1.

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.

Ans: C

Volume of limiting reagent only affects quantity of product, not rate.

2.

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.

Ans: C

- If directly proportional to Y, rate/conc of Y should be a constant value.
- Not affected by X, since whenever conc of Y = 0.1, rate = 0.0001, despite conc of X.

3.

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.

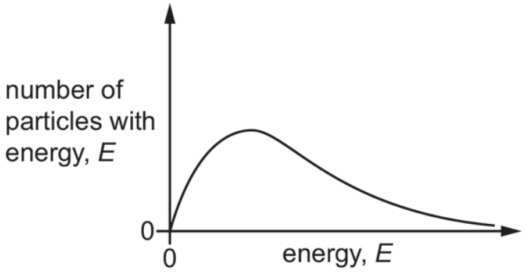
C The particles have more energy at the higher concentration.

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

Ans: D

4.

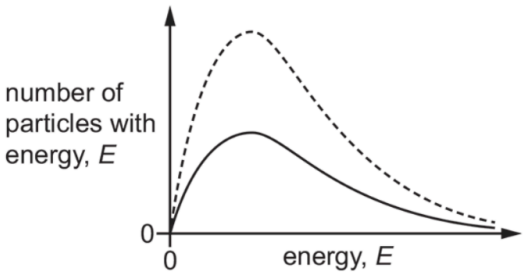
The Boltzmann distribution for one mole of a gas at temperature *T* is shown.



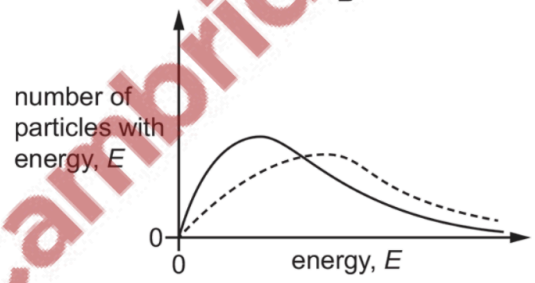
One mole of the same gas is added, and the gas remains at temperature *T*.

Which dotted curve shows the distribution with the added gas?

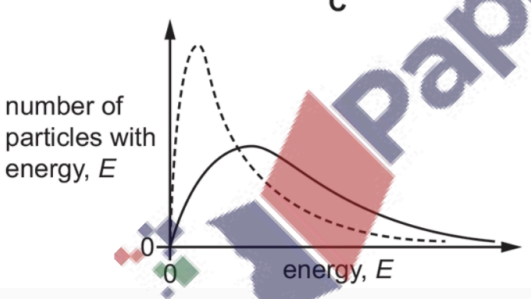
A



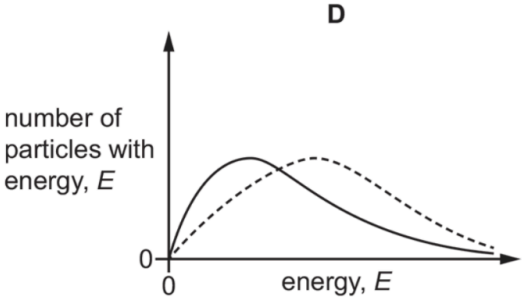
B



C



D

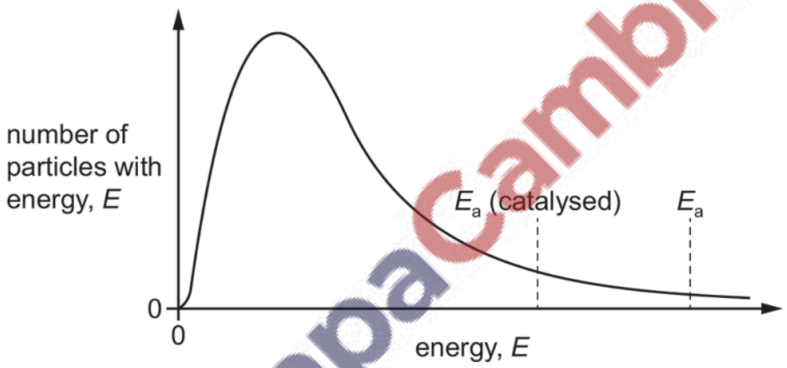


Ans: A

- Molecular distribution remains the same, but peak would increase.
- Number of particles at every energy value will be higher.
- B occurs if temperature is increased, C occurs if temperature is decreased, D is incorrect.

5.

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.

Ans: D

Temperature doesn't change Ea.

6.

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.

Ans: B

7.

