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VCE Chemistry ¾
Rates of Reaction [2.6]
Homework Solutions

Admin Info & Homework Outline:

Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2 - Pg 11
Supplementary Questions	Pg 12 - Pg 21

Section A: Compulsory Questions (36.5 Marks)

Sub-Section [2.6.1]: Explain How Factors Increase Frequency of Collisions

Question 1 (1.5 marks)

State what happens to the rate of reaction for each of the following scenarios for the following reaction:

$$Ca(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_2(g)$$

Change	Effect on Rate of Reaction
a. More water is added to sulphuric acid.	rate [increases] / [decreases] / [stays same]
b. Calcium solid is ground into powder.	rate [increases] / [decreases] / [stays same]
c. Concentration of sulphuric acid is increased to 2.0 *M*.	rate [increases] / [decreases] / [stays same]

Question 2 (2 marks)

Explain how decreasing the volume of the aqueous mixture of the reaction between potassium hydroxide and phosphoric acid will affect the rate of reaction.

By decreasing volume, particles drift closer together, resulting in increased frequency of collisions (1). This will increase the frequency of successful collisions with the correct orientation, thus increasing the rate of reaction (2).

Space for Personal Notes

Question 3 (2 marks)

Finely grounded powder of potassium solid reacts with hydrochloric acid according to the following equation:

$$2K(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2(g)$$

Explain what would happen to the rate of reaction if lumps of potassium solid were to be used instead.

If lumps of potassium are used instead of ground powder, the surface area to volume ratio exposed to HCl would decrease (1). This results in a decreased frequency of total collisions and hence a decreased frequency of successful collisions with the correct orientation. This results in a decreased rate of reaction. (2)

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Sub-Section [2.6.2]: Explain How Temperature & Catalyst Affect the Proportion of Successful Collisions

Question 4 (1 mark)

Sue is investigating a reaction between two gas reagents in a reaction vessel. She heats the beaker up to 60°C. Predict which of the following will have the greatest impact on the rate of reaction when temperature is increased.

A. The increase in the total number of collisions.

B. The increase in the mean energy per collision between reactant particles.

C. The gas particles will increase in size due to a temperature increase, causing a pressure increase in the vessel.

D. The reaction vessel shrinking in size due to the exposure to higher temperatures.

Question 5 (3 marks)

Adeeb sets up a reaction between potassium iodide (KI) and hydrochloric acid (HCl) in a reaction vessel. Given that Adeeb increases the temperature of the reaction vessel, predict the effect on the reaction rate.

By increasing the temperature of the vessel, the mean kinetic energy of reactant particles will increase resulting in increased frequency in total collisions as particles (1). Further, a greater proportion of successful collisions will occur where reactant particles will collide with sufficient force to overcome the activation energy at the correct orientation (2). This causes a greater rate of reaction (3).

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Question 6 (1 mark)

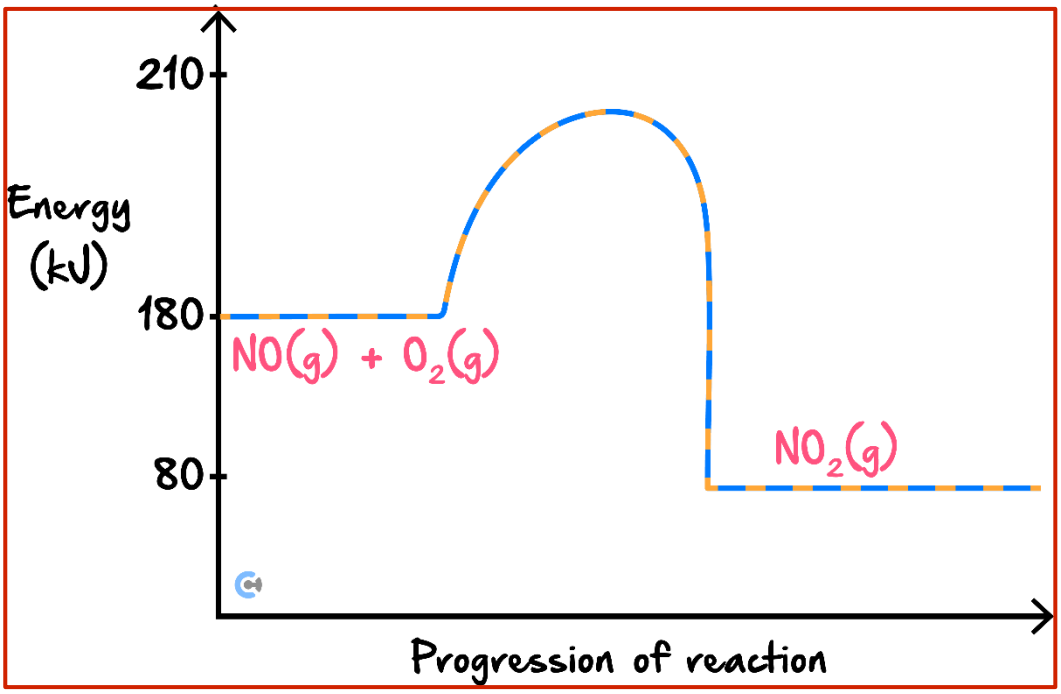
Nitric monoxide is added to oxygen gas in a reaction vessel.

Justin decreases the temperature in the reaction vessel from 35°C to 10°C.

a. State and justify what happens to the rate of reaction.

By decreasing the temperature of the vessel, the mean kinetic energy of reactant particles will decrease resulting in decreased frequency in total collisions as particles (1). Further, a lower proportion of successful collisions will occur where reactant particles will collide with sufficient force to overcome the activation energy at the correct orientation (2). This causes a lower rate of reaction (3).

b. The energy profile for the original equation is provided before. Draw the new energy profile for the reaction occurring at a lower temperature on the same graph. (1 mark)



