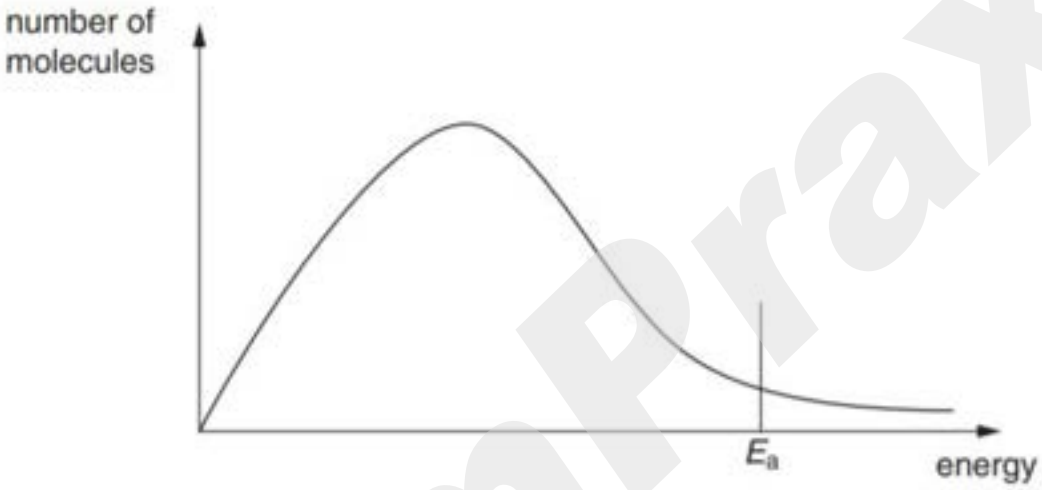
Reaction Kinetics

(Past Year Topical Questions 2010-2015)

May/June 2010 (21)

2 The diagram 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, such as nitrogen and hydrogen.
The activation energy for the reaction, E_a, is marked.



(a) On the graph above,

(i) draw a new distribution curve, **clearly labelled T′**, for the same mixture of gases at a higher temperature, T′;

(ii) mark clearly, as H, the position of the activation energy of the reaction at the higher temperature, T′.

[3]

ChemPraxis

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

.....

.....

.....

..... [2]

The reaction between nitrogen and hydrogen to produce ammonia in the Haber process is an example of a large-scale gaseous reaction that is catalysed.

(c) **(i)** State the catalyst used and give the operating temperature and pressure of the Haber process.

catalyst .....

temperature .....

pressure .....

(ii) **On the energy axis of the graph opposite**, mark the position, **clearly labelled C**, of the activation energy of the reaction when a catalyst is used.

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

.....

.....

.....

[3]

ChemPraxis

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

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

$HCl + NaOH \rightarrow NaCl + H_2O$ **reaction 2**

In order for **reaction 1** to occur, the reagents must be heated together for some time. On the other hand, **reaction 2** is almost instantaneous at room temperature.

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

reaction 1 .....

.....

.....

reaction 2 .....

.....

..... [4]

ChemPraxis

May/June 2012 (22)/Q2

(c) The operating conditions for this reaction are as follows.

pressure	200 atmospheres (2×10^7 Pa)
temperature	600 K
catalyst	oxides of Cr, Cu, and Zn

In the spaces below, explain how **each** of these conditions affects the **rate of formation** of methanol.

pressure

.....

.....

.....

temperature

.....

.....

.....

catalyst

.....

.....

.....

[6]

ChemPraxis

Oct/Nov 2012 (23)/Q3

(c) What will be the effect on the rate of the reaction of increasing the pressure at which it is carried out? Explain your answer.

.....

.....

..... [2]

Oct/Nov 2014 (23)

2 The Haber process for the manufacture of ammonia, NH_3, was originally devised at the start of the 20th century and was developed into a full-scale industrial process by Carl Bosch in 1913.

The key step in the process is the reversible reaction of nitrogen and hydrogen in the presence of an iron catalyst.

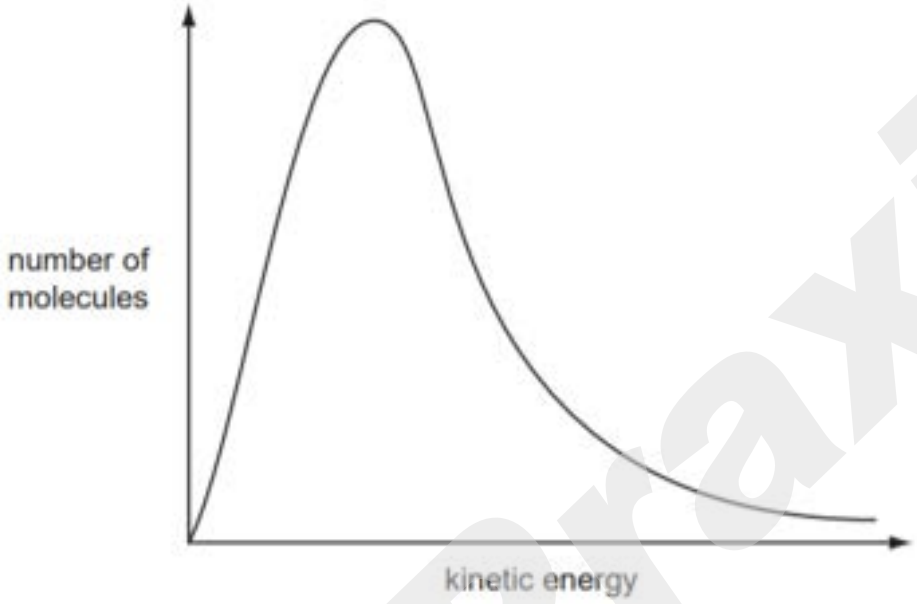
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

(a) The hydrogen for this reaction can be formed by reacting methane with steam, during which carbon monoxide is also produced. Write an equation for this reaction.

..... [1]

ChemPraxis

(b) Use the Boltzmann distribution shown to explain why a catalyst increases the rate of this reaction.



.....

.....

.....

..... [4]

ChemPraxis

(d) The Haber process is typically carried out at a temperature of 400 °C.

(i) With reference to Le Chatelier's Principle and reaction kinetics, state and explain one advantage and one disadvantage of using a higher temperature.

.....

.....

.....

.....

.....

..... [4]

ChemPraxis