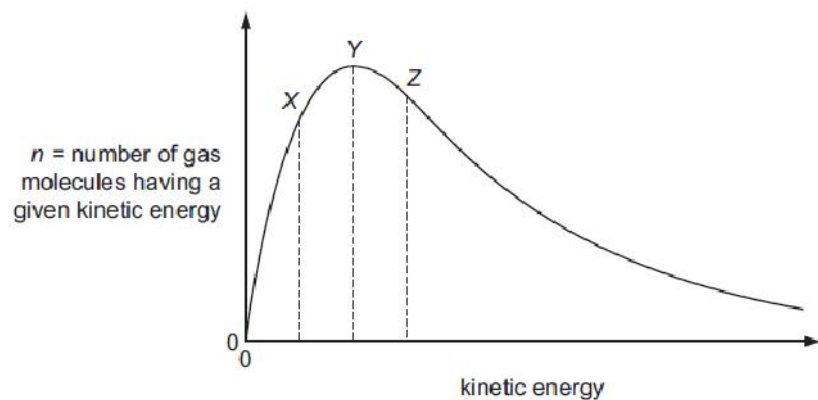

Which alteration to the original experimental conditions would produce curve Y?

A   adding some $0.1\,mol\,dm^{-3}$ hydrogen peroxide

B   adding water

C   lowering the temperature

D   using less manganese(IV) oxide

[2011 M/J-11 (6)]

33.

The Boltzmann distribution for a gas at constant temperature is shown below.

n = number of gas molecules having a given kinetic energy

kinetic energy

If the temperature of the gas is **reduced** by 10 °C the graph changes shape.

What happens to the values of n for the points marked X, Y and Z?

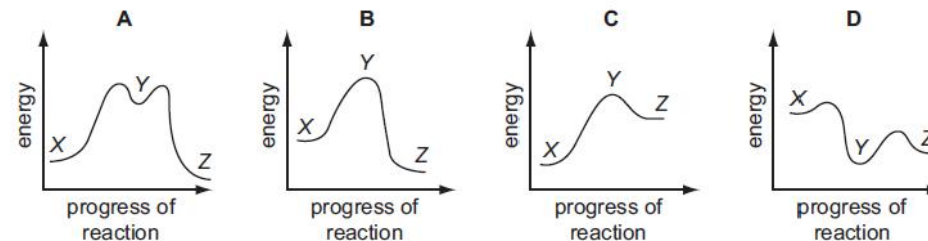|	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

[2011 M/J-12 (6)]

34.

In the conversion of compound X into compound Z, it was found that the reaction proceeded by way of compound Y, which could be isolated. The following steps were involved.

$$X \rightarrow Y \; ; \Delta H, \text{positive}$$

$$Y \rightarrow Z \; ; \Delta H, \text{negative}$$

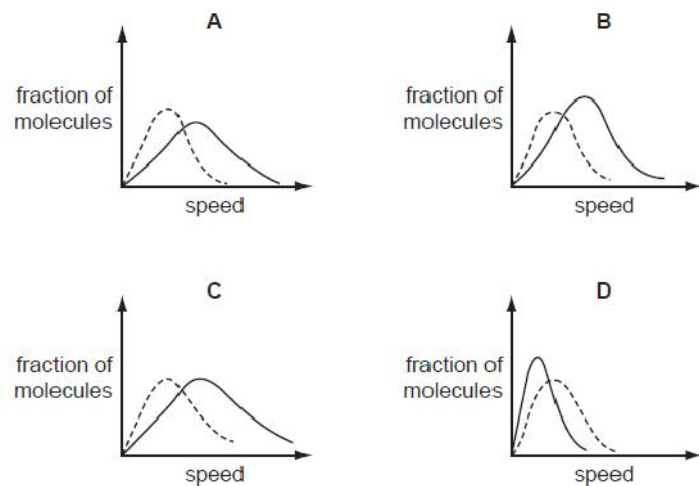Which reaction profile fits these data?

[2011 M/J-12 (9)]

35.

Solid calcium carbonate is added to 100 cm^3 of dilute hydrochloric acid and the rate of the reaction is measured. 100 cm^3 of distilled water is then added to a second 100 cm^3 portion of the acid, and the experiment repeated under the same conditions.