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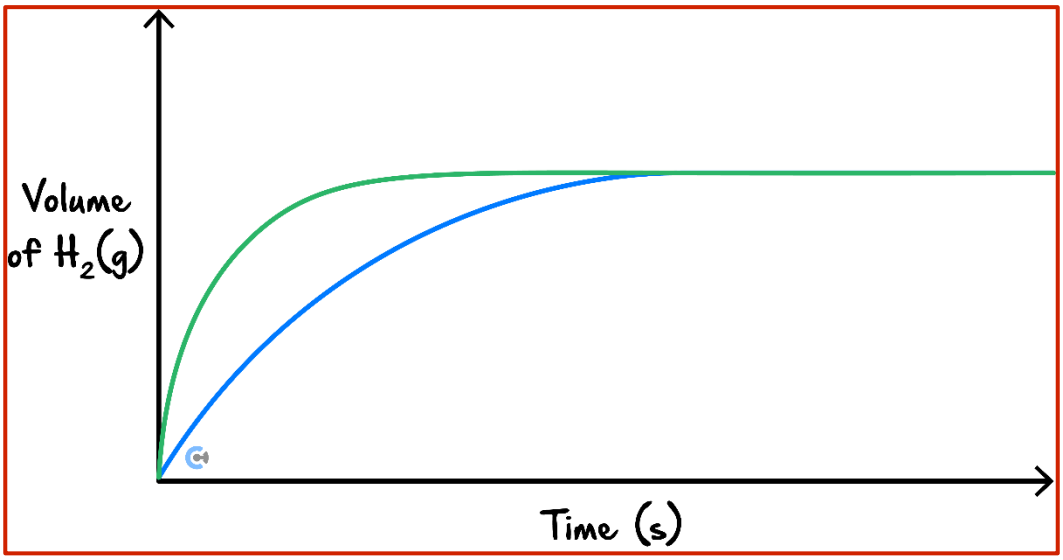
Sub-Section [2.6.3]: Graph Differences in Rate & Yield

Question 7 (3 marks)

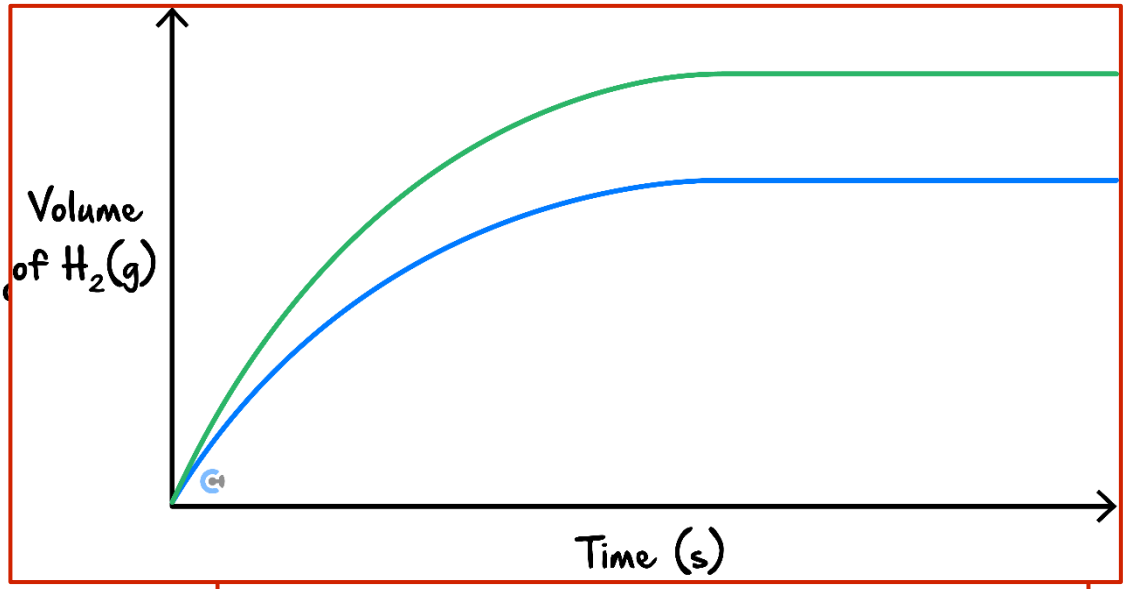
A graph has been provided below, showing how hydrogen gas is formed from a reaction between water and 2.0 g magnesium metal.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

a. Draw with a dotted line, a curve which represents what happens when the temperature is increased on the graph below. (1 mark)



b. Draw with a solid line, a curve which represents what happens when the mass of magnesium is increased from 2.0 g to 4.0 g on the curve below. (2 marks)



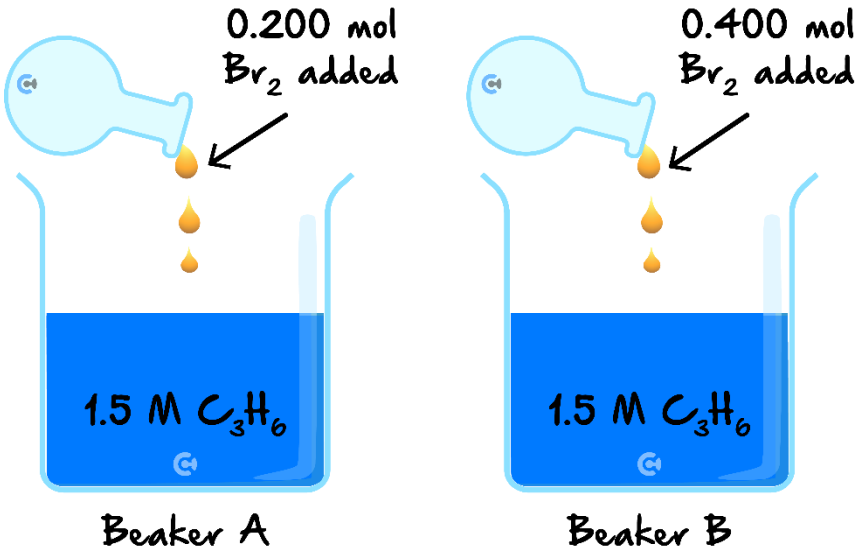
1 mark for increased yield, 1 mark for the same gradient for the curve.

Question 8 (7 marks)

Angel adds bromine, a brown liquid, to two beakers containing the same volume of 1.5 M propene. In beaker A, Angel adds 0.200 mol of bromine liquid whereas in beaker B, 0.400 mol is added.

The chemical equation between propene and bromine liquid has been provided below:

$$C_3H_6(l) + Br_2(l) \rightarrow C_3H_6Br_2(l)$$



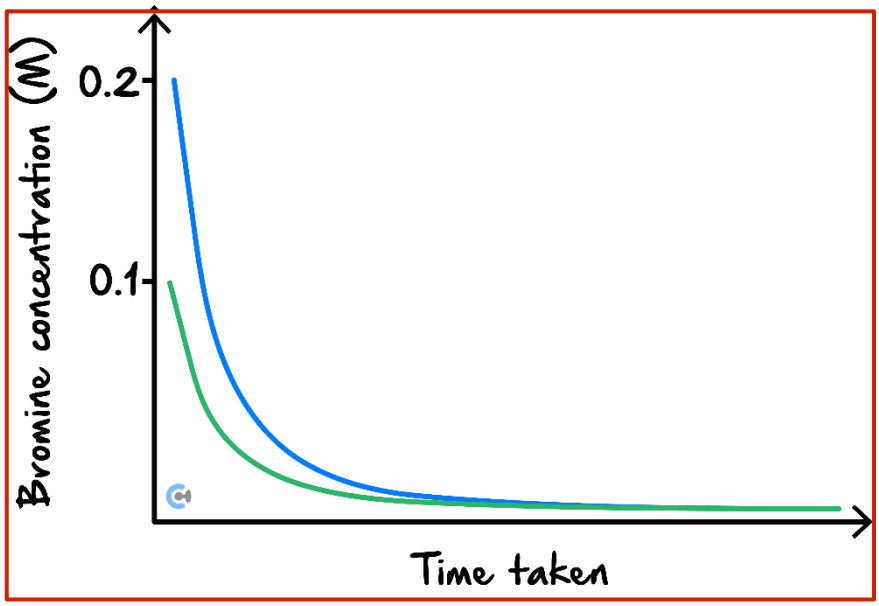
a. Predict and justify which beaker will have the greatest rate of reaction. (3 marks)

