6.1 Chemical Kinetics

Question Paper

Course	DP IB Chemistry
Section	6. Chemical Kinetics
Topic	6.1 Chemical Kinetics
Difficulty	Medium

Time allowed: 60

Score: /50

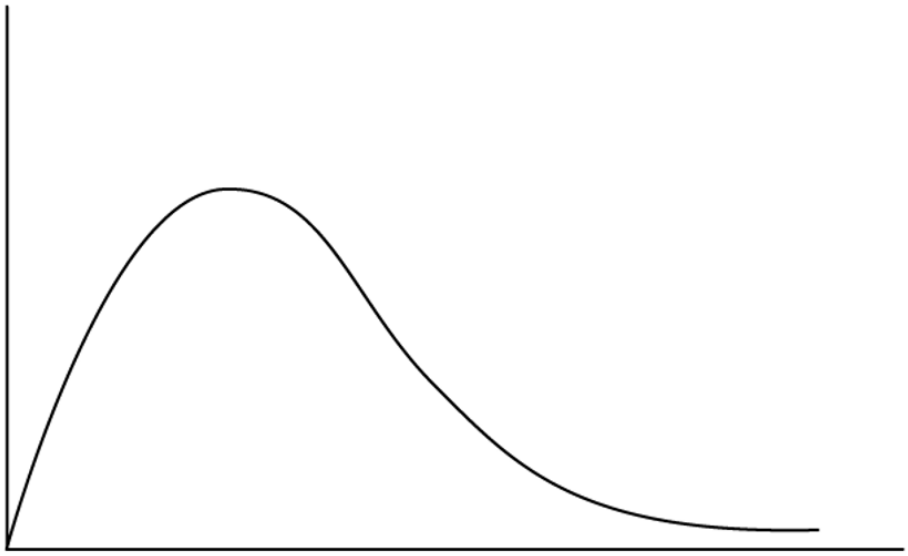
Percentage: /100

Question 1a

a) In any chemical reaction, the particles will all be moving around in different directions, at different speeds, with different amounts of energy.
A Maxwell-Boltzmann distribution is a graph which shows the distribution of energy amongst particles within a chemical reaction.

Figure 1 below shows the Maxwell-Boltzmann distribution in a sample of a gas at a fixed temperature, T_1.

Figure 1



(i) Label the x and y axes of the graph.

(ii) Sketch a distribution for this same sample of gas, at a higher temperature, and label it as T_2.

[4 marks]

Question 1b

b) State why a Maxwell-Boltzmann distribution curve always starts at the origin and what the area under the curve represents.

[2 marks]

Question 1c

c) Chemical reactions take place at different speeds. For a chemical reaction to take place, particles must collide with each other in the correct orientation and with sufficient energy.

(i) Explain why most collisions between particles in the gas phase do not result in a reaction taking place.

(ii) State and explain one way that the rate of reaction could be increased, other than by increasing the temperature.

[3 marks]

Question 1d

d) Give one reason why a reaction may be slow at room temperature.

[1 mark]

Question 2a

a) State the meaning of the term *rate of reaction*.

[1 mark]