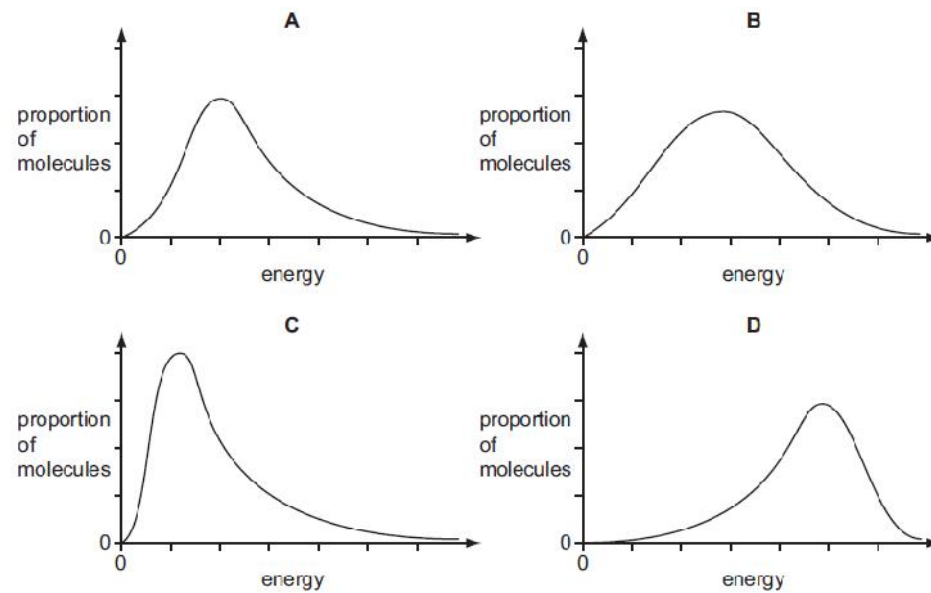Why does the addition of water decrease the rate of the reaction?

1   Adding water reduces the frequency of collisions between reactant molecules.

2   Adding water reduces the proportion of effective collisions between reactant molecules.

3   Adding water reduces the proportion of reactant molecules possessing the activation energy.

[2011 M/J-12 (31)]

36.

Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500K if the dotted-line curve represents the corresponding distribution for the same gas at 300K?

A

fraction of molecules

speed

B

fraction of molecules

speed

C

fraction of molecules

speed

D

fraction of molecules

speed

[2011 O/N-11 (11)]

A

proportion of molecules

energy

B

proportion of molecules

energy

C

proportion of molecules

energy

D

proportion of molecules

energy

[2012 M/J-12 (1)]

37.

The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.

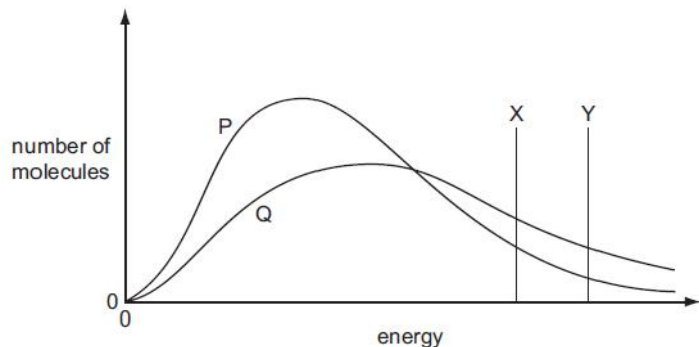proportion of molecules

energy
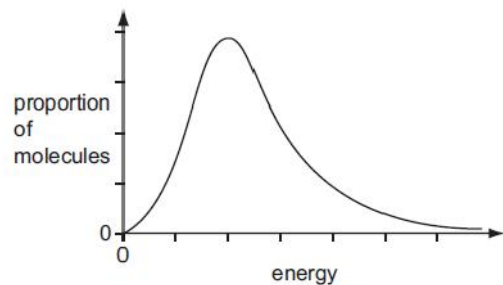
Which curve applies for the same gas at a lower temperature?

38.

The gaseous compound Z decomposes on heating.

In the diagram below, Boltzmann distributions for Z at two different temperatures P and Q are shown. The lines X and Y indicate activation energies for the decomposition of Z with and without a catalyst.

Which curve and which line describe the decomposition of Z at a higher temperature and with a catalyst present?

	higher temperature	catalyst present
A	P	X
B	P	Y
C	Q	X
D	Q	Y

[2012 O/N-13 (8)]

39.

Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

A   More particles have energy that exceeds the activation energy.

B   The particles have more space in which to move.

C   The particles move faster.

D   There are more frequent collisions between particles.

[2013 M/J-11 (8)]

40.

Which factor can affect the value of the activation energy of a reaction?

A   changes in concentration of the reactants

B   decrease in temperature

C   increase in temperature

D   the presence of a catalyst

[2013 M/J-12 (4)]

41.

The diagram shows the Maxwell-Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.
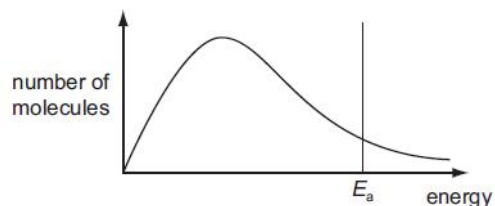
Which letter on the axes represents the most probable energy of the molecules at the **lower** temperature?
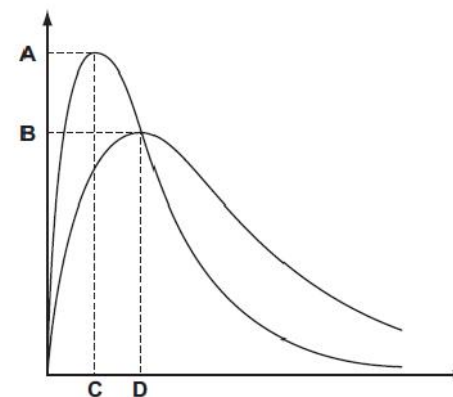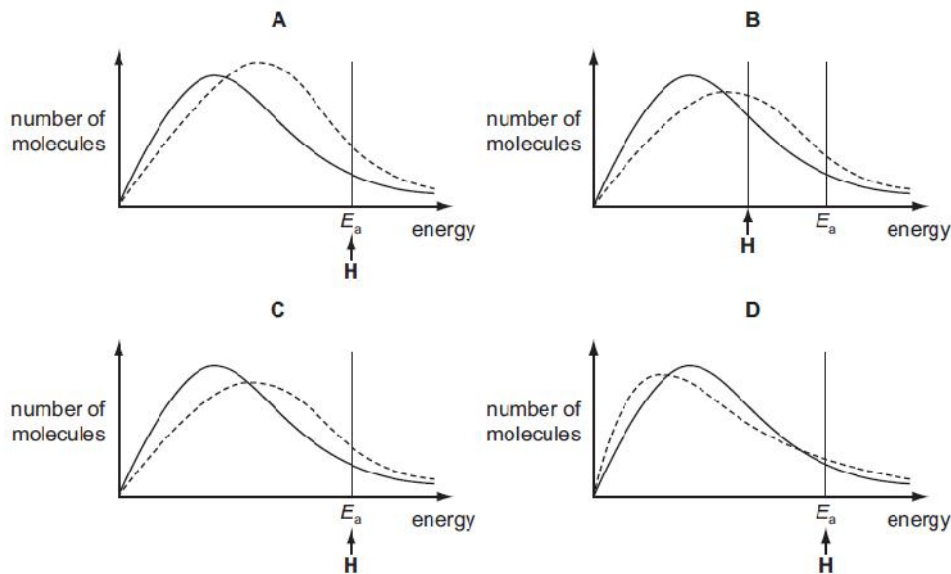

[2013 M/J-12 (5)]

42.

The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that will 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.
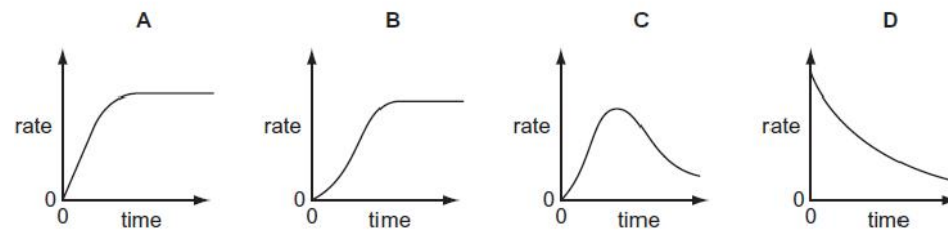
Which diagram is correct?