Beaker *B* (1). As the concentration of Bromine liquid is greater in the beaker *B*, there is a greater frequency in total collisions than in Beaker *A* (2). Hence, there is a greater frequency of successful collisions, where particles collide with sufficient energy to overcome activation energy at the correct orientation, resulting in a greater rate of reaction in Beaker *B* than in Beaker *A* (3).

b. Hence, explain which beaker will require the **most** amount of time for the colour to fade. (2 marks)

Beaker *B* - as more moles of Br_2 is added and it is the limiting reagent, more Br_2 is required to be reacted before the colour fades (1). Even with the faster rate of reaction beaker *B* will still take a longer time to react. (2)

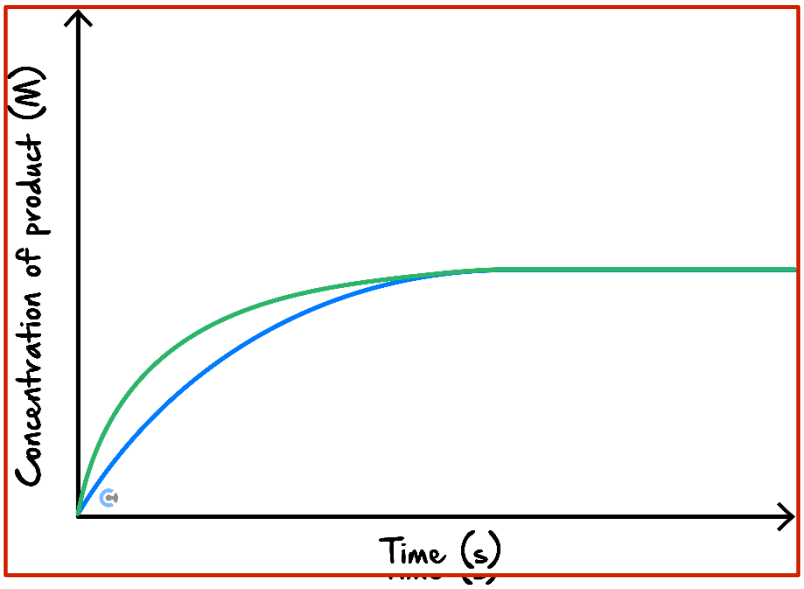
c. Angel graphs the bromine concentration vs time graph for beaker *B*. Given that beaker *A* and *B* are 2.0 *L*, on the graph below, draw the curve for beaker *A*. (2 marks)



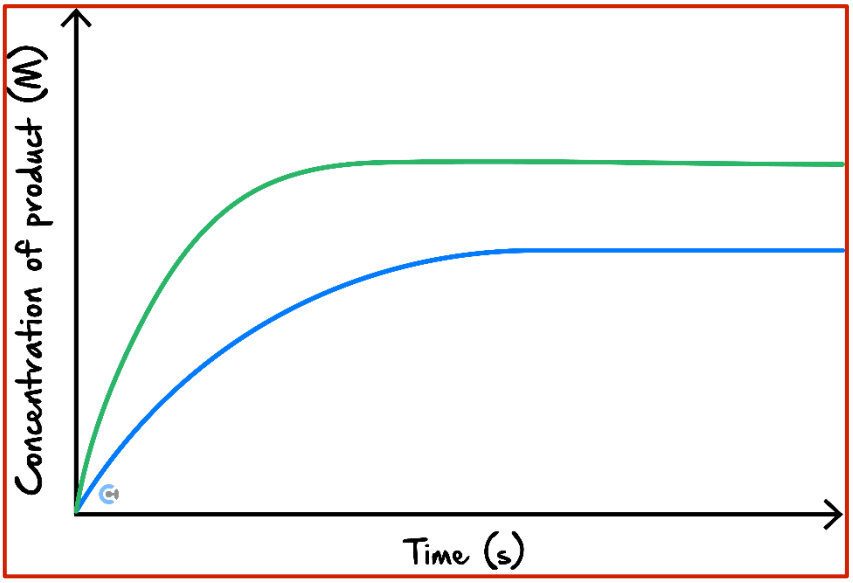
Question 9 (4 marks)

In the graphs below:

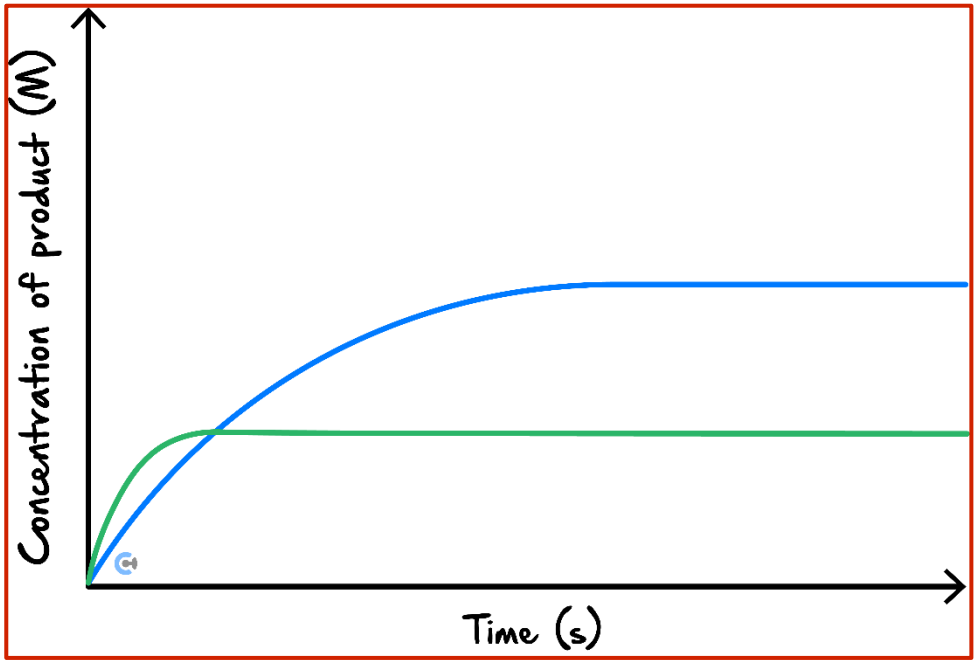
a. Draw a curve if a catalyst was added to the reaction. (1 mark)



b. If a reactant was doubled in concentration. (1 mark)



c. If a catalyst was added, but the reactant concentration was halved. (2 marks)