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

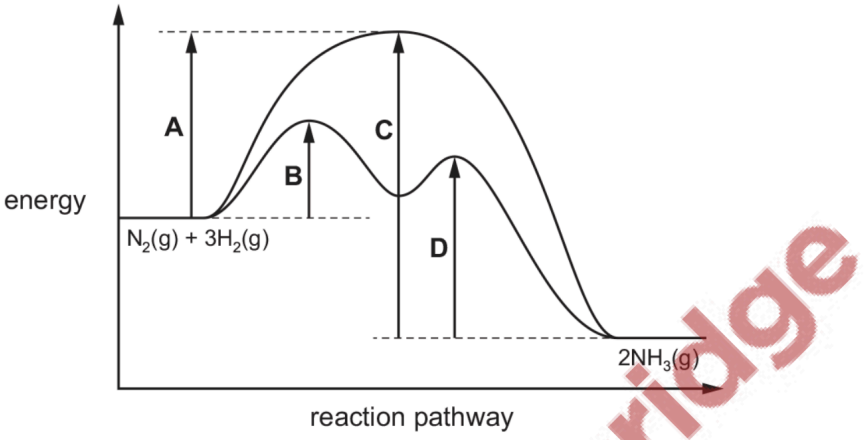
Ans: B

8.

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?

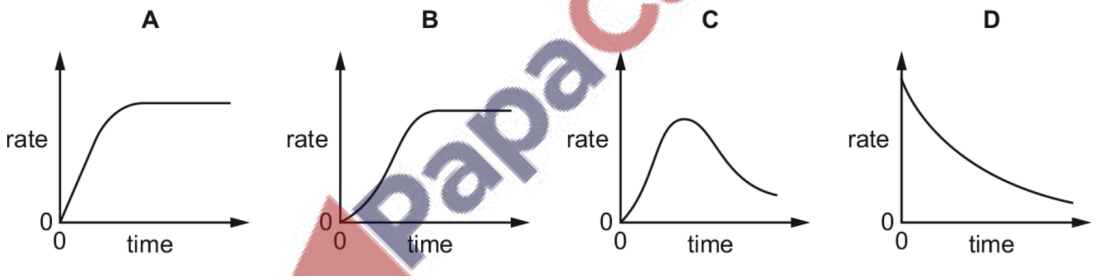


Ans: D

9.

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?



Ans: C

- At the start, there are maximum number of reactants and zero amount of products = reaction rate slow at start as there is no catalyst.
- Reaction rate increases as more product (catalyst) is formed.
- Concentration of reactant starts to decrease after some time, so rate of reaction also decreases.

10.

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.

Ans: B

11.

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.

Ans: A

- It decreases Ea, so particles with lower energy can also convert into product.

- It cannot change the energy of particles, so it can't increase the number of particles with high energy!

12.

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 initial rate of the reaction also increases.

What could be the reason for this?

A A greater proportion of collisions are 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 per second between particles at the higher concentration.

Ans: D

13.

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 higher energy?

	number of molecules with the most probable energy	number of molecules with higher energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Ans: B

- Number of molecules with most probable energy = peak
- Peak is lower when temperature is increased
- Number of molecules with higher energy = vertical extent of graph, which is greater at higher temperature

14.

In reaction 1, a student measures the initial rate of production of $CO_2(g)$ when $CuCO_3(s)$ is added to 50 cm^3 of 0.1 mol dm^{-3} $HNO_3(aq)$.

In reaction 2, the student repeats the experiment using 50 cm^3 of 0.5 mol dm^{-3} $HNO_3(aq)$ and the same mass of $CuCO_3(s)$.

In reaction 1 and reaction 2, the acid is in excess and samples of the same $CuCO_3$ powder are used.

Which row is correct?

	$\frac{\text{rate of reaction 1}}{\text{rate of reaction 2}}$	$\frac{\text{initial number of effective collisions in reaction 1 per second}}{\text{initial number of effective collisions in reaction 2 per second}}$
A	greater than 1	greater than 1
B	greater than 1	less than 1
C	less than 1	greater than 1
D	less than 1	less than 1

Ans: D

15.

The equations for two reactions are shown.

reaction X $2NOBr \rightarrow 2NO + Br_2$

reaction Y $2NOCl \rightarrow 2NO + Cl_2$

The two reactions have similar reaction mechanisms.

The initial rate of reaction X is greater than that of reaction Y when measured under identical conditions of temperature, pressure and reactant concentration.

Which statements explain this difference?

1 The activation energy for reaction X is less than that of reaction Y.

2 The Br–Br bond is weaker than the Cl–Cl bond.

3 A higher frequency of collisions between molecules of NOBr occur than between molecules of NOCl.

A 1 and 2 **B** 2 and 3 **C** 1 only **D** 3 only

Ans: C

- Low activation energy = high rate, so 1.
- Statement 2 is true, but Br–Br bond is being made in this case, not broken. If Br–Br was in the reactants, then this statement would be true, since only less energy is required to break it.

