EXAM PAPERS PRACTICE

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Detailed mark scheme

Suitable for all boards

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Level: CIE AS and A Level (9701)
Subject: Chemistry
Topic: CIE Chemistry
Type: Topic Question

Chemistry CIE AS & A Level
To be used for all exam preparation for 2025+

CHEMISTRY AS and A

This to be used by all students studying CIE AS and A level Chemistry (9701) But students of other boards may find it useful

Question 1.

(a) This question is about the following general reaction

$$A + B \rightleftharpoons C + D$$

The reaction pathway diagram for the reaction is shown in Fig. 1.1.

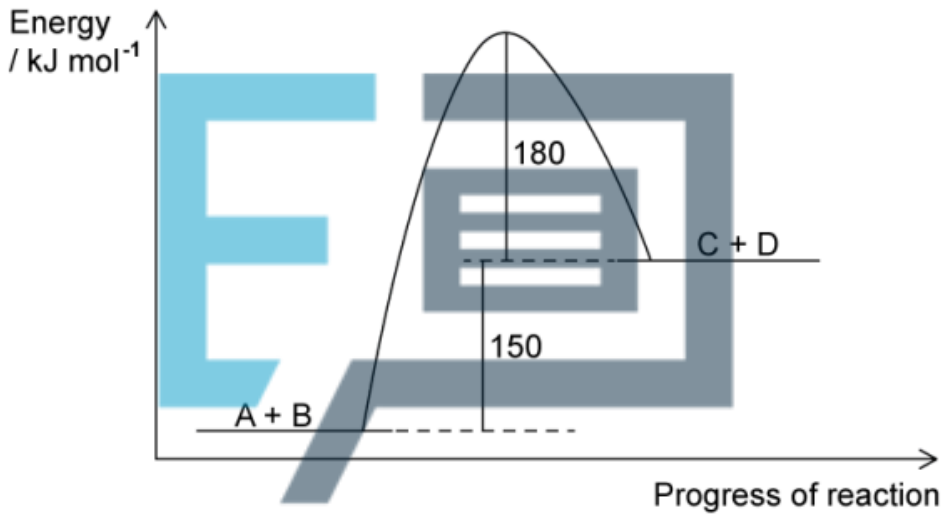

Fig. 1.1

Explain whether the forward reaction is exothermic or endothermic.

(2 marks)

(b) Define the term activation energy.

(1 mark)

(c) Use Fig. 1.1 to calculate the activation energy for the forward and backward reactions.

(2 marks)

(d) Explain, using Fig. 1.2, how the addition of a catalyst affects the rate of reaction.

Fig. 1.2

(3 marks)

Question 2.

(a) This question is about Boltzmann distribution curves.

The Boltzmann distribution curve of molecular energies for a general reaction at a given temperature is shown in Fig. 2.1.

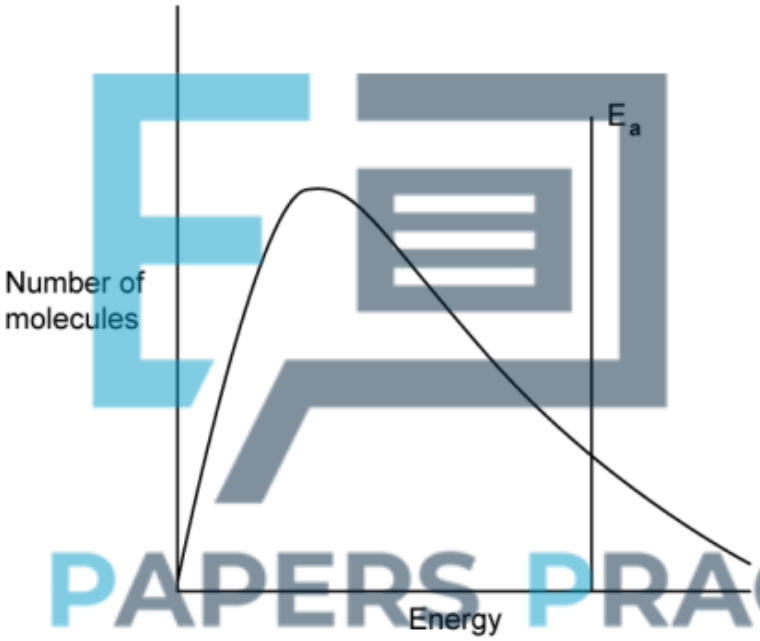

Fig. 2.1

State what will happen to the curve when the temperature of the reaction is decreased.