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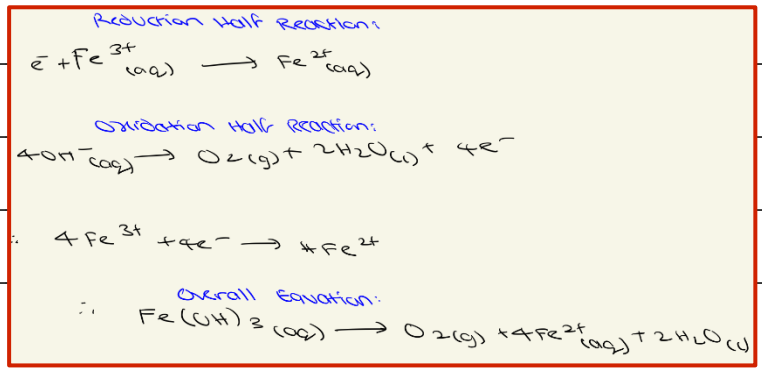
Sub-Section: The 'Final Boss'

Question 10 (12 marks)

A reaction occurs between a 100 mL beaker of 1.0 M iron (III) chloride and a 100 mL beaker of 1.0 M sodium hydroxide at 25℃.

a. Write the balanced overall reaction which takes place. (2 marks)



b. Devise a method to measure the rate of reaction. (2 marks)

Oxygen gas is produced, so gas will accumulate (1). Use a gas syringe, measure the volume of gas produced per unit time to find the rate of reaction (2).

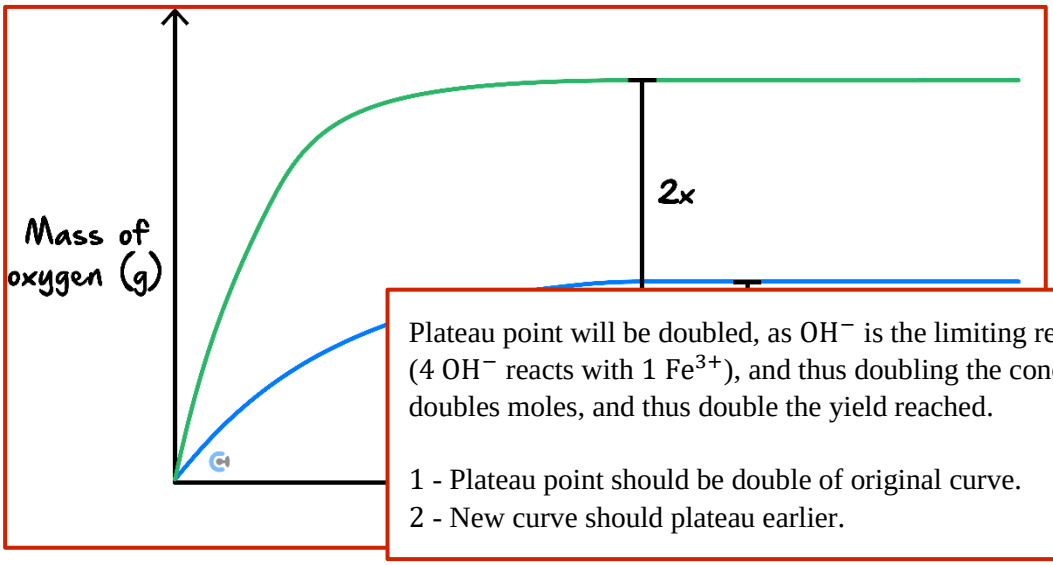
c. The graph for the mass of oxygen gas produced is shown below.

i. The concentration of sodium hydroxide is then doubled to 2.0 *M* with the same volume.

Explain the effect this change has on the rate of formation of oxygen gas, referring to collision theory. (2 marks)

When the concentration of sodium hydroxide is doubled, the total number of reactant collisions will increase in frequency. Hence, the frequency of successful collisions will increase where particles collide with sufficient force to overcome activation energy at correct orientation (1). This results in oxygen gas formation rate increasing as rate of reaction increases (2).

ii. On the graph provided below, show how this would change the mass of oxygen gas formed. Explain the reason for this shape. (3 marks)



Plateau point will be doubled, as OH^- is the limiting reagent (4 OH^- reacts with 1 Fe^{3+}), and thus doubling the conc. of OH^- doubles moles, and thus double the yield reached.

1 - Plateau point should be double of original curve.
2 - New curve should plateau earlier.

d. On a separate occasion, the temperature of the whole mixture is decreased to 15°C. Explain the expected effect on the time taken for the same mass of oxygen gas to form. (3 marks)

By decreasing the temperature of the vessel, the mean kinetic energy of reactant particles will decrease resulting in decreased frequency in total collisions as particles (1). Further, a lower proportion of successful collisions will occur where reactant particles will collide with sufficient force to overcome the activation energy at correct orientation (2). This causes a lower rate of reaction and hence more time will be taken for the same mass of oxygen gas to be formed (3).

Section B: Supplementary Questions (32.5 Marks)

Sub-Section [2.6.1]: Explain How Factors Increase Frequency of Collisions

Question 11 (1.5 marks)

State what happens to the rate of reaction for each of the following scenarios for the following reaction:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(s) + H_2(g)$$

Change	Effect on Rate of Reaction
a. The mass of magnesium metal added is halved.	rate [increases] / [decreases] / [stays same]
b. Magnesium solid is added in clumps.	rate [increases] / [decreases] / [stays same]
c. Concentration of sulphuric acid is decreased to 1.5 M.	rate [increases] / [decreases] / [stays same]

Question 12 (2 marks)

Explain how increasing the volume of the aqueous mixture of the reaction between potassium hydroxide and sulphuric acid will affect the rate of reaction.

By increasing volume, particles drift further apart, resulting in decreased frequency of collisions (1). This will decrease the frequency of successful collisions with correct orientation, thus decreasing rate of reaction (2).

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Question 13 (2 marks)

Lumps of sodium solid react with hydrochloric acid according to the following equation:

$$2Na(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2(g)$$

Explain what would happen to the rate of reaction if finely grounded powder of sodium solid were to be used instead.

