



A-Level Chemistry

Effects of Catalysts

Question Paper

Time available: 56 minutes

Marks available: 55 marks

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1.

A study of equilibrium is important for understanding chemical reactions.

(a) State le Chatelier's principle.

(1)

(b) Catalysts play an important role in many reactions.

(i) State the meaning of the term *catalyst*.
Explain, in general terms, how catalysts work.

Meaning of the term *catalyst* _____

How catalysts work _____

(3)

(ii) State the effect, if any, of a catalyst on the time taken to reach equilibrium.

(1)

(iii) State the effect, if any, of a catalyst on the position of an equilibrium.

(1)

(c) Consider the following equilibrium reactions.

				$\Delta H^\circ / \text{kJ mol}^{-1}$
P	$\text{H}_2(\text{g}) + \text{I}_2(\text{g})$	\rightleftharpoons	$2\text{HI}(\text{g})$	-10
Q	$\text{CO}_2(\text{g}) + 3\text{H}_2(\text{g})$	\rightleftharpoons	$\text{CH}_3\text{OH}(\text{g}) + \text{H}_2\text{O}(\text{g})$	-49
R	$\text{N}_2\text{O}_4(\text{g})$	\rightleftharpoons	$2\text{NO}_2(\text{g})$	+58
S	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$	\rightleftharpoons	$2\text{NH}_3(\text{g})$	-92
T	$\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$	\rightleftharpoons	$\text{CH}_3\text{CH}_2\text{OH}(\text{g})$	-42

In each of parts (c)(i) to (c)(v), you should record in the box one of the letters, **P**, **Q**, **R**, **S** or **T**, that corresponds to the equilibrium that best fits the information provided.

You may use each letter once, more than once or not at all.

- (i) A decrease in temperature at constant pressure shifts the position of this equilibrium from right to left.

(1)

- (ii) This equilibrium uses concentrated phosphoric acid as a catalyst in a hydration reaction.

(1)

- (iii) A decrease in pressure at constant temperature shifts the position of this equilibrium from left to right.

(1)

- (iv) There is no change in the position of this equilibrium when the pressure is increased at constant temperature.

(1)

- (v) An increase in the concentration of steam at constant temperature and constant pressure shifts the position of this equilibrium from right to left.

☐

(1)

(Total 11 marks)

2.

The rate of a chemical reaction is influenced by the size of the activation energy. Catalysts are used to increase the rates of chemical reactions but are not used up in the reactions.

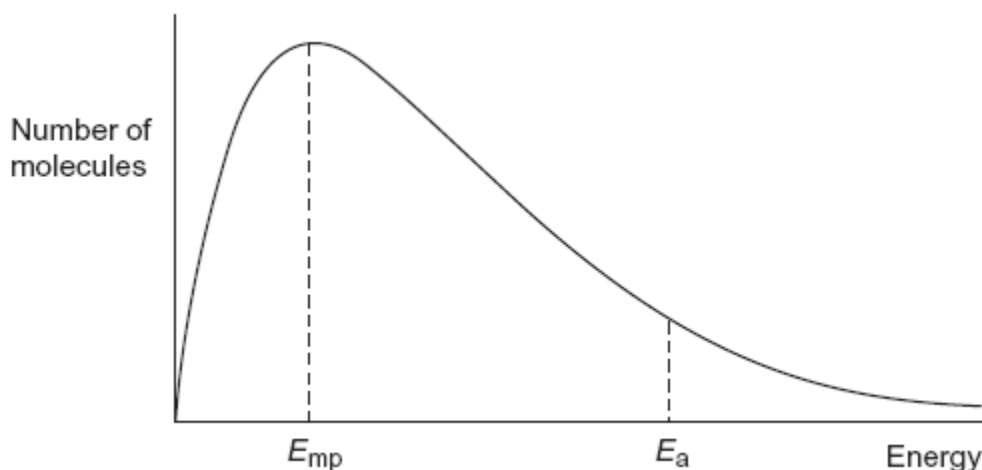
- (a) Give the meaning of the term *activation energy*.

