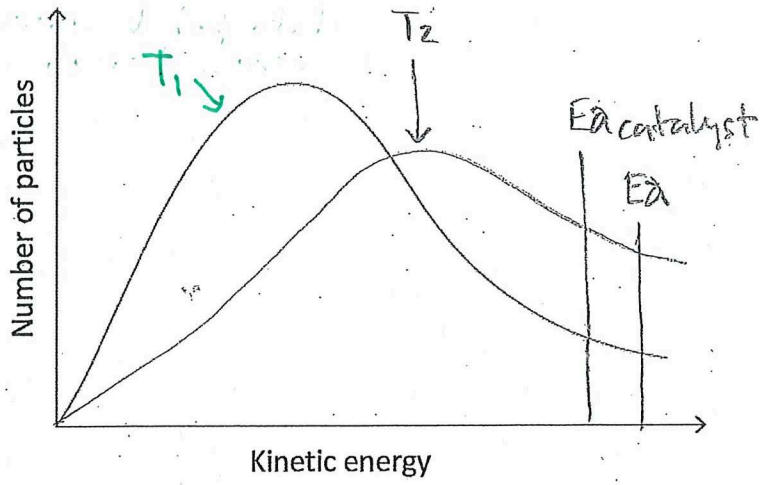
KINETICS Core (SL & HL)

1. The diagram below shows a Maxwell-Boltzmann distribution of a sample of gas at a given temperature, T.



(a) Sketch on the graph a distribution of the same sample of gas at a higher temperature, T_2. [2]

peak to right of T1 and lower ✓ ✓

(b) Explain how and why increasing temperature affects the rate of a chemical reaction. [3]

Increasing temperature increases the rate of reaction ✓ as particles have more energy / move more quickly so collide more frequently (more collisions per second) ✓ and the collisions have greater energy / a greater proportion of particles have enough energy to overcome the activation energy. ✓

2nd mark is more frequent collisions
3rd mark is higher energy / Ea (or over) mark.

(c) A catalyst increases the rate of a reaction. Explain, in words, how a catalyst functions and indicate this by appropriate annotations on the Maxwell-Boltzmann graph. [3]

A catalyst provides the reaction with an alternative pathway / mechanism ... ✓ of lower activation energy. ✓

Ea catalyst and Ea lines marked on diagram above ✓

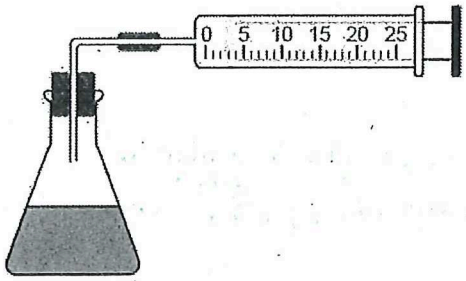
2. A reaction was carried out in a laboratory to measure the volume of gas produced when excess calcium carbonate chips react with hydrochloric acid using a gas syringe.

