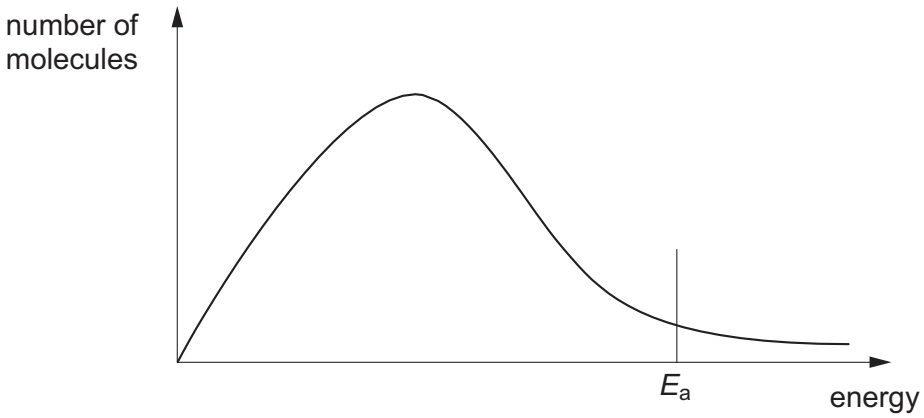
Specimen 2016 9701/2 Question 2

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′**, [1]

(ii) **mark clearly, as H**, the position of the activation energy of the reaction at the higher temperature, **T′**. [1]

(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 ..... [1]

(ii) **On the energy axis of the graph above**, mark the position, **clearly labelled C**, of the activation energy of the reaction when a catalyst is used. [1]

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

.....

..... [1]

(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

(i) In order for **reaction 1** to occur, the reagents must be heated together for some time. **Reaction 2** however is almost instantaneous at room temperature.

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

reaction 1 .....

.....

.....

reaction 2 .....

.....

..... [4]

(ii) State the reagent needed to confirm the presence of the $–CH(OH)CH_3$ group in the products of **reaction 1** and the observations that would be made.

.....

.....

..... [2]

[Total: 13]

Specimen 2016 9701/2 Mark Scheme

2 **(a)** **(i)** new graph has lower maximum and maximum is to the right of previous maximum [1]

(ii) **H** is at E_a (1) [1]

(b) the minimum amount of energy molecules must have or energy required (1)
in order for the reaction to take place (1) [2]

(c) **(i)** iron or iron oxide
100 to 500 atm and 400–550 °C
units necessary – allow other correct values and units [1]

(ii) C is placed to the left of H [1]

(iii) more molecules now have energy > E_a [1]

(d) **(i)** reaction 1
has greater E_a (1)
because energy is needed to break covalent bonds (1)

reaction 2
has lower E_a (only valid if converse not awarded for reaction 1)
or actual reaction is $H^+ + OH^- \rightarrow H_2O$
or reaction involves ions (1)
opposite charges attract (1) [4]

(ii) alkaline aqueous iodine (1)
yellow ppt (1) [2]

[Total: 13]