Reaction Kinetics – 2021 AS

1. Nov/2021/Paper_11/No.31

Which changes can be used to measure the rates of chemical reactions?

1 the decrease in concentration of a reactant per unit time

2 the rate of appearance of a product

3 the increase in total volume of gas per unit time at constant pressure

2. Nov/2021/Paper_11/No.33

Ethylene glycol, $HOCH_2CH_2OH$, is used as a de-icer. It allows ice to melt at temperatures below 0 °C.

Which statements are correct?

1 Ethylene glycol disrupts the extensive network of hydrogen bonds in ice.

2 Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.

3 Ethylene glycol molecules will dissolve in the water formed from the ice.

3. Nov/2021/Paper_13/No.31

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4. Nov/2021/Paper_13/No.32

Iron reacts with steam to produce hydrogen and an oxide of iron.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

A system containing all four substances is at equilibrium.

Which changes will decrease the mass of Fe present at equilibrium?

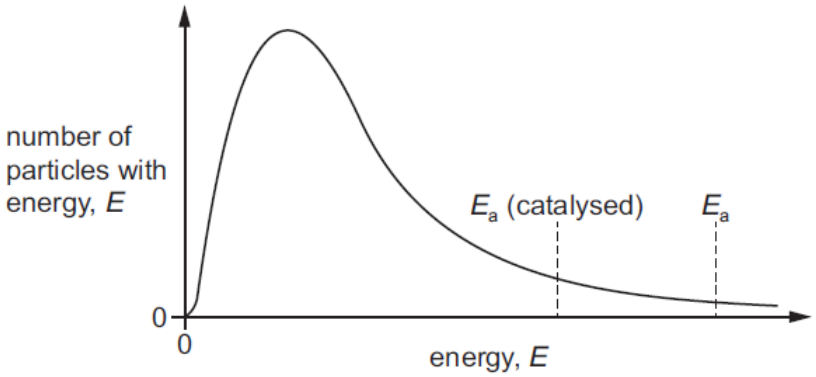
1 addition of steam at constant pressure

2 increase in overall pressure

3 addition of an effective catalyst

5. March/2021/Paper_12/No.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.

6. March/2021/Paper_12/No.33

Many gases do **not** obey the general gas equation at high pressures.

Why is this?

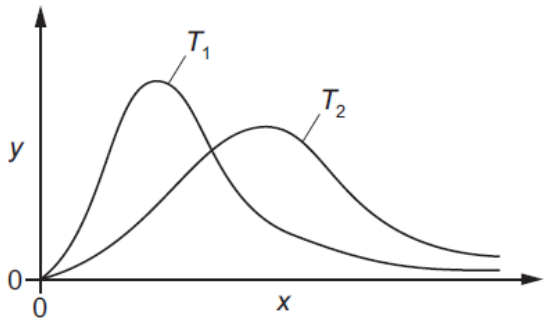
1 At higher pressures the molecules have more energy.

2 At higher pressures the volume of the molecules is a larger proportion of the total volume.

3 At higher pressures the molecules experience greater intermolecular forces.

7. June/2021/Paper_11/No.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

8. June/2021/Paper_11/No.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.

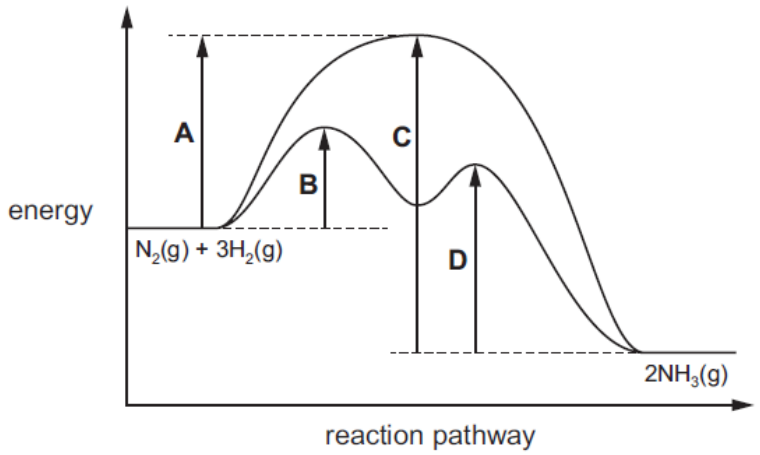
D Heterogeneous catalysts are in the same state as the reactant.

9. June/2021/Paper_12/No.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?



10. June/2021/Paper_12/No.11

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.

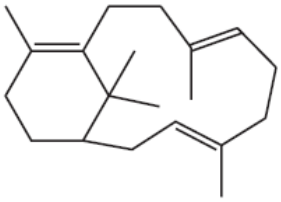
C The rate of the reaction is **not** affected by the concentration of reagent X.