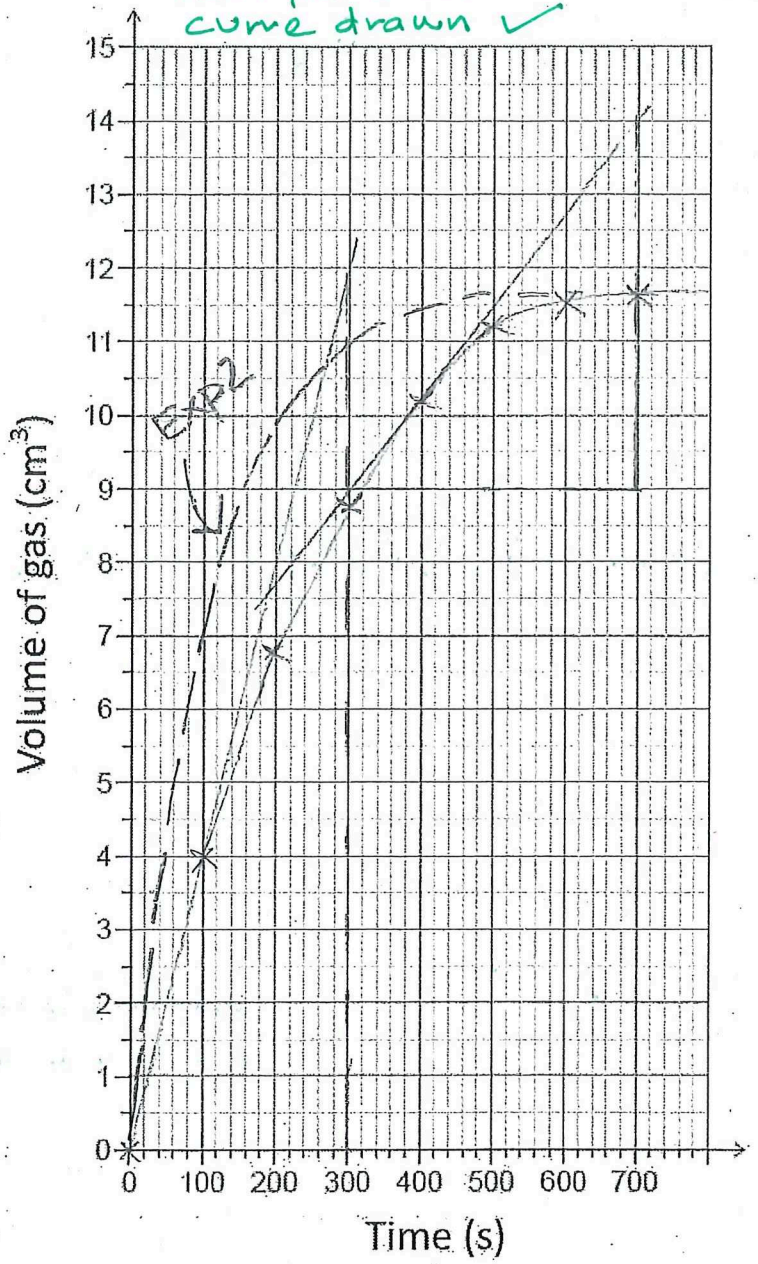
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) Plot a graph of the data on the axes below. Draw a line of best fit on the graph. [3]

data points correct ✓
curve drawn ✓

Time (secs)	Volume of gas (cm^3)
0	0.0
100	4.0
200	6.8
300	8.8
400	10.2
500	11.2
600	11.6
700	11.6





(b) Calculate the **initial** rate of reaction. Show your working on the graph. [2]

gradient of tangent = $\frac{12.0}{300}$ = 0.0400 ($cm^3\ s^{-1}$) ✓

tangent working on graph ✓ (allow similar value from graph tangent)

units not required

(c) Calculate the rate of reaction at 400 seconds.

[2]

gradient of tangent = $\frac{(14-9)}{(700-300)} = \frac{5.0}{400} = 0.0125$ ✓

$cm^3 s^{-1}$ ✓ units.

allow similar value from graph tangent.

(d) State and explain what happens to the rate of reaction over time.

[2]

The rate decreases with time, ✓

as the hydrochloric acid gets used up / there are fewer molecules of acid, so fewer collisions per second. ✓

or reaction goes to completion.

(e) A second reaction was carried out under exactly the same conditions as the first experiment, except that the calcium carbonate was crushed into smaller pieces. Sketch on the graph above a line to predict the results of this reaction. Label the line 'Exp2'.