(2)

- (b) Explain how a catalyst increases the rate of a reaction.

(2)

- (c) The diagram below shows the Maxwell–Boltzmann distribution of molecular energies, at a constant temperature, in a gas at the start of a reaction.
On this diagram the most probable molecular energy at this temperature is shown by the symbol E_{mp}
The activation energy is shown by the symbol E_a



To answer the questions (c)(i) to (c)(iv), you should use the words **increases**, **decreases** or **stays the same**. You may use each of these answers once, more than once or not at all.

- (i) State how, if at all, the value of the most probable energy (E_{mp}) changes as the total number of molecules is increased at constant temperature.

(1)

- (ii) State how, if at all, the number of molecules with the most probable energy (E_{mp}) changes as the temperature is decreased without changing the total number of molecules.

(1)

- (iii) State how, if at all, the number of molecules with energy greater than the activation energy (E_a) changes as the temperature is increased without changing the total number of molecules.

(1)

- (iv) State how, if at all, the area under the molecular energy distribution curve changes as a catalyst is introduced without changing the temperature or the total number of molecules.

(1)

(d) For each of the following reactions, identify a catalyst and name the organic product of the reaction.

(i) The fermentation of an aqueous solution of glucose.

Catalyst _____

Name of organic product _____

(2)

(ii) The hydration of but-2-ene.

Catalyst _____

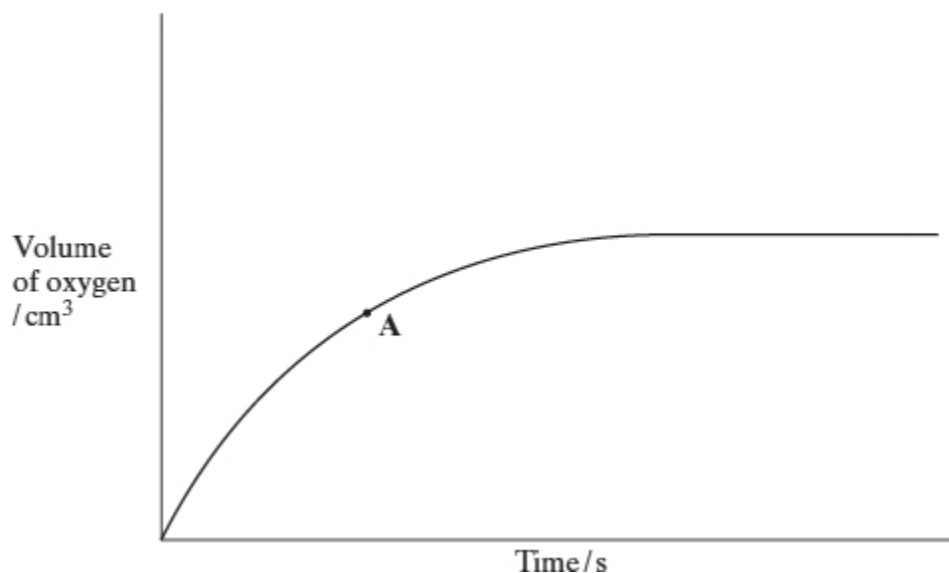
Name of organic product _____

(2)

(Total 12 marks)

3.

The curve below shows how the volume of oxygen evolved varies with time when 50 cm³ of a 2.0 mol dm⁻³ solution of hydrogen peroxide, H₂O₂, decomposes at 298 K.



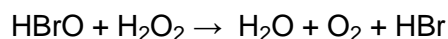
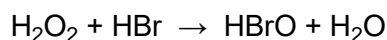
(a) State how you could use the curve to find the rate of reaction at point A.

(1)

- (b) Sketch curves, on the above axes, to illustrate how the volume of oxygen evolved would change with time if the experiment was repeated at 298 K using the following.
- (i) 100 cm³ of a 1.0 mol dm⁻³ solution of H₂O₂. Label this curve **X**.
- (ii) 25 cm³ of a 2.0 mol dm⁻³ solution of H₂O₂ in the presence of a catalyst. Label this curve **Y**.