[2013 M/J-13 (4)]

43.

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

Which curve was obtained if the rate of reaction was plotted against time for an autocatalytic reaction?
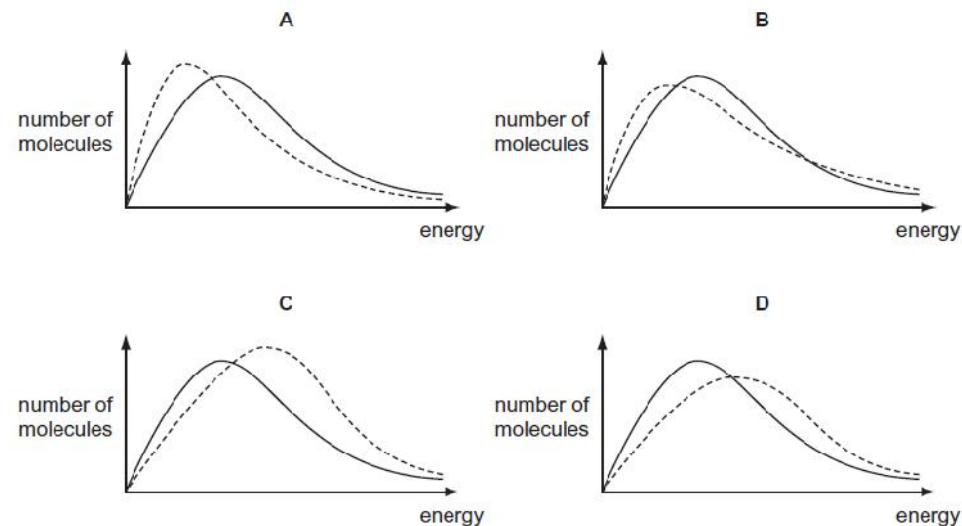

[2013 O/N-11 (5)]

44.

The diagrams below show the Boltzmann distribution for air at two temperatures.

The solid line represents the distribution at −20 °C.

The dotted line represents the distribution at −10 °C.

Which diagram is correct?

[2013 O/N-11 (6)]

45.

$Na_2S_2O_3$ reacts with dilute HCl to give a pale yellow precipitate. If $1\,cm^3$ of $0.1\,mol\,dm^{-3}$ HCl is added to $10\,cm^3$ of $0.02\,mol\,dm^{-3}$ $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with $1\,cm^3$ of $0.1\,mol\,dm^{-3}$ HCl and $10\,cm^3$ of $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

A   The activation energy of the reaction is lower when $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ is used.

B   The collisions between reactant particles are more violent when $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ is used.

C   The reactant particles collide more frequently when $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ is used.

D   The reaction proceeds by a different pathway when $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ is used.

[2013 O/N-13 (5)]

46.

The diagram represents the Boltzmann distribution of molecular energies at a given temperature.
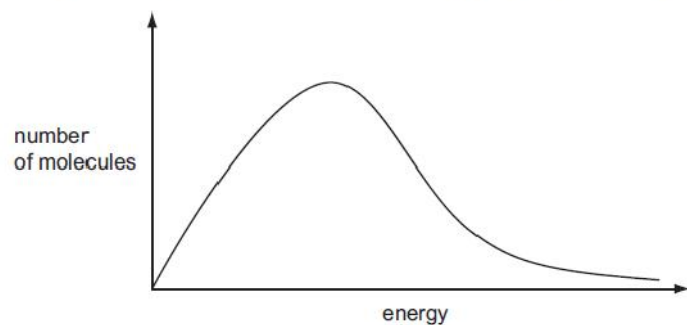
Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1   increasing the concentration of reactants

2   increasing the temperature

3   the addition of a catalyst

[2013 O/N-13 (32)]

47.

When making sparkler fireworks, a mixture of barium nitrate powder with aluminium powder, water and glue is coated onto wires and allowed to dry. At this stage, the following exothermic reaction may occur.