[2]

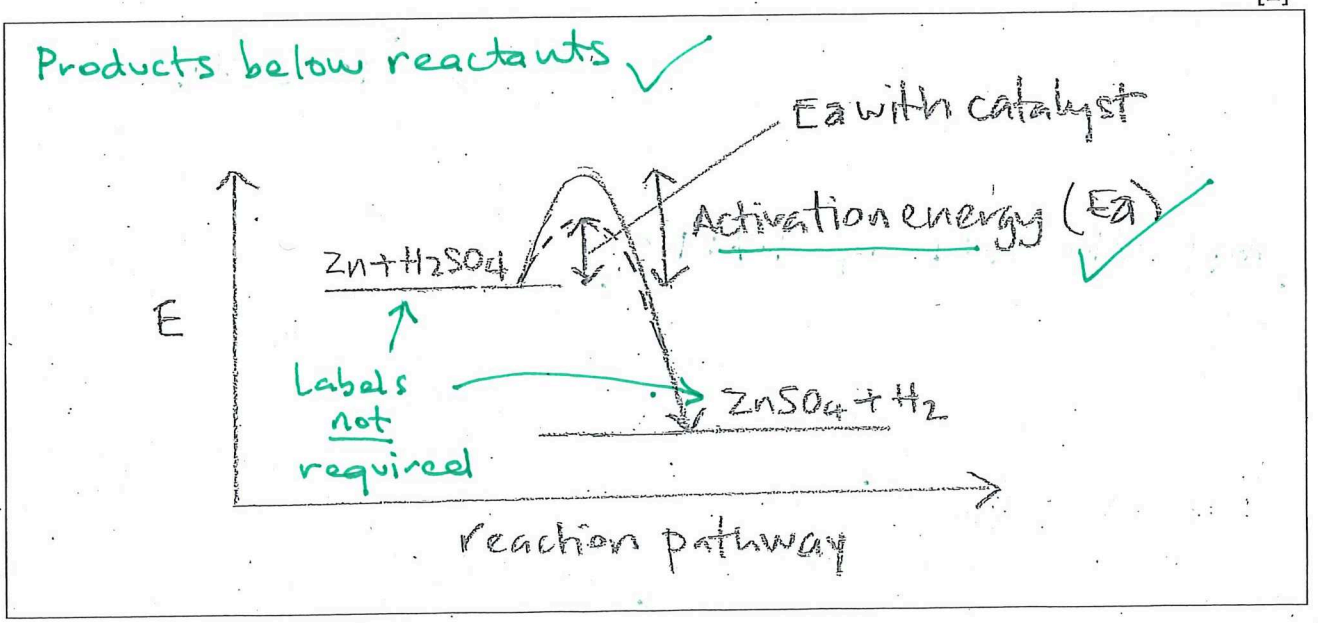
steeper initial gradient ✓ to same vol of gas ✓ (see graph)

3. (a) Zinc reacts with sulfuric acid. The reaction is exothermic.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

(i) Sketch a potential energy profile for this reaction; label the activation energy.

[2]



(ii) Copper catalyses the zinc and sulfuric acid reaction. Annotate your potential energy profile above with a dotted line to show the effect of a catalyst.

[1]

smaller Ea ✓ (shown with dotted line) but label not required

(b) Zinc also reacts with copper sulfate solution:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

(i) State one way in which the rate of reaction might be monitored. No practical details are required.

[1]

Colour change (blue to colourless) ✓
or Heat (of reaction)

(ii) Explain why increasing the concentration of the copper sulfate solution would increase the rate of reaction.

[2]

(Increasing the concentration increases the particles in the same volume) so (increases the frequency of the collisions/number of collisions per second.) ✓

(iii) Two experiments were carried out by reacting powdered zinc and then zinc shavings with copper sulfate solution (all other conditions were the same).
Reaction **A** took 92 seconds to go to completion, reaction **B** took 156 seconds to complete.
Calculate the relative average rates of these two reactions.

[1]

Relative rate $\propto \frac{1}{\text{time}}$

$\frac{1}{92} = 0.0109$ (1.09×10^{-2}) ✓ for both

$\frac{1}{156} = 0.00641$ (6.41×10^{-3})

(Any ratio A : B of 1.7 : 1.0)

(iv) Explain the effect of using powdered zinc rather than zinc shavings on the rate of reaction.

[2]

Powdered zinc increases the rate by increasing surface area. ✓
This increases the frequency of the collisions/number of collisions per second. ✓

Total Marks 28 (42 minutes)