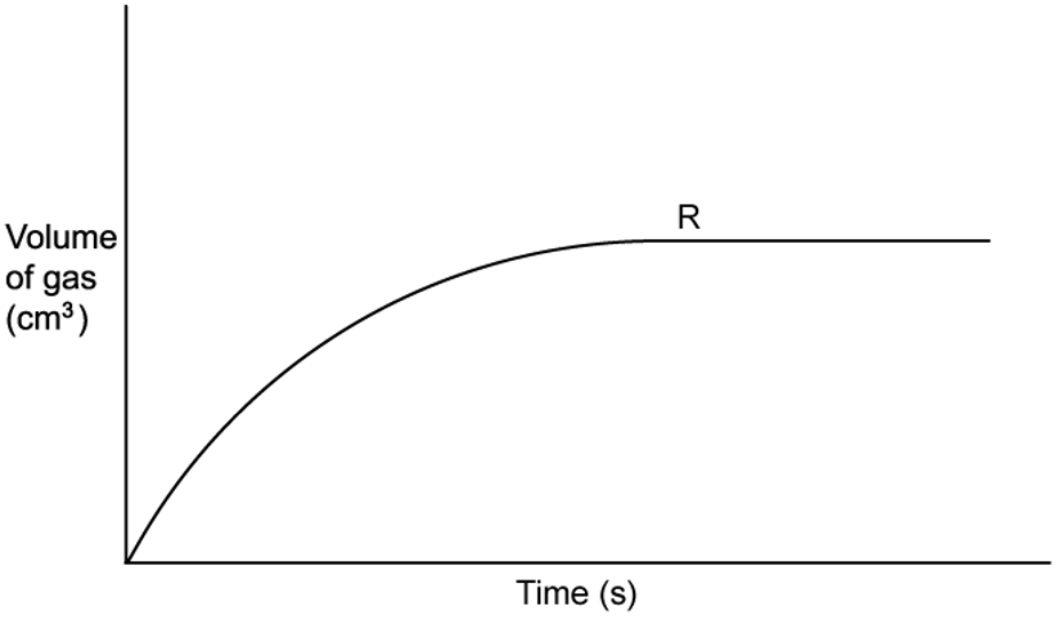
Question 2b

b) A group of students were completing a practical, investigating the factors which affect the rate of the chemical reaction shown below.

$$\mathbf{A(s) + B(aq) \rightarrow C(g)}$$

The students collected the gas produced and plotted the graph shown in **Figure 1**.

Figure 1



(i) State and explain what the letter R represents on the students graph in **Figure 1**.

(ii) In the original reaction above, the students used 0.5 g of **A** and 50 cm^3 of 1.0 mol dm^{-3} **B**.

Sketch a curve on the graph to show how the total volume of gas collected would change if the students still used 0.5 g of **A,** but used 50 cm^3 of 2.0 mol dm^{-3} of **B**.

[3 marks]

Question 2c

c) Explain why the gradient of the curve in part (b) decreases as the time of the reaction progresses.

[2 marks]

Question 2d

d) Another way to increase the rate of reaction is to increase the temperature.

Explain why a small increase in temperature has a large effect on the initial rate of a chemical reaction.

[2 marks]

Question 3a

a) The decomposition of hydrogen peroxide into water and oxygen is an awfully slow chemical reaction.

Write the equation for the decomposition of hydrogen peroxide.

[1 mark]

Question 3b

b) The rate of decomposition of hydrogen peroxide can be ascertained by collecting and measuring the volume of gas formed at specific time intervals.

(i) Draw a labelled diagram to show the apparatus that you would use to collect and measure the volume of gas formed during this reaction.

(ii) Explain how you would use the results to determine the initial rate of the reaction.

[5 marks]

Question 3c

c) The decomposition of hydrogen peroxide is a slow reaction, so a catalyst is often added to speed up the rate of the reaction. Catalysts are used in many chemical reactions to increase the rate.

The following shows a two-step reaction mechanism of a chemical reaction, where a catalyst, **X** is used.

STEP 1:	$W + X \rightarrow Y + Z$
STEP 2:	$Y + W \rightarrow Z + A + X$
OVERALL REACTION:	$2W \rightarrow 2Z + A$