(4)

- (c) Hydrogen peroxide decomposes more rapidly in the presence of aqueous hydrogen bromide. The decomposition proceeds as shown by the following equations.



- (i) Write an equation for the overall reaction.

- (ii) Define the term *catalyst*.

- (iii) Give **two** reasons, other than an increase in the reaction rate, why these equations suggest that hydrogen bromide is behaving as a catalyst.

Reason 1

Reason 2

(5)

(Total 10 marks)

4.

- (a) Define the term *activation energy* for a reaction.

(2)

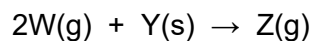
- (b) Give the meaning of the term *catalyst*.

(2)

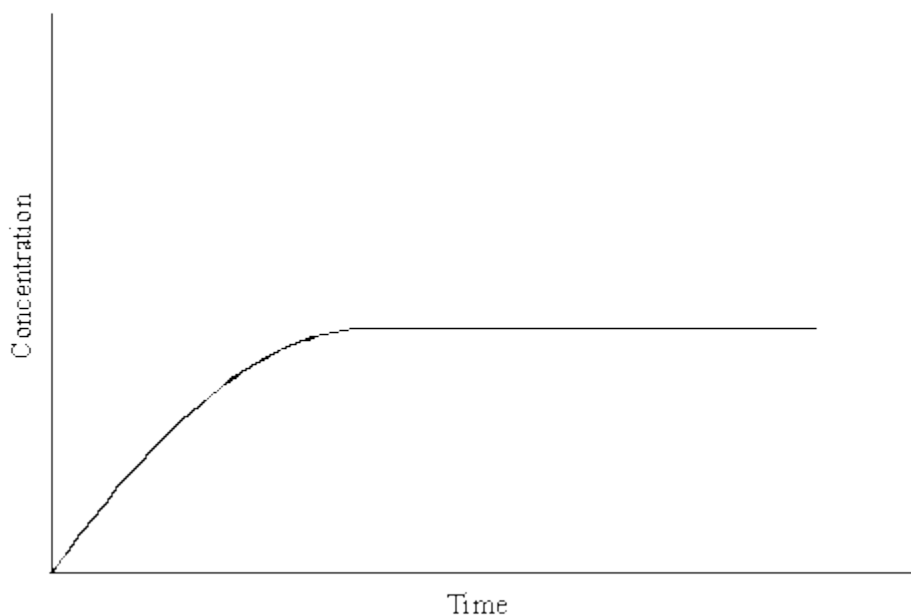
- (c) Explain in general terms how a catalyst works.

(2)

- (d) In an experiment, two moles of gas **W** reacted completely with solid **Y** to form one mole of gas **Z** as shown in the equation below.



The graph below shows how the concentration of **Z** varied with time at constant temperature.



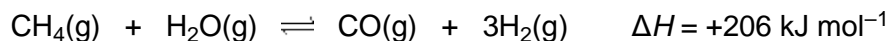
- (i) On the axes above, sketch a curve to show how the concentration of **W** would change with time in the same experiment. Label this curve **W**.
- (ii) On the axes above, sketch a curve to show how the concentration of **Z** would change with time if the reaction were to be repeated under the same conditions but in the presence of a catalyst. Label this curve **Z**.
- (iii) In terms of the behaviour of particles, explain why the rate of this reaction decreases with time.

(6)

(Total 12 marks)

5.

Hydrogen is produced by the reaction between steam and methane when the following dynamic equilibrium is established.



- (a) Use Le Chatelier's principle to predict the separate effects of an increase in temperature and of an increase in pressure on the yield of hydrogen obtained in the above reaction. In each case, explain your answer.

(6)

- (b) State how, and explain why, the use of a catalyst might or might not change the equilibrium yield of hydrogen, and also the amount of hydrogen produced, in a given time.

(4)

(Total 10 marks)