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

11. June/2021/Paper_12/No.20

Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

compound P



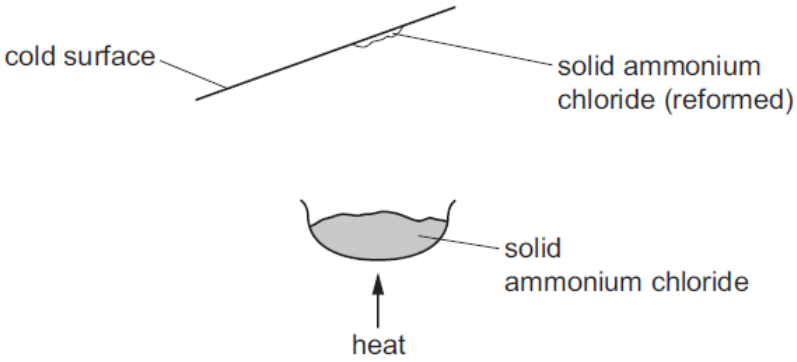
What is the number of chiral carbon atoms in the product Q?

A 4 **B** 5 **C** 6 **D** 7

12. June/2021/Paper_12/No.33

When a sample of ammonium chloride is warmed it decomposes into ammonia and hydrogen chloride gas.

$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$ reaction 1



When the mixture of hot ammonia and hydrogen chloride gases hit a cold surface, a white solid of ammonium chloride reforms.

Which statements are correct?

1 Reaction 1 is in dynamic equilibrium.

2 Reaction 1 is reversible.

3 Reaction 1 is an endothermic reaction.

13. June/2021/Paper_12/No.34

Hydrogen chloride gas is formed by the reaction shown.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

What will change the average kinetic energy of the reacting gas particles?

1 increasing the temperature and increasing the concentration of hydrogen

2 cooling the reaction mixture and adding a catalyst

3 adding a catalyst and increasing the concentration of chlorine

14. June/2021/Paper_13/No.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.

15. June/2021/Paper_13/No.33

Disaccharides are hydrolysed in slightly acidic solutions. This reaction is very slow.

A biological catalyst is added to a slightly acidic mixture of three disaccharides, sucrose, maltose and lactose. The hydrolysis reaction remains slow for sucrose and maltose but is now much faster for lactose.

Which statements about the catalyst are correct?

1 The catalyst increases the activation energy of all three hydrolysis reactions.

2 The catalyst shows specificity.

3 The hydrolysis of lactose using a catalyst has a different mechanism to the hydrolysis of lactose without a catalyst.

16. June/2021/Paper_22/No.3

A large excess of 2-bromo-2-methylpropane is added to 0.0010 mol of NaOH(aq), which contains a few drops of phenolphthalein indicator. A stopwatch is started as soon as the substances are mixed. The time taken for the pink colour to disappear is recorded.

The experiment is repeated at different temperatures, keeping all concentrations and volumes of reagents constant.

temperature / °C	time taken for pink colour to disappear / s
20	300
25	65
35	20

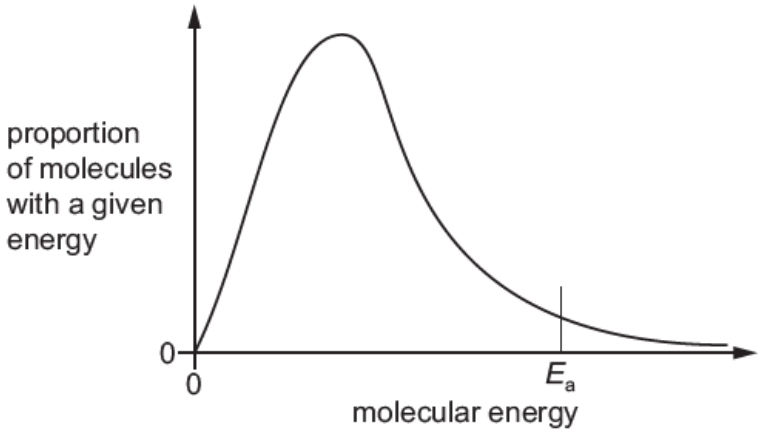
(a) Explain what is meant by the term *rate of reaction*.

.....

..... [1]

(b) The graph shows the energy distribution of molecules in a sample of 2-bromo-2-methylpropane at 25 °C.

E_a represents the activation energy for the reaction.



(i) Label the graph to show the proportion of 2-bromo-2-methylpropane molecules which have sufficient energy to react. [1]

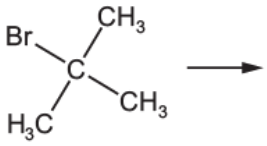
(ii) Use the same axes to sketch the distribution of energies of molecules in a sample of 2-bromo-2-methylpropane at 50 °C. [2]

(iii) State the effect of an increase in temperature on E_a for this reaction.

..... [1]

(c) (i) Draw the mechanism to show the reaction of 2-bromo-2-methylpropane with $OH^-(aq)$. Show the intermediate formed in this reaction.

Include all charges, partial charges, lone pairs and curly arrows as appropriate.



[3]

(ii) Name the mechanism for this reaction.

..... [1]

(d) The original experiment is repeated at 25 °C with 2-chloro-2-methylpropane instead of 2-bromo-2-methylpropane. All other variables remain constant.

Predict the effect of using 2-chloro-2-methylpropane compared to 2-bromo-2-methylpropane on the time taken for the pink colour to disappear. Explain your answer.

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..... [2]

[Total: 11]