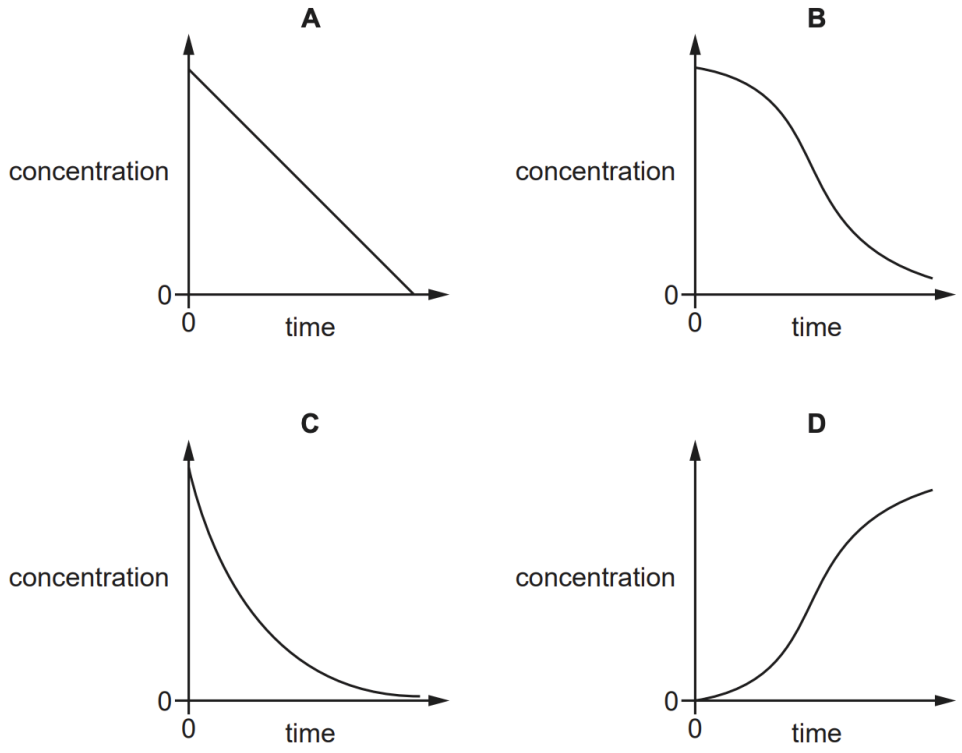
- Not 3, because frequency of collisions is affected by temperature, pressure and concentration, which are constant in this case.

16.

The rate of an exothermic reaction is followed by measuring the concentration of a reactant at regular time intervals.

During the experiment the temperature of the reaction mixture is **not** controlled.

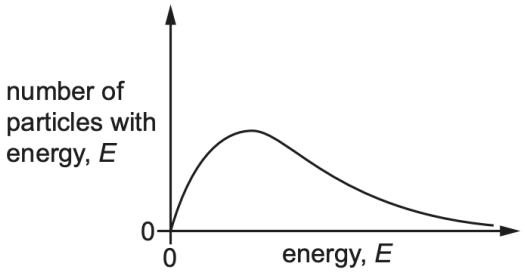
Which graph shows the change in concentration of reactant against time?



Ans: B

17.

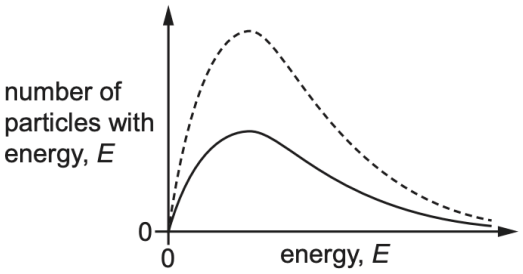
15 The Boltzmann distribution for one mole of a gas at temperature *T* is shown.



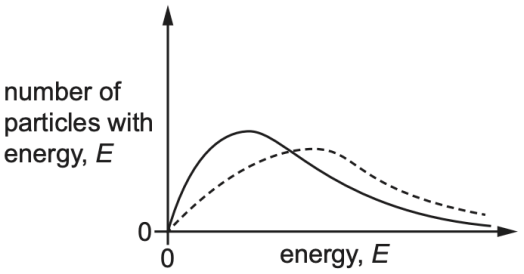
One mole of the same gas is added, and the gas remains at temperature *T*.

Which dotted curve shows the distribution with the added gas?

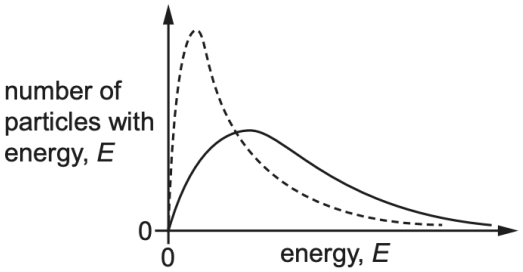
A



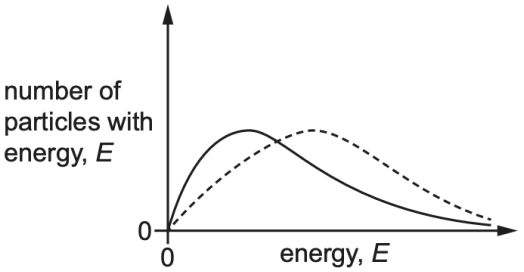
B



C



D



Ans: A

18.