If grounded powder of sodium is used instead of lumps, the surface area to volume ratio exposed to HCl would increase (1). This results in an increased frequency of total collisions and hence an increased frequency of successful collisions with correct orientation. This results in an increased rate of reaction. (2)

Question 14 (4 marks)

Eric is preparing two solutions:

Solution 1: Adding 100 ml Silver Nitrate (1.0 M) to 200 ml Sodium Chloride (2.0 M).

Solution 2: Adding 100 ml Silver Nitrate (1.0 M) to 200 ml Sodium Chloride (3.0 M).

Assuming all other conditions are controlled, which solution will have the greater rate of reaction? Explain using Collision Theory.

Solution 2. (1)
Solution 2 contains more concentrated species (1.0 M and 3.0 M), indicating less availability of water molecules in comparison to solution 1 (2). As there is less water volume in solution 2, reactant particles (Ag^+ & Na^+) drift closer together resulting in an increased frequency of collisions (3). Consequently, the frequency of successful collisions will increase, resulting in an increased rate of reaction (4).
Reactants must be named explicitly for 3rd mark.

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Sub-Section [2.6.2]: Explain How Temperature & Catalyst Affect the Proportion of Successful Collisions

Question 15 (1 mark)

Predict which of the following will have the greatest impact on the rate of reaction when temperature is decreased.

A. The decrease in total number of collisions.

B. The decrease in the mean energy per collision between reactant particles.

C. The gas particles will decrease in size due to a temperature decrease, causing a pressure decrease in the vessel.

D. The reaction vessel shrinking in size due to the exposure to decreased temperatures.

Question 16 (3 marks)

Rehansa sets up a reaction between Sodium iodide (NaI) and hydrochloric acid (HCl) in a reaction vessel. Given that Rehansa decreases the temperature of the reaction vessel, predict the effect on the reaction rate.

By decreasing the temperature of the vessel, the mean kinetic energy of reactant particles will decrease resulting in decreased frequency in total collisions as particles (1). Further, a lower proportion of successful collisions will occur where reactant particles will collide with sufficient force to overcome the activation energy at correct orientation (2). This causes a lower rate of reaction (3).

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Question 17 (1 mark)

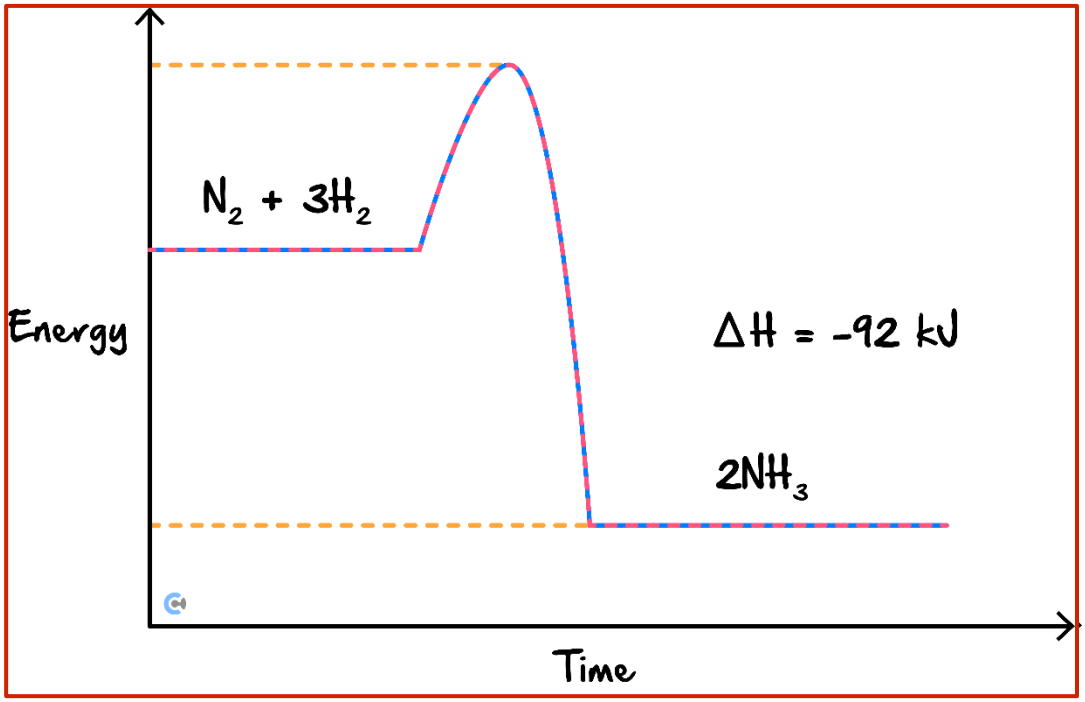
Nitrogen gas is added to a reaction vessel containing hydrogen gas, forming ammonia gas.

Aaliah decreases the temperature in the reaction vessel from 35°C to 10°C.

a. State and justify what happens to the rate of reaction.

By decreasing the temperature of the vessel, the mean kinetic energy of reactant particles will decrease resulting in decreased frequency in total collisions as particles (1). Further, a lower proportion of successful collisions will occur where reactant particles will collide with sufficient force to overcome the activation energy at the correct orientation (2). This causes a lower rate of reaction (3).

b. The energy profile for the original equation is provided before. Draw the new energy profile for the reaction occurring at a lower temperature on the same graph. (1 mark)



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Question 18 (3 marks)

To ensure bread dough rises, it is recommended that the dough is left at room temperature rather than in the fridge. Explain this phenomenon using the collision theory.

At warmer temperatures (such as in the room rather than in the fridge), the mean kinetic energy of particles in the dough (such as yeast and sugars) will be greater, resulting in a greater frequency of collisions (1). Further, a greater proportion of successful collisions will occur where particles collide with sufficient force to overcome the activation energy at correct orientation (2). Hence, there is a greater rate of reaction, meaning that the dough will rise faster (3).