(2 marks)

(b) Comment on how, if at all, the total area under a Boltzmann distribution curve changes with temperature.

_____

(1 mark)

(c) State what happens to the Boltzmann distribution curve in Fig. 2.1 when a catalyst is added to the reaction.

_____

_____

(2 marks)

(d) The Boltzmann distribution of energies for a gas is shown in Fig. 2.2.

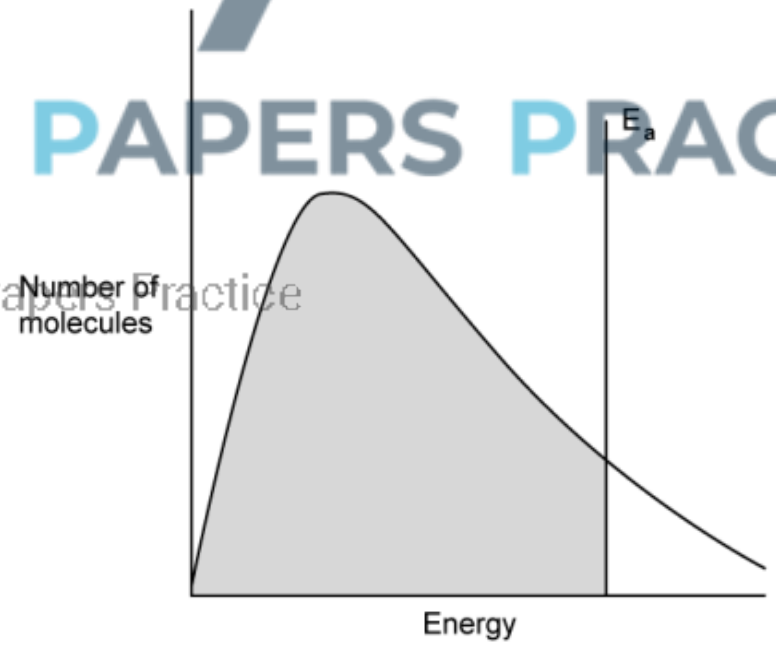

Fig. 2.2

State what the shaded area of Fig. 2.2 represents.

_____

(1 mark)

(a) Fig. 1.1 below shows, for a given temperature T, a Boltzmann distribution of the kinetic energy of the molecules of a mixture of two gases that will react together.

The activation energy for the reaction, E_a, is marked.