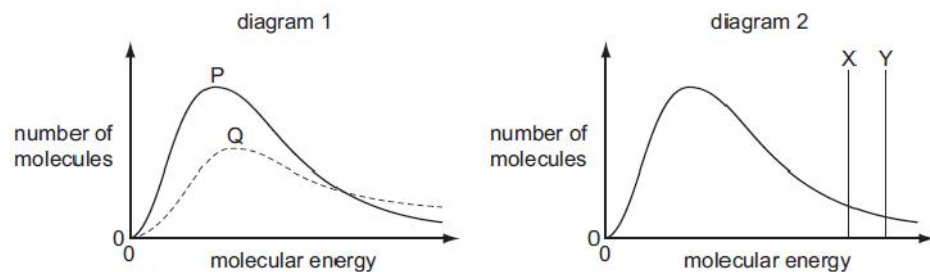$$16Al + 3Ba(NO_3)_2 + 36H_2O \rightarrow 3Ba(OH)_2 + 16Al(OH)_3 + 6NH_3$$

Which conditions would be best to reduce the rate of this reaction during the drying process, and would also keep the aluminium and barium nitrate unchanged?

	temperature/K	pH
A	298	7
B	298	14
C	398	7
D	398	14

[2014 M/J-11 (8)]

48.

Boltzmann distributions are shown in the diagrams.

diagram 1

diagram 2

In diagram 1, one curve, P or Q, corresponds to a temperature higher than that of the other curve.

In diagram 2, one line, X or Y, corresponds to the activation energy in the presence of a catalyst and the other line corresponds to the activation energy of the same reaction in the absence of a catalyst.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

[2014 M/J-11 (11)]

49.

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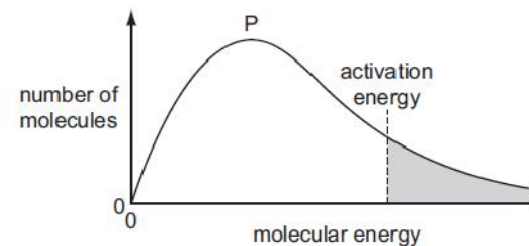

What happens when the temperature of the mixture increases?

A The height of the peak, P, decreases and the activation energy moves to the left.

B The height of the peak, P, decreases and the activation energy moves to the right.

C The height of the peak, P, decreases and the activation energy does not change.

D The height of the peak, P, increases and the activation energy moves to the left.

[2014 M/J-12 (1)]

50.

In the diagram, curve X was obtained by observing the decomposition of $100\,cm^3$ of $1.0\,mol\,dm^{-3}$ hydrogen peroxide, catalysed by manganese(IV) oxide.
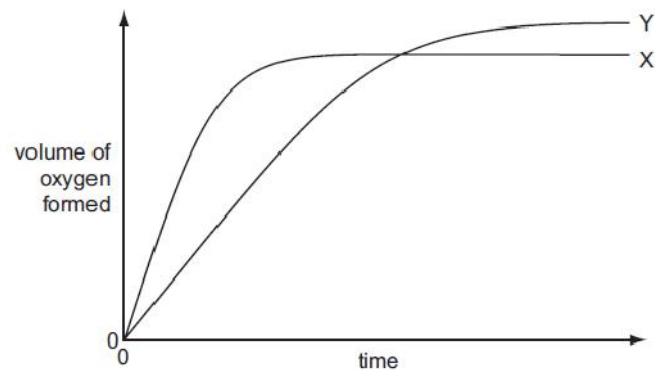
Which alteration to the original experimental conditions would produce curve Y?

A   adding more manganese(IV) oxide

B   adding some $0.1\,mol\,dm^{-3}$ hydrogen peroxide

C   adding water

D   raising the temperature

[2014 M/J-12 (5)]

51.

The reaction

$$E + F \rightleftharpoons G + H$$

is catalysed by platinum.

Which statements about the properties of the catalyst are correct?

1   The catalyst has no effect on the enthalpy change of the reaction.

2   The catalyst increases the rate of the reverse reaction.

3   The catalyst increases the average kinetic energy of the reacting particles.

[2014 M/J-12 (32)]

52.

The Boltzmann distribution for a gas at constant temperature is shown below.
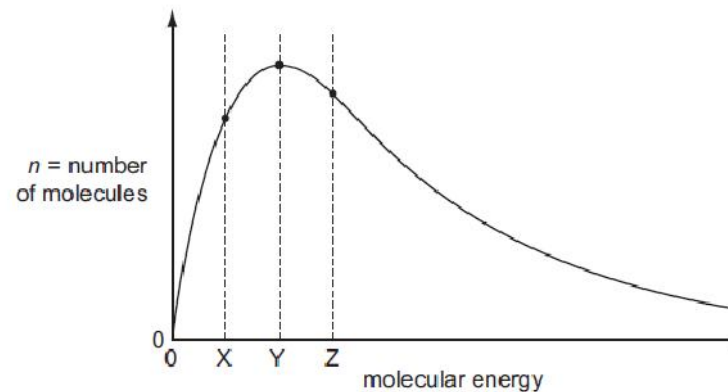
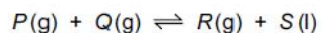If the temperature of the gas is **reduced** by $10\,°C$ the graph changes shape.