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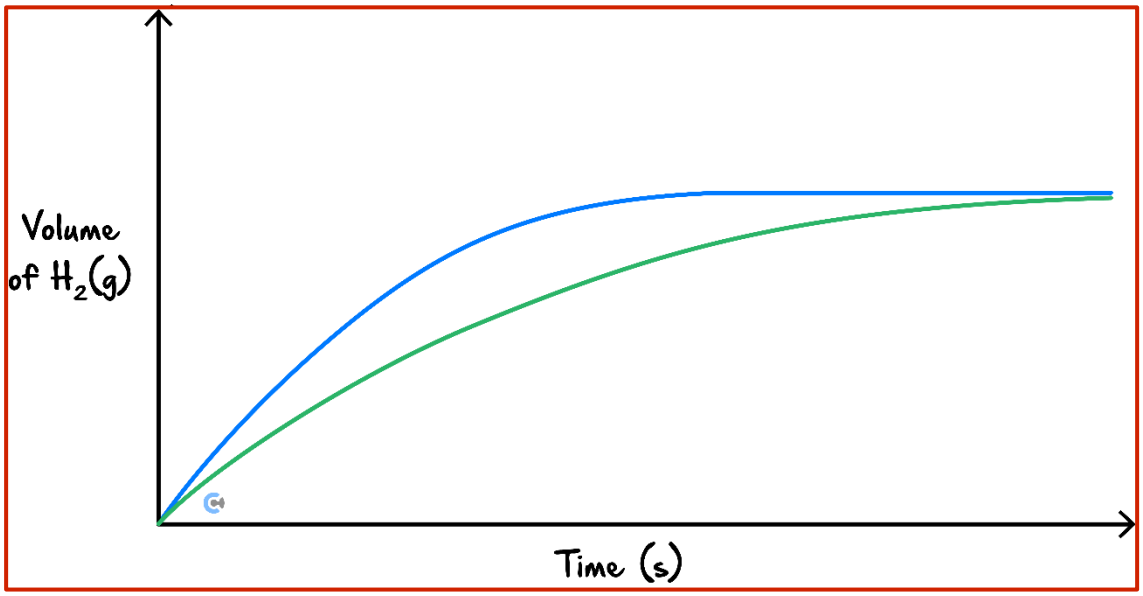
Sub-Section [2.6.3]: Graph Differences in Rate & Yield

Question 19 (3 marks)

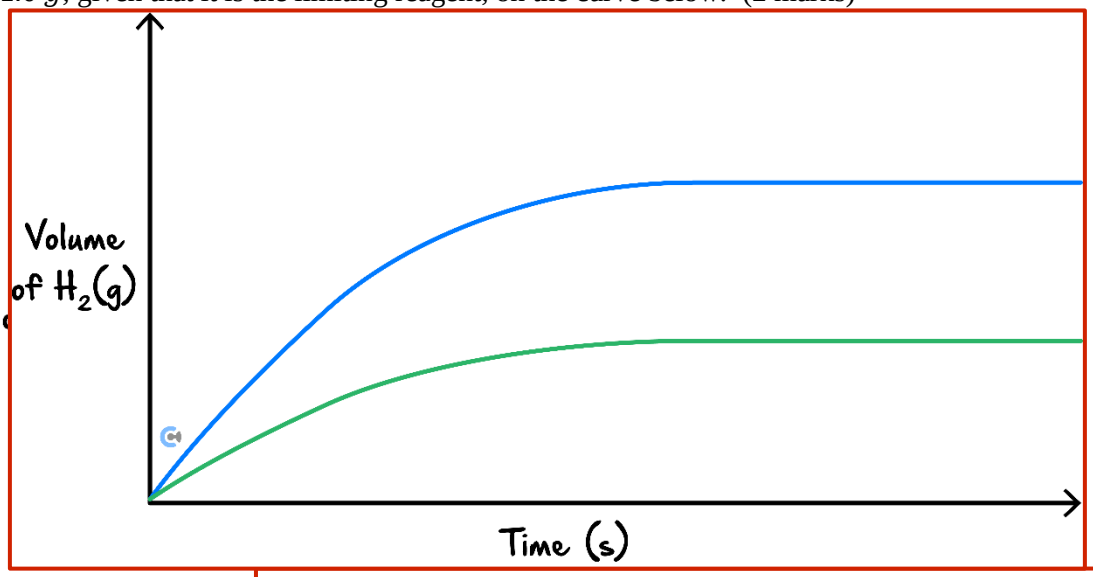
A graph has been provided below, showing how hydrogen gas is formed from a reaction between water and 2.0 g magnesium metal.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

a. Draw with a dotted line, a curve which represents what happens when the temperature is decreased on the graph below. (1 mark)



b. Draw with a solid line, a curve which represents what happens when the mass of magnesium is decreased from 2.0 g to 1.0 g, given that it is the limiting reagent, on the curve below. (2 marks)

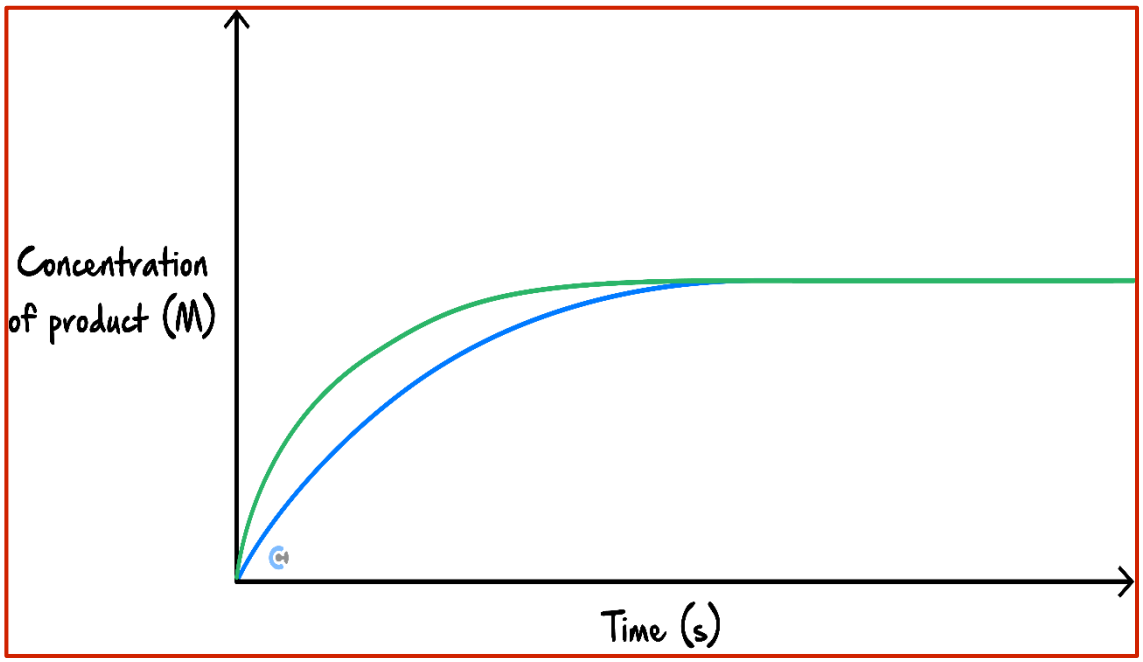


1 mark for decreased yield, 1 mark for the same gradient for the curve.