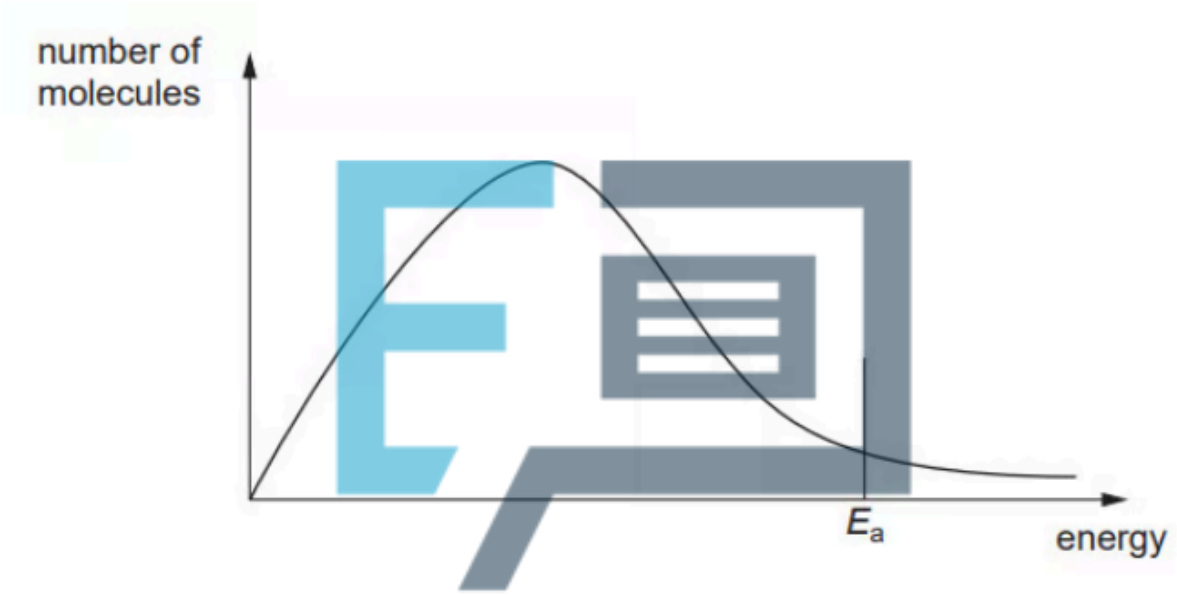

Fig. 1.1

On Fig. 1.1 above,

i) draw a new distribution curve, clearly labelled T_2, for the same mixture of gases at a lower temperature, T_2.

[2]

ii) mark clearly, as **H**, the position of the activation energy of the reaction at the lower temperature, T_2.

[1]

(3 marks)

(b) Explain the meaning of the term **activation energy**.

(2 marks)

(c) i) On the energy axis in Fig. 1.1, mark the position, clearly labelled **C**, of the activation energy of the reaction when a catalyst is used.

[1]

ii) Use your answer to **(i)** to explain how the use of a catalyst results in reactions occurring at a faster rate.

[1]

(2 marks)

(d) Two reactions involving aqueous NaOH are given below.

$CH_3CHBrCH_3 + NaOH \rightarrow CH_3CH(OH)CH_3 + NaBr$ **reaction 1**

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ **reaction 2**

The reagents in **reaction 1** must be heated together for some time for the reaction to occur.
Whereas, **reaction 2** is almost instantaneous at room temperature.

Suggest brief explanations why the rates of these two reactions are very different.

(4 marks)

Question 4.

(a) Ammonia can be produced by the reaction of nitrogen and hydrogen.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \qquad \Delta H = -92\ kJ\ mol^{-1}$$

The reaction can be catalysed and the activation energy for this catalysed reaction is $+109\ kJ\ mol^{-1}$

Complete the reaction pathway diagram in Fig. 2.1 for the uncatalysed **and** the catalysed reaction between nitrogen and hydrogen.

You should label the following:

- products
- the enthalpy change of reaction, ΔH
- the activation energy of the forward, uncatalysed reaction, E_a
- the activation energy of the forward, catalysed reaction, E_c

