Kinetics

Collision theory

This question is all about the reaction between zinc metal and hydrochloric acid to produce zinc chloride and hydrogen gas.

1. Write a balanced symbol equation for the reaction that occurs.

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(1 mark)

2. The reaction flasks below show the same reaction but under different conditions. The acid is in excess in all five flasks.

A
1 g granular zinc,
100 cm^3 1 mol dm^{-3} HCl

B
1 g granular zinc
100 cm^3 2 mol dm^{-3} HCl at 35 °C

C
0.5 g powdered zinc
100 cm^3 1 mol dm^{-3} HCl at 55 °C

D
2 g powdered zinc
100 cm^3 1 mol dm^{-3} HCl at 35 °C

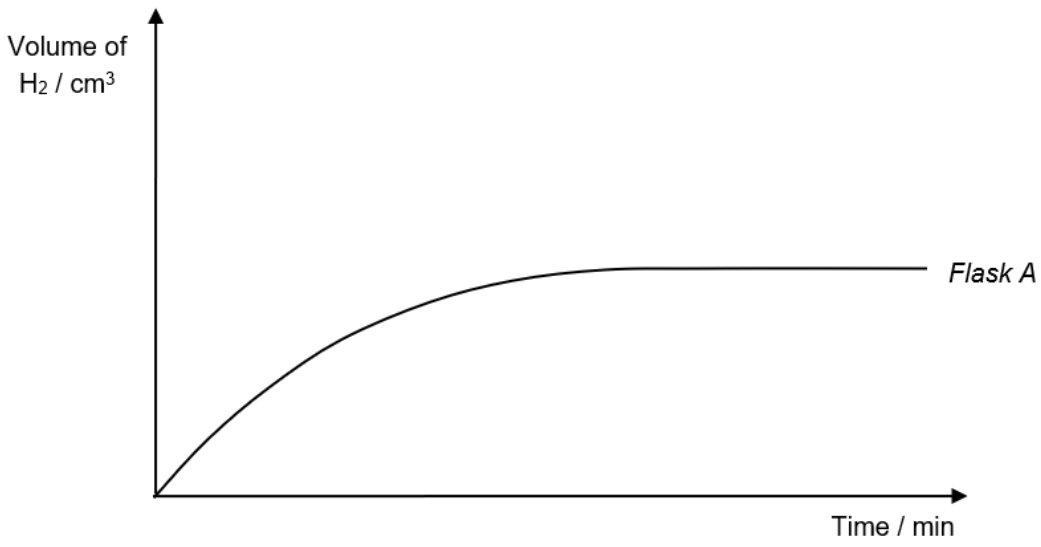
E
0.5 g granular zinc
100 cm^3 0.5 mol dm^{-3} HCl at 35°C

(a) In which flask is the reaction rate the slowest?

(1 mark)

(b) The graph below shows how the volume of hydrogen given off changed with time for the reaction that occurred in flask A. Sketch on the same set of axes, the curves you would expect to get if you repeated the measurements for *flasks B, C, D* and *E*.

(8 marks)



The Maxwell-Boltzmann distribution

Sketching Maxwell-Boltzmann

1. (a) Without using your notes, sketch on the axes below the Maxwell-Boltzmann distribution of molecular energies. Label this curve A. Make sure you include axes labels.

(4 marks)

(b) Add a line into the diagram to show the likely position of the activation energy for the reaction. Label this E_a.

(1 mark)

2. Now consider what would happen to the distribution if the temperature of the system was raised. Sketch a new distribution onto the axes and label this curve B.

(3 marks)

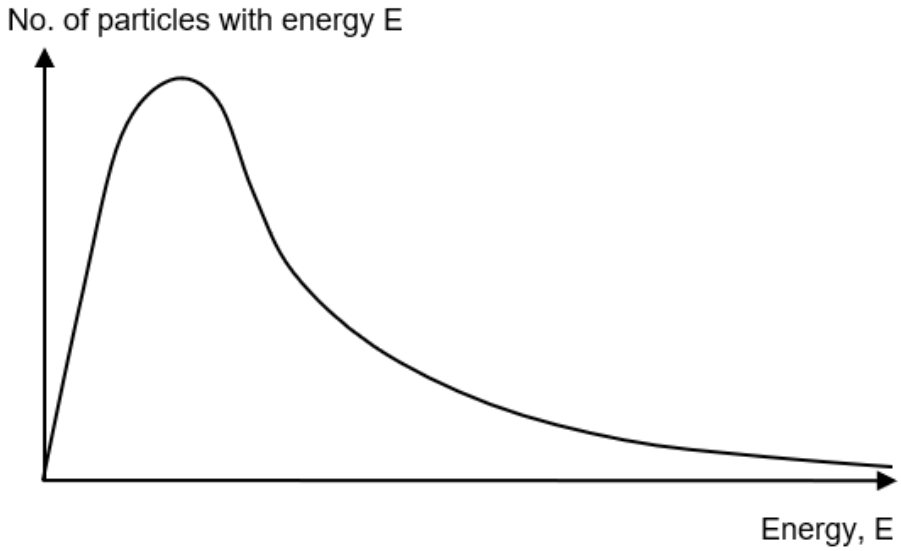
3. Using the two distributions you have drawn, explain why increasing the temperature of a reaction results in an increase in the rate of the reaction.