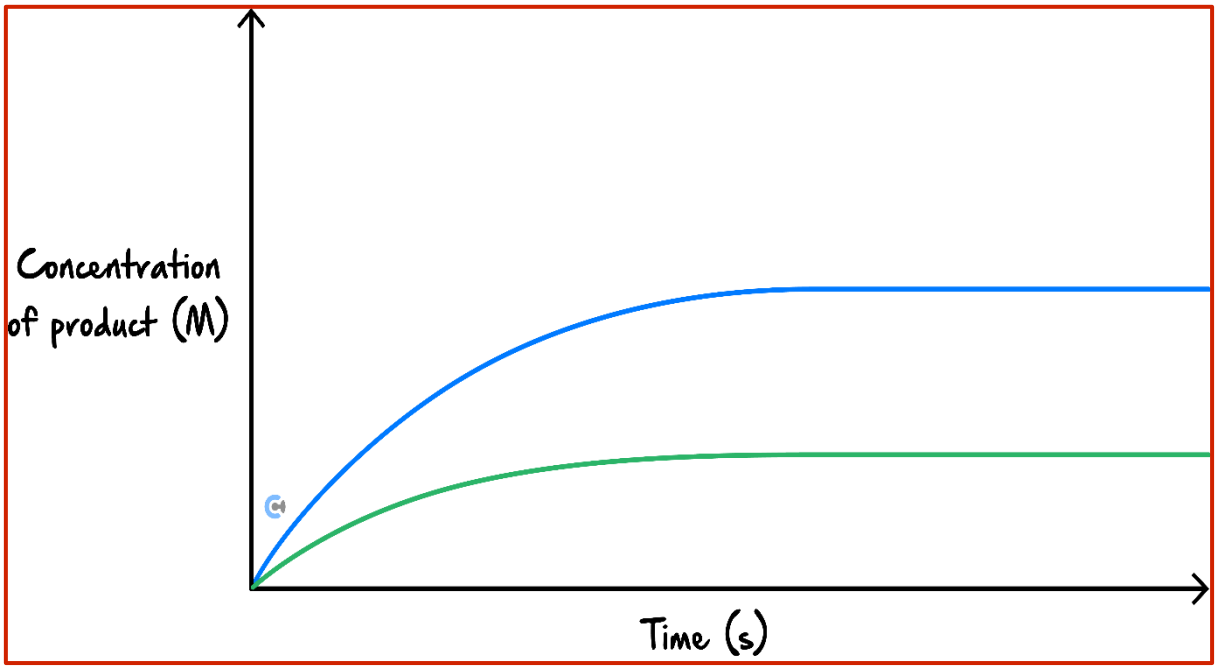
Question 20 (2 marks)

In the graphs below:

a. Draw a curve if the reactant was crushed into a fine powder instead of added as larger pellets. (1 mark)



b. If a reactant was halved in concentration. (1 mark)



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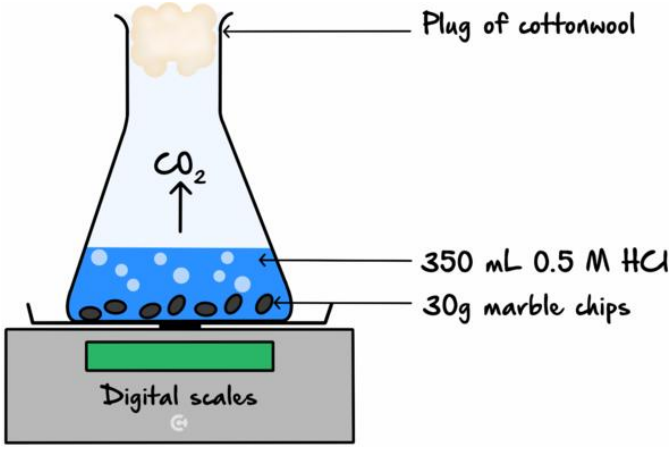
Question 21 (10 marks)

A student set up an experiment to test the effect of different factors on the rate and extent of the reaction between a strong acid and marble chips (Calcium Carbonate, $CaCO_3$). In each trial, the mass of the flask and its contents was measured every 30 seconds, from the instant the reactants were mixed.

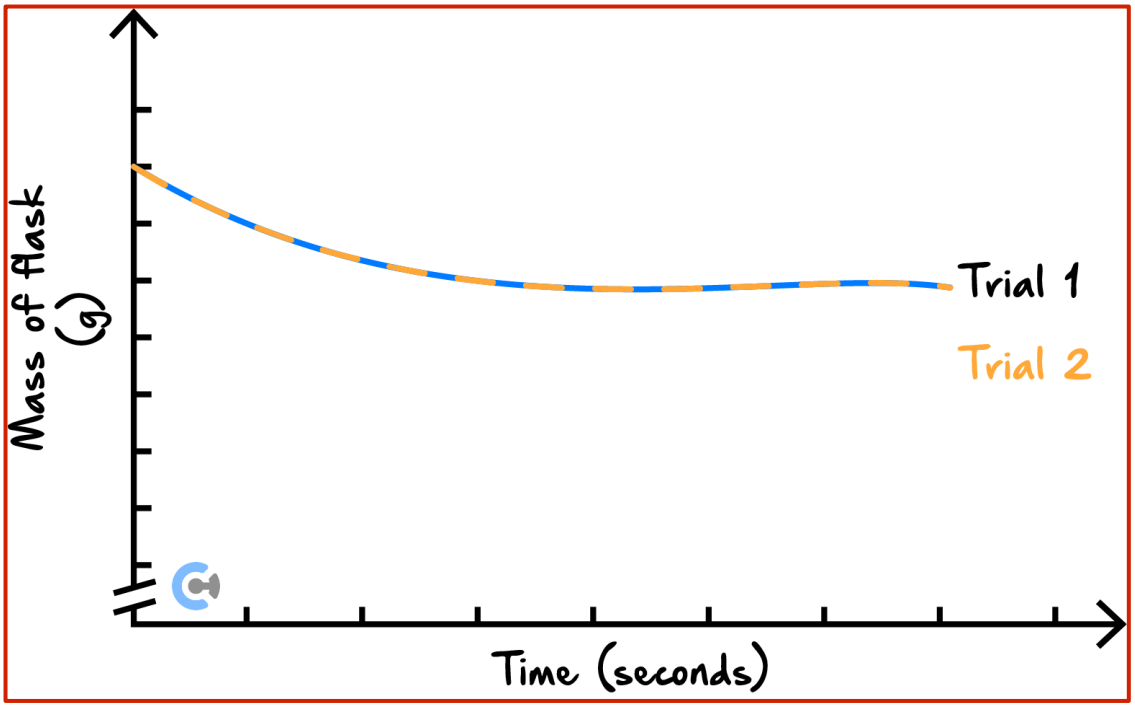
The strong acid used was Hydrochloric acid, HCI. The equation for the reaction is as follows.