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.

Ans: B

19.

A student carries out four experiments to investigate the rate of reaction between 3.0 g of calcium carbonate and hydrochloric acid.

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

experiment 1	$CaCO_3$ powder + 2.0 mol dm^{-3} HCl at 35 °C
experiment 2	$CaCO_3$ powder + 2.0 mol dm^{-3} HCl at 35 °C
experiment 3	large chips of $CaCO_3$ + 1.0 mol dm^{-3} HCl at room temperature
experiment 4	large chips of $CaCO_3$ + 1.0 mol dm^{-3} HCl at 35 °C

The student collects the $CO_2(g)$ and times how long it takes to produce the same volume of gas for each experiment.

What could be the correct times for the four experiments?

	experiment 1 / s	experiment 2 / s	experiment 3 / s	experiment 4 / s
A	5	10	30	95
B	5	10	95	30
C	5	30	95	10
D	95	30	10	5

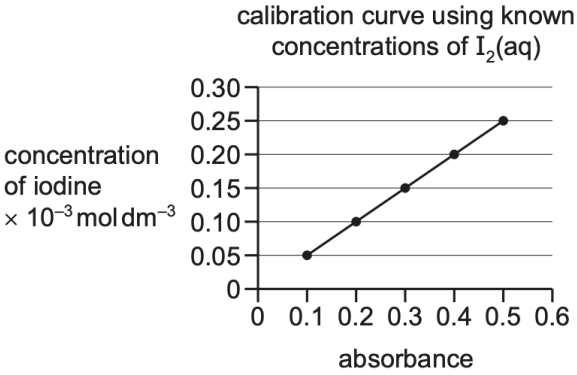
Ans: B

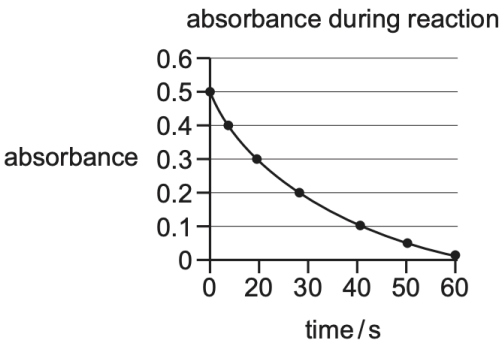
20.

14 In acidic conditions, iodine reacts with propanone in a substitution reaction.

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

The kinetics of the reaction are investigated using a colorimeter. As the I_2 reacts, the yellow / brown colour of the $I_2(aq)$ fades to colourless, changing the absorbance of the solution. Known concentrations of $I_2(aq)$ are used to prepare a calibration curve graph and the absorbance is then measured as the reaction proceeds.





What is the rate of reaction at 20 s?

A 5×10^{-6} mol dm^{-3} s^{-1}

B 1×10^{-5} mol dm^{-3} s^{-1}

C 5×10^{-3} mol dm^{-3} s^{-1}

D 1×10^{-2} mol dm^{-3} s^{-1}

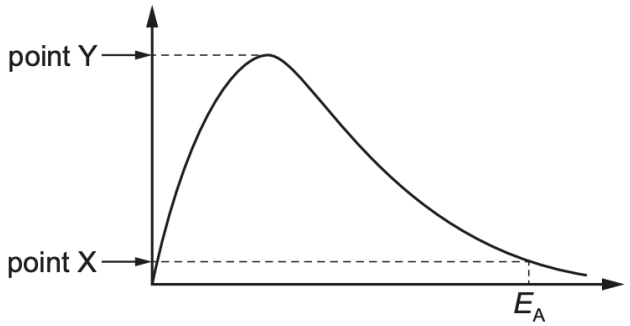
Ans: A

NOTE: for rate at 20, take the difference from 10-20. The one right before!

21.

The diagram shows a Boltzmann distribution curve.

The axes are not labelled.



Points X and Y are points on the vertical axis.

What is represented by both points X and Y?

	point X	point Y
A	number of molecules with energy equal to E_A	largest number of molecules with the same energy
B	number of molecules with energy equal to or greater than E_A	largest number of molecules with the same energy
C	number of molecules with energy equal to E_A	the amount of energy of the greatest number of molecules
D	number of molecules with energy equal to or greater than E_A	the amount of energy of the greatest number of molecules

Ans: A