(2 marks)

The importance of Maxwell-Boltzmann

The distribution of energy amongst the particles in a gas is represented by the **Maxwell Boltzmann** distribution. The key characteristics are;

1. No particles have zero energy
2. Most particles have intermediate energies
3. A few particles have very high energies indeed
4. The average energy is not the same as the most probable energy



1. The sketch opposite shows a typical Maxwell Boltzmann distribution. Indicate where on the curve each of the above characteristics 1 - 4 is shown.

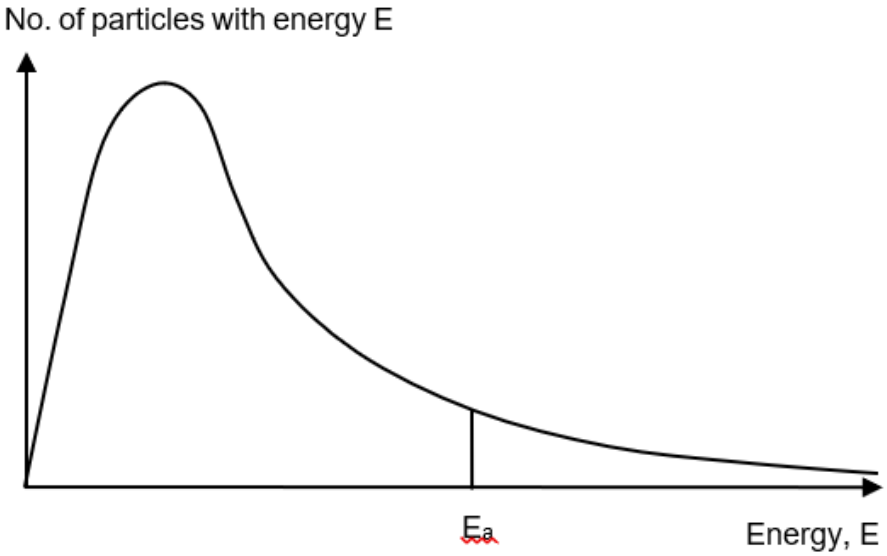
(4 marks)

2. Catalytic converters in cars reduce pollution by removing toxic gases from exhaust fumes. The gases pass over a ceramic honeycomb coated with platinum and rhodium metals. As the car warms up, the ceramic honeycomb reaches its operating temperature and catalyses the reaction between the gases.

(a) The distribution of energies of particles of gas at the start of the car journey is shown on the graph below. Draw a second line on the graph to indicate how the distribution will have changed 30 minutes into the journey when the catalyst has reached its operating temperature.

(4 marks)

$$2NO + 2CO \rightarrow N_2 + 2CO_2$$



(b) Why is it very important that the catalytic converter reaches its operating temperature as quickly as possible?

(2 marks)

Kinetics – Answers

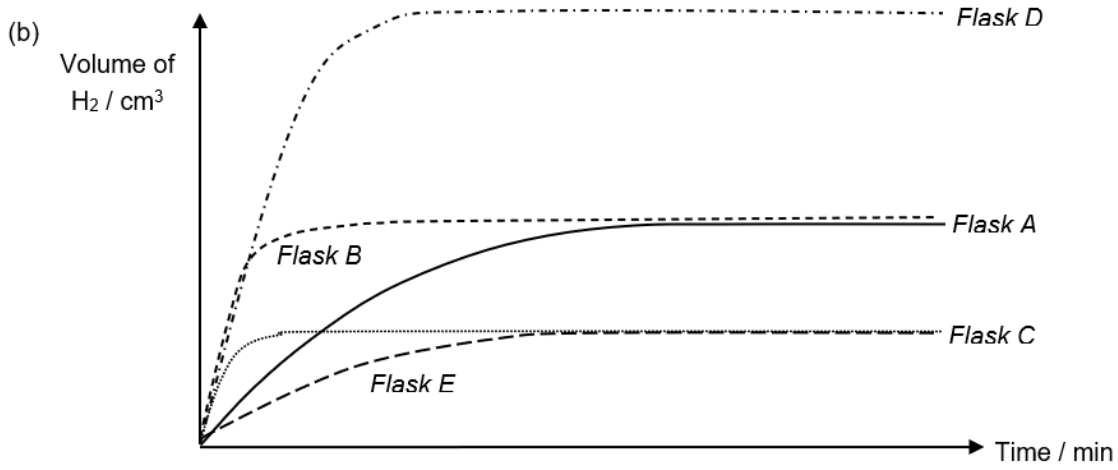
Collision theory

1. $Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

(1 mark)

2. (a) Flask E would go the slowest.