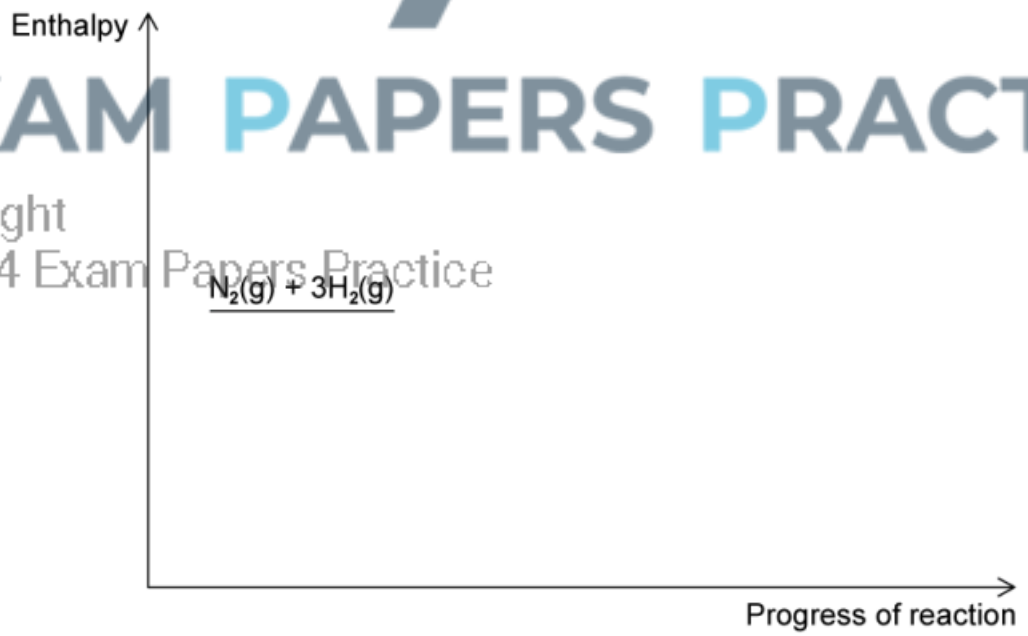

Fig. 2.1

_____

_____

_____

(4 marks)

(b) Calculate the value of the activation energy of the catalysed decomposition of ammonia into nitrogen and hydrogen.

Show your working.

activation energy ..... kJ mol^{-1}

_____

(1 mark)

(c) Catalysts, such as iron used in the production of ammonia, increase the rate of reaction.

Explain why. Use a labelled Boltzmann distribution to explain your answer.

_____

(1 mark)

(d) Platinum is used as a catalyst in catalytic converters which are fitted to vehicle exhaust systems to remove nitrogen oxide from the exhaust gases.

$$2NO\,(g) + 2CO\,(g) \rightarrow N_2\,(g) + 2CO_2\,(g)$$

i) State the type of catalyst that platinum is in a catalytic converter

[1]

ii) Explain, using oxidation numbers, if nitrogen is being oxidised or reduced in this reaction.

[2]

(3 marks)

Question 5.

(a) In any chemical reaction, the particles will all be moving in different directions, at different speeds and with different amounts of energy. Maxwell-Boltzmann distributions show the distribution of energy amongst particles within a chemical reaction.

Fig. 3.1 below shows the Maxwell-Boltzmann distribution in a sample of a gas at a fixed temperature, T_1.

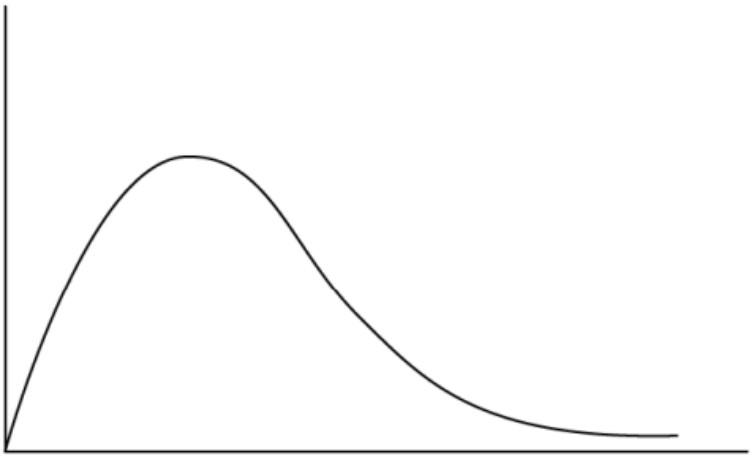

Fig. 3.1

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

[2]

ii) Sketch a distribution for a sample of the same gas at a higher temperature, T_2.

[2]

(4 marks)

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

(2 marks)

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

Consider your Maxwell-Boltzmann distribution curve from part **(a)**. 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.

[2]

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

[2]

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

[2]

(6 marks)

Question 6.