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

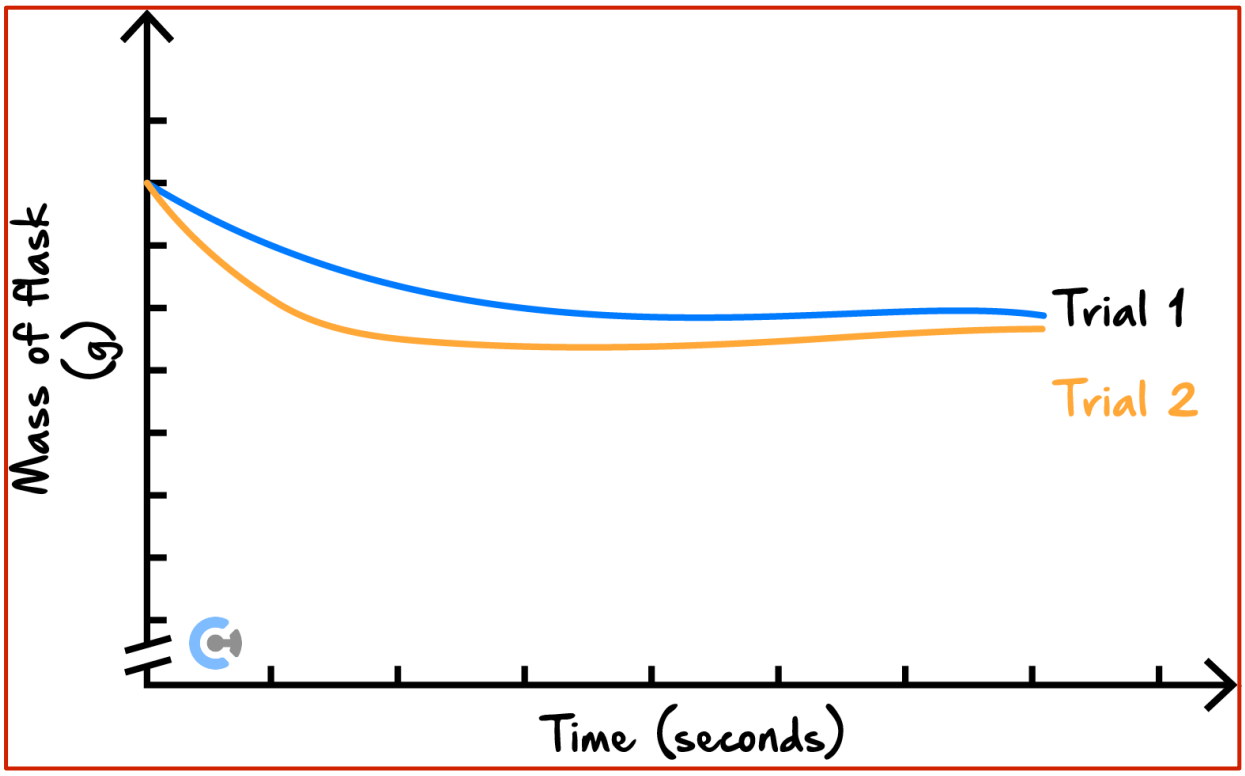


The student then goes about making several changes to the experimental design. Assume trial 1 is the condition of the experiment as shown above.

a. First, the student adds 350 ml of Nitric acid (Trial 2) instead of 350 ml of HCl (Trial 1). On the same set of axes, draw the two trials. (2 marks)

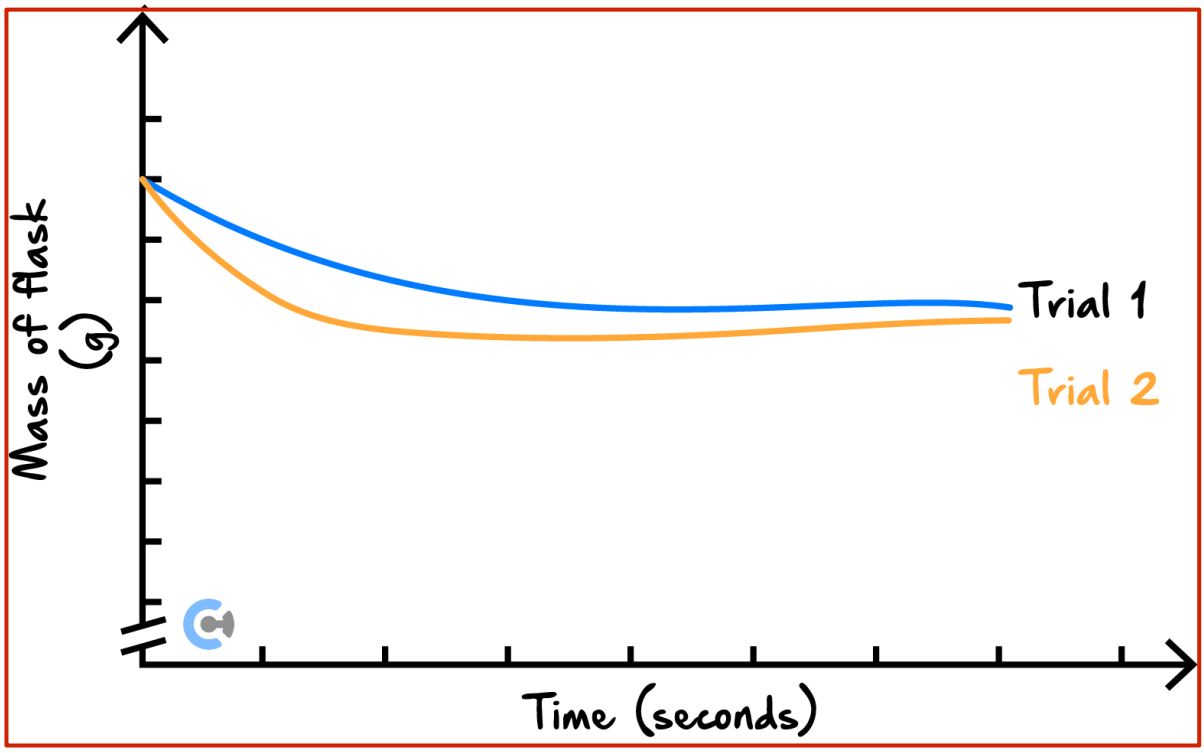


b. The student then crushes the 30 *g* of marble chips and conducts another trial. Draw what would be expected from the trial on the graph below. (2 marks)



c. The student then decides to add MnO_2 and conducts another trial.

i. Draw what would be expected from the trial below. (2 marks)



ii. Explain why this graph is observed. (4 marks)

MnO_2 provides an alternative chemical reactionary pathway with a decreased activation energy (1). Hence, although the frequency of collisions is the same, a greater proportion of successful collisions occur (2), where reactant Calcium Carbonate and HCl particles will collide with sufficient force to overcome the lower activation energy, thereby increasing the rate of reaction (3). This results in the curve of Trial 2 plateauing quicker than in the absence of a catalyst (4).

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