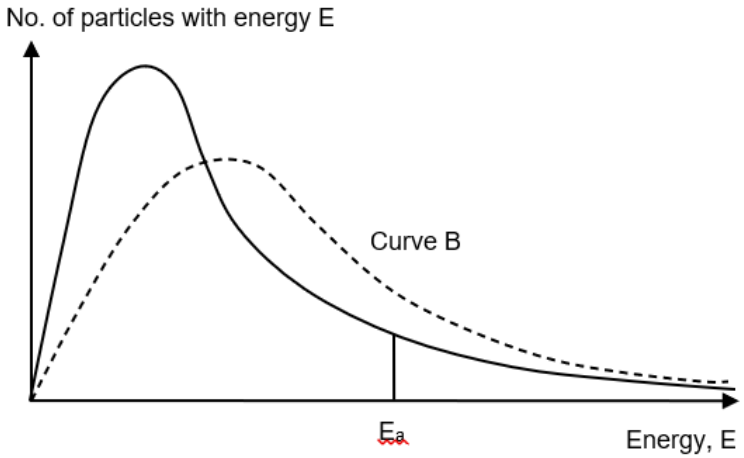
(1 mark)



(2 marks for each of the curves for flasks B, C, D and E; 1 for the correct initial gradient, 1 for the correct finishing point)

Sketching Maxwell-Boltzmann

1 mark – both axes correctly labelled
1 mark – curve starts at origin
1 mark – curve never touches x-axis
1 mark – correct shape
1 mark – drawing of E_a



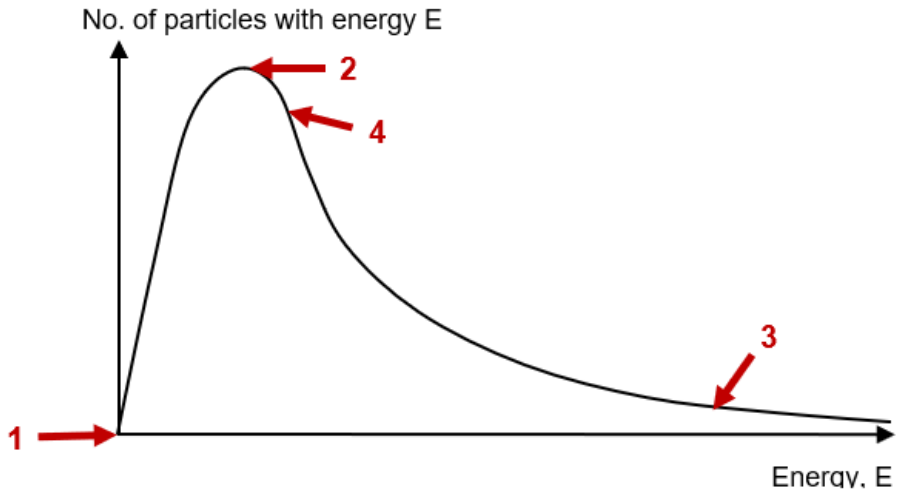
2. For the drawing of curve B above;

1 mark – peak to the right of original curve
1 mark – peak height is lower
1 mark – approximately the same area under the two curves

3. At a higher temperature many more of the particles will have an energy greater than the activation energy (1 mark) resulting in a higher percentage of particle collisions resulting in a reaction (1 mark).

The Importance of Maxwell-Boltzmann

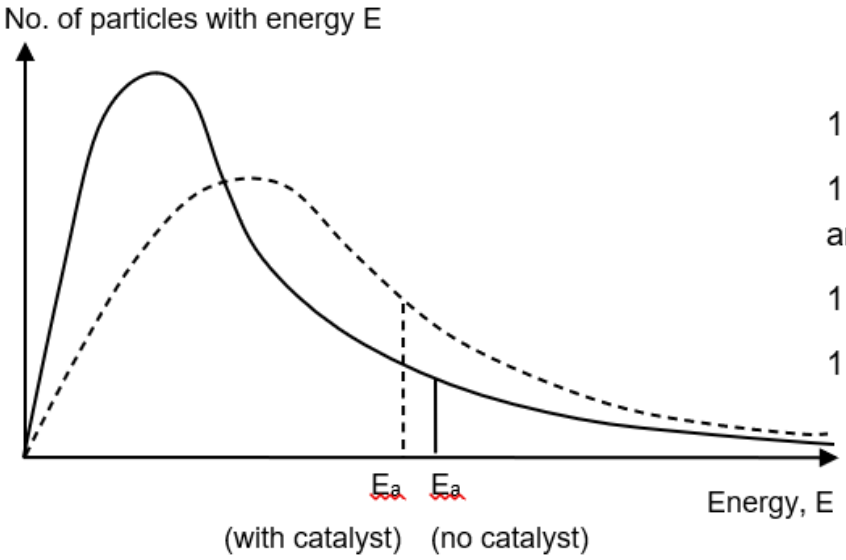
1.



(4 marks)

2.

(a)



1 mark – approximate same area

1 mark – most probable energy is lower and to the right

1 mark – the lines never cross

1 mark – E_a lower in energy

(b) It is important that catalytic converter reaches its operating temperature quickly because at higher temperatures and with the catalyst active many more particles have sufficient energy to react. Hence the catalytic converter is much more efficient (removes more polluting gases) at operating temperature.

(2 marks)