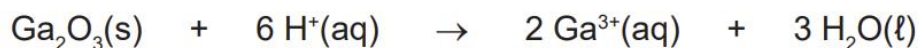


**Question 37****(12 marks)**

Gallium is present as gallium(III) oxide,  $\text{Ga}_2\text{O}_3$ , in the red mud waste from the processing of bauxite. The first step in its recovery from the red mud is the addition of hydrochloric acid,  $\text{HCl}(\text{aq})$ . This is represented by the equation below.



The results in the table below show the effect of temperature on the rate of gallium extraction from a red mud sample. Note that all of the other reaction conditions were constant.

Temperature (°C)	Reaction rate (as percentage of gallium extracted after four hours)
40	77
55	88
70	95
85	96
100	97

- (a) Explain the effect of temperature on reaction rate by applying collision theory. Support your explanation with an appropriate and clearly-labelled diagram. (7 marks)

---

---

---

---

---

---

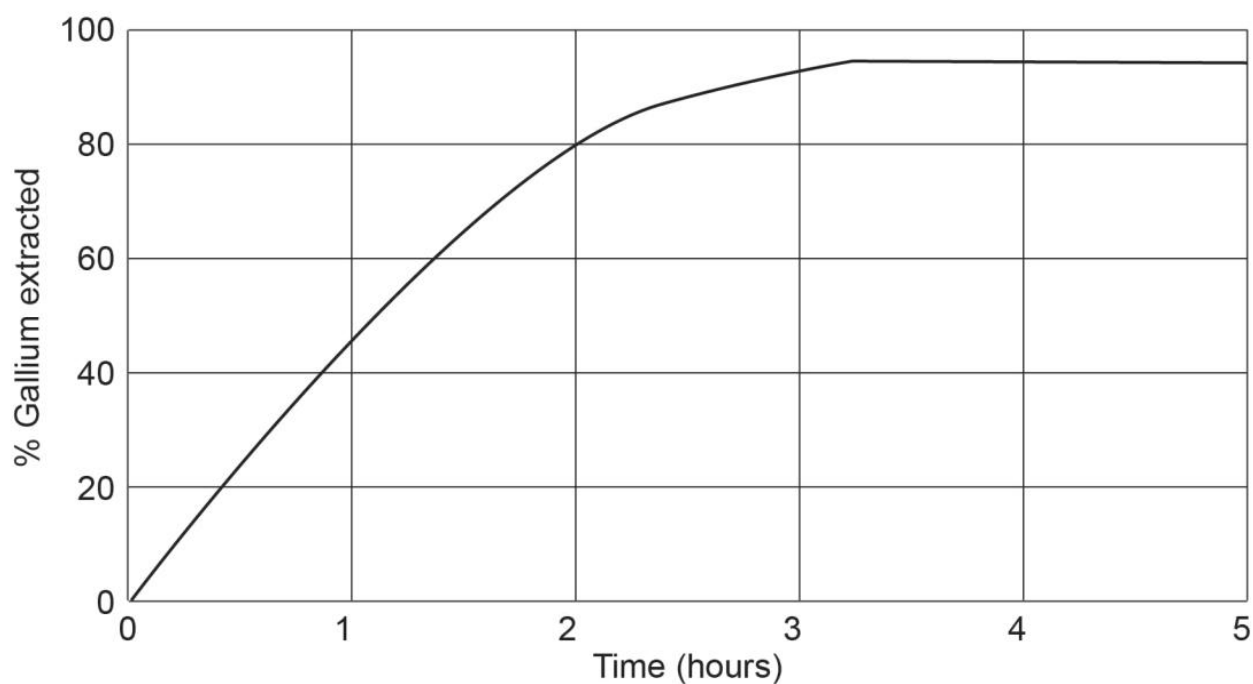
---

---

---

---

This graph shows how the amount of gallium extracted from red mud varies over time at a hydrochloric acid concentration of  $1.00 \text{ mol L}^{-1}$ .



- (b) Sketch on the graph above the result that would be obtained if the hydrochloric acid concentration was changed to  $2.00 \text{ mol L}^{-1}$ . (2 marks)

- (c) Use collision theory to justify the position and shape of the graph you sketched in part (b). Assume that all other reaction conditions were kept constant. (2 marks)

---

---

---

---

In a laboratory analysis, the red mud containing gallium(III) oxide, was mixed with excess hydrochloric acid solution. The concentration of gallium(III) ions,  $\text{Ga}^{3+}(\text{aq})$ , in the resulting solution was analysed and the percentage of gallium in the red mud was determined.

- (d) State **one** reason why the hydrochloric acid used in this analysis needed to be in excess. (1 mark)

---

---