What happens to the values of n for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

[2014 M/J-13 (1)]

53.

The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(l)$$

Two experiments were carried out in which the rate of production of R was measured. The results are shown in the diagram below.
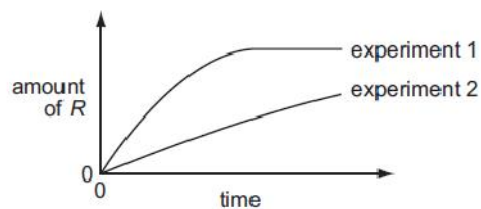
Which changes in the conditions might explain the results shown?

1   A lower pressure was used in experiment 2.

2   A different catalyst was used in experiment 2.

3   Product S was continuously removed from the reaction vessel in experiment 2.
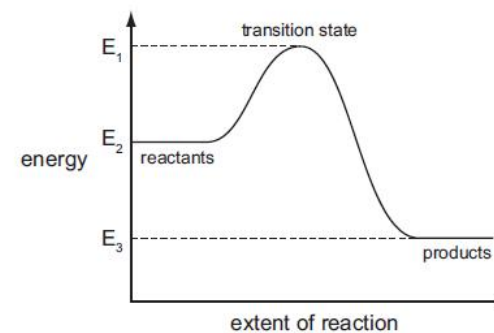
[2014 M/J-13 (34)]

54.

Which solid-line curve most accurately represents the distribution of molecular energies in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?
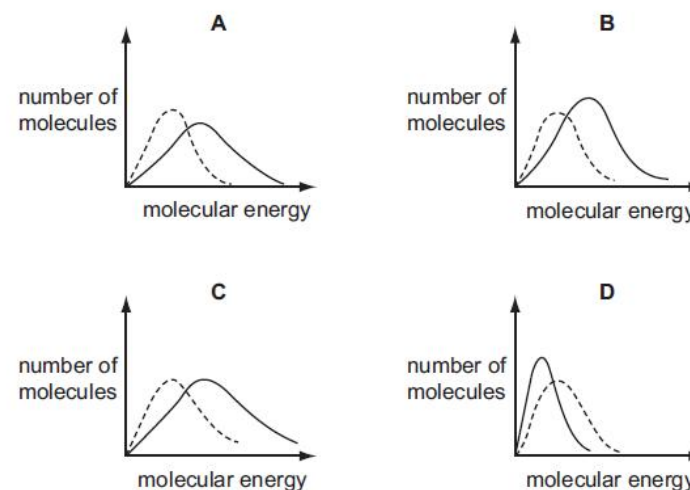
[2014 O/N-11 (1)]

55.

The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.

Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ B $E_2 - E_1$ C $E_2 - E_3$ D $E_3 - E_2$
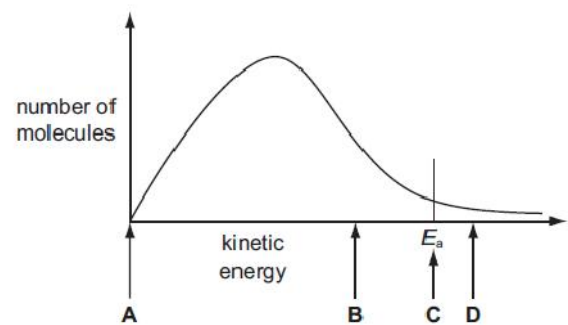
[2014 O/N-11 (8)]

56.

The diagram below represents, for a given temperature, the Boltzmann distribution of the kinetic energy of the molecules in a mixture of two gases that react slowly together.

The activation energy for the reaction, E_a, is marked.

When the reaction is catalysed, the rate of reaction increases a little.

What will be the position of E_a for the catalysed reaction?

number of molecules

kinetic energy

E_a

A   B   C   D

[2014 O/N-13 (1)]