(a) A Maxwell-Boltzmann distribution curve is shown below in Fig 1.1

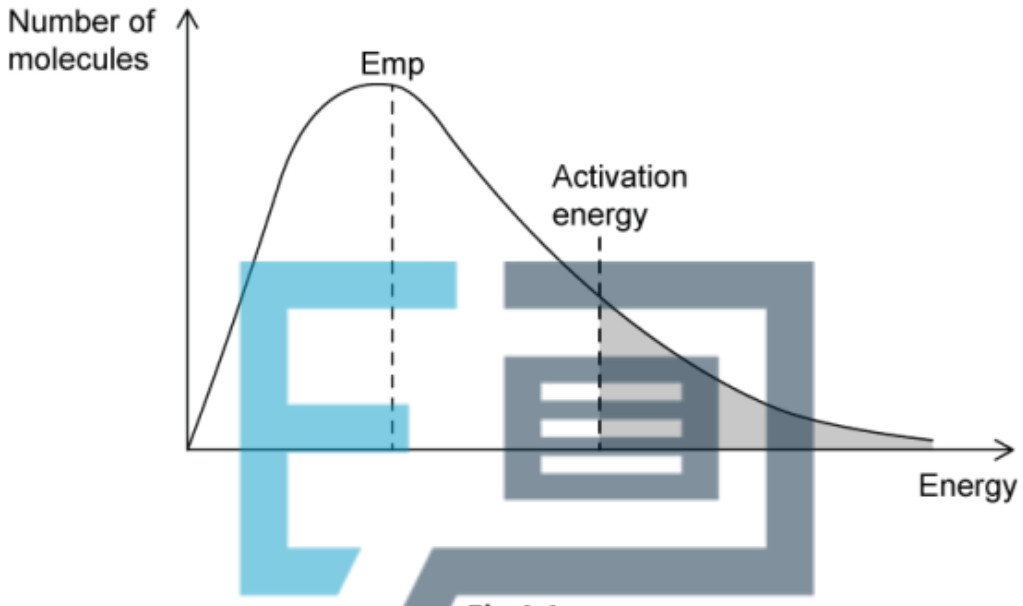

Fig 1.1

For the changes detailed in part **(i)** and **(ii)** state and explain the effect the change would have on:

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

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

[2]

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

[2]

(4 marks)

(b) A chemist performed a reaction at three different temperatures, 100 K, 300 K and 700 K as shown by the Maxwell-Boltzmann distribution graph in Fig 1.2.

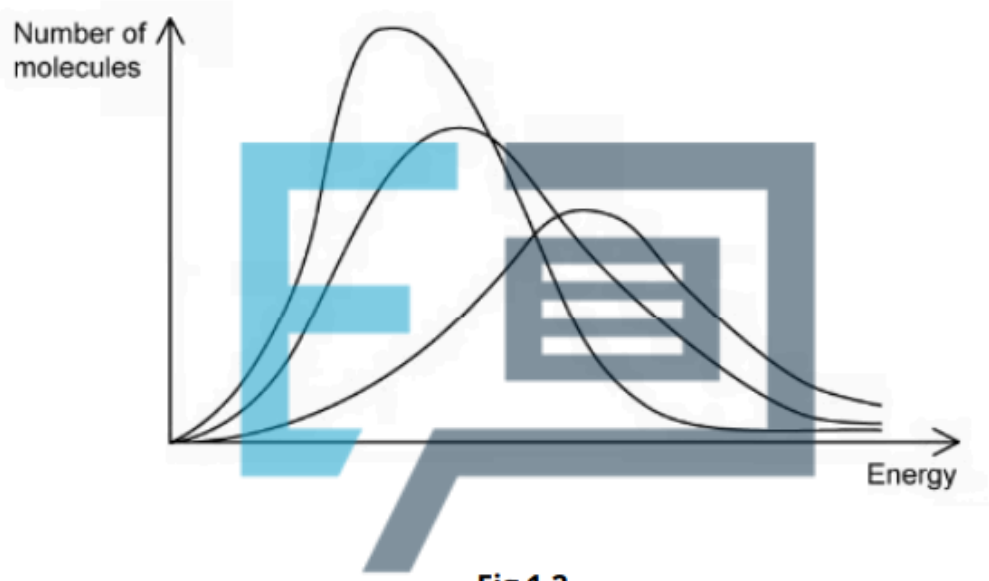

Fig 1.2

i) Label each curve in Fig 1.2 with the correct temperature values, 100 K, 300 K and 700 K.

[1]

ii) Consider the following statement, 'All reacting molecules have higher kinetic energy at 700 K than they do at 300 K'.

State whether you agree this statement is correct and justify your reasons.

[3]

(4 marks)

(c) Hydrogen will react with chlorine to form the hydrogen halide, hydrogen chloride, a colourless gas.

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

i) Give one reason why most collisions between hydrogen and chlorine molecules do not lead to the formation of hydrogen chloride.

[1]

ii) Apart from changing the temperature, state and explain two ways of speeding up the formation of hydrogen chloride.

[4]

(5 marks)