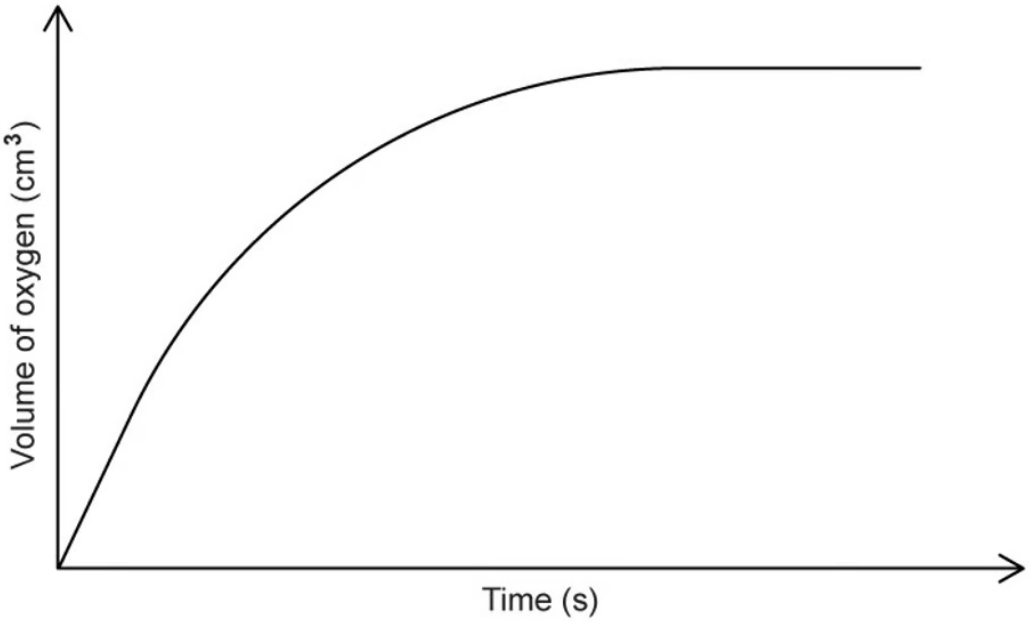
Give a reason, other than the rate of reaction increasing, why it can be deduced from the three equations above that X is a catalyst.

[1 mark]

Question 3d

d) The graph shown below represents the decomposition of hydrogen peroxide.

Figure 1



The graph starts to plateau as the reaction slows down.

State why the rate of the reaction slows down over time.

[1 mark]

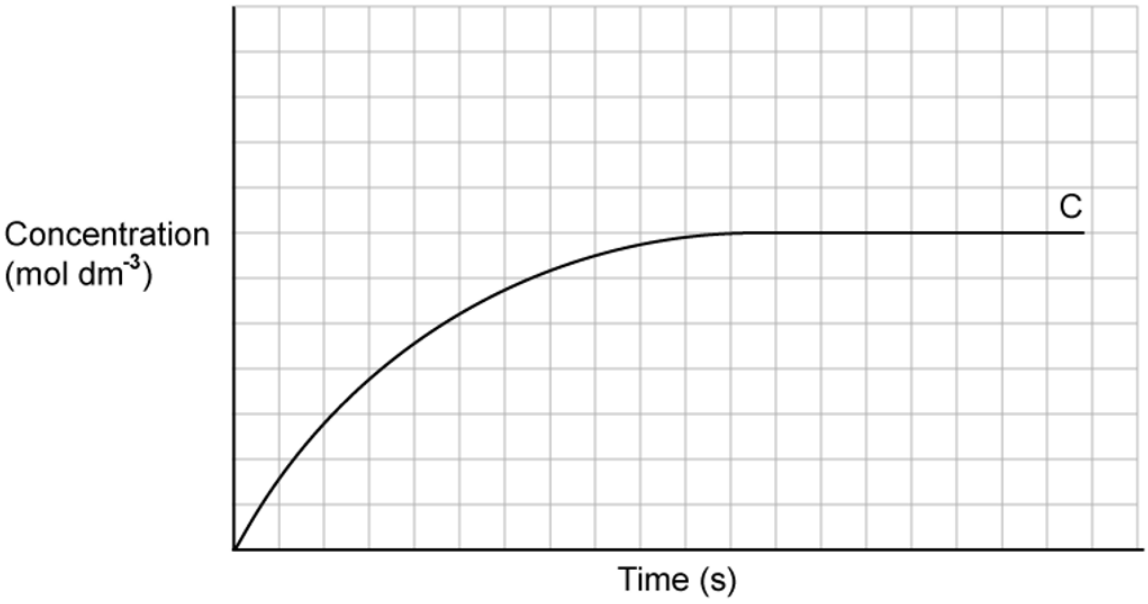
Question 4a

a) During the following reaction, **A** and **B** react together to produce **C**.

$$\mathbf{A + 2B \rightarrow C}$$

Figure 1 shows the production of C over time.

Figure 1



(i) Sketch a graph to show what happens to **A** and **B** during the progress of the reaction.

(ii) On your graph, write the letter **E** at the point at which an equilibrium is first established.

[2 marks]

Question 4b

b) In the reaction in part (a), lumps of **A** were used.
Use collision theory to explain what would happen to the rate of the reaction if powdered **A** was used instead of lumps.

[3 marks]

Question 4c

c) In a different reaction, gaseous W and X were added together to produce Y and Z as shown in the equation below:

$$\mathbf{2W(g) + X(g) \rightarrow Y(g) + 2Z(g)}$$

A catalyst was added to speed up the rate of reaction.

i) Sketch a Maxwell-Boltzmann distribution on the axes below in **Figure 2** to show the distribution of molecular energies at a constant temperature with **and** without a catalyst. Use E_a to label the activation energy without a catalyst and E_c to label the activation energy with a catalyst.

ii) Explain what your distribution shows.

Figure 2

[6 marks]

Question 4d

d) Some changes were made individually to the experiment completed in part (c).

Consider your Maxwell-Boltzmann distribution curve from part (c). For each of the changes in parts (i), (ii) and (iii) below, state and explain the effect that the change would have on:

- The area under the curve
- The value of the most probably energy of the molecules (E_{mp})
- The proportion of molecules with energy greater than or equal to E_a

(i) The temperature of the original reaction is increased, but no other changes are made.

(ii) The number of molecules in the original reaction mixture is increased, but no other changes are made.

(iii) A catalyst is added to the original reaction mixture, but no other changes are made.

[6 marks]

Question 5a

a) Iodine reacts with propanone in a catalyzed reaction, according to reaction equation below.

$$CH_3COCH_3\ (aq) + I_2\ (aq) \rightarrow CH_3COCH_2I\ (aq) + H^+\ (aq) + I^-\ (aq)$$

Suggest how the change in concentration of iodine could be used to determine the rate of the above reaction.

[1 mark]

Question 5b

b) A group of students completed the iodination of propanone reaction using the same acid catalyst, but with different concentrations. The results achieved are shown in the table below:

Table 1

Concentration of acid, $[H^+]$ / moldm^{-3}	Relative Rate of Iodination Reaction
0.100	0.0046
0.200	0.0092
0.300	0.0138

Use the table to state and explain the relationship between the concentration of acid used in the reaction and the rate.

[2 marks]

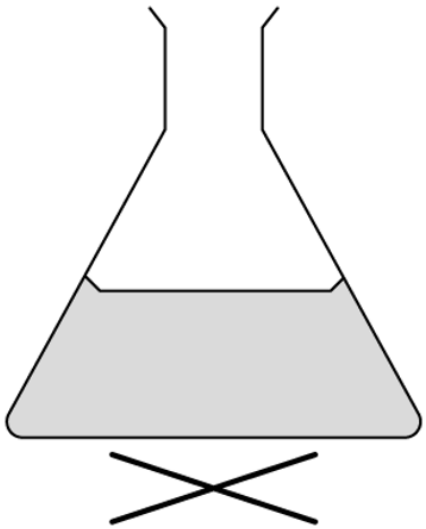
Question 5c

c) Sodium thiosulfate and hydrochloric acid will react together readily, as shown by the equation below:

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + S + SO_2 + H_2O$$

This reaction is often referred to as the 'disappearing cross' experiment. The cross disappears because the solution turns cloudy as a sulfur precipitate is formed, covering the cross.

Figure 1



The speed of the reaction can be increased, by increasing the temperature of the sodium thiosulfate solution in the reaction. The thiosulfate solution is heated to different temperatures before the acid is added, and the time it takes for the cross to disappear is recorded. The times can then be compared.

Suggest one reason why the value for the rate of reaction when a higher temperature was used may be less accurate than at a lower temperature.

[1 mark]

Question 5d

d) Collision theory can be used to explain why different factors affect the rate of a chemical reaction.

Describe collision theory.

[3 marks]