



Website: contoureducation.com.au | Phone: 1800 888 300

Email: hello@contoureducation.com.au

VCE Chemistry $\frac{3}{4}$
AOS 2 Revision II [2.10]
Contour Check



Contour Check

[2.6] - Rates of Reaction (Checkpoints)

- [2.6.1] - Explain How Factors Increase Frequency of Collisions Pg 3-4
- [2.6.2] - Explain How Temperature & Catalyst Affect the Proportion of Successful Collisions Pg 5-7
- [2.6.3] - Graph Differences in Rate & Yield Pg 8-12

[2.7] - Equilibrium (Checkpoints)

- [2.7.1] - Write Equilibrium Constant Expression & Find its Value (Including Units) Pg 13-17
- [2.7.2] - Identify the Extent of Reaction Pg 18-19
- [2.7.3] - Find Equilibrium Constant When Equation is Changed Pg 20-21
- [2.7.4] - Apply Q_c To find the Direction of the Equilibrium Shift Pg 22-23
- [2.7.5] - Apply RICE Tables to Find K_c Pg 24-28

[2.8] - Le Chatelier's Principle (Checkpoints)

- [2.8.1] - Explain Effects of Addition/Removal of Substances or Pressure/Volume Changes on Equilibrium System Pg 29-31
- [2.8.2] - Graph Effects of Addition/Removal of Substances or Pressure/Volume Changes on Equilibrium System Pg 32-34
- [2.8.3] - Apply Partial Opposition during Equilibrium to the Effects on Amount, Concentration & Colour of Substance Pg 35-37

[2.9] - Rate Yield Conflict (Checkpoints)

- [2.9.1] - Explain Effects of Temperature, Inert Gas or Catalyst on Equilibrium System Pg 38-39
- [2.9.2] - Graph Effects of Temperature, Inert Gas Catalyst on Equilibrium Systems Pg 40
- [2.9.3] - Find the Change Made to System from Equilibrium Graph Pg 41
- [2.9.4] - Find Equilibrium Constant Changes Due to Temperature Pg 42-43
- [2.9.5] - Find Optimum Operating Conditions in All Circumstances such as the Rate-Yield Conflict Pg 44-45

[2.6 - 2.9] - Overall (VCAA Qs) Pg 46-64

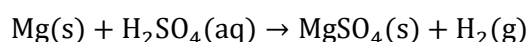
Section A: [2.6] - Rates of Reaction (Checkpoints) (32.5 Marks)

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:



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 2 (2 marks)

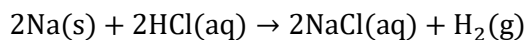


Explain how increasing the volume of the aqueous mixture of the reaction between potassium hydroxide and sulphuric acid will affect the rate of reaction.

Space for Personal Notes

Question 3 (2 marks)


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



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

Question 4 (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.

Space for Personal Notes



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

Question 5 (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 6 (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.

Space for Personal Notes



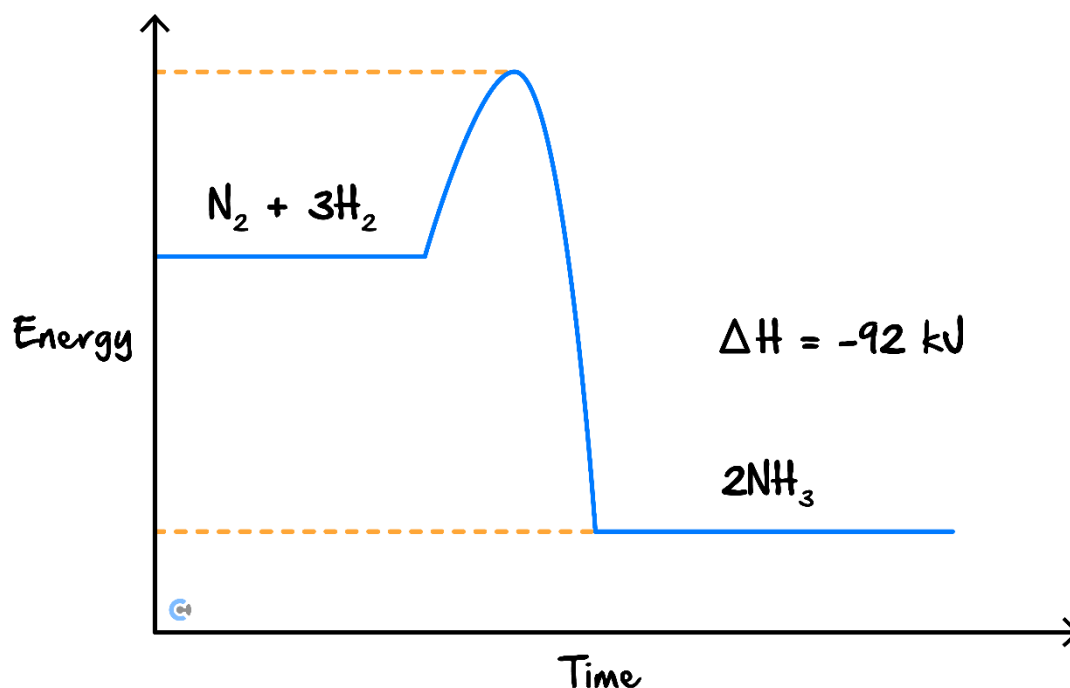
Question 7 (1 mark)

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.

- 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)



Space for Personal Notes

Question 8 (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.

Space for Personal Notes

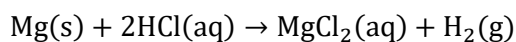
Sub-Section [2.6.3]: Graph Differences in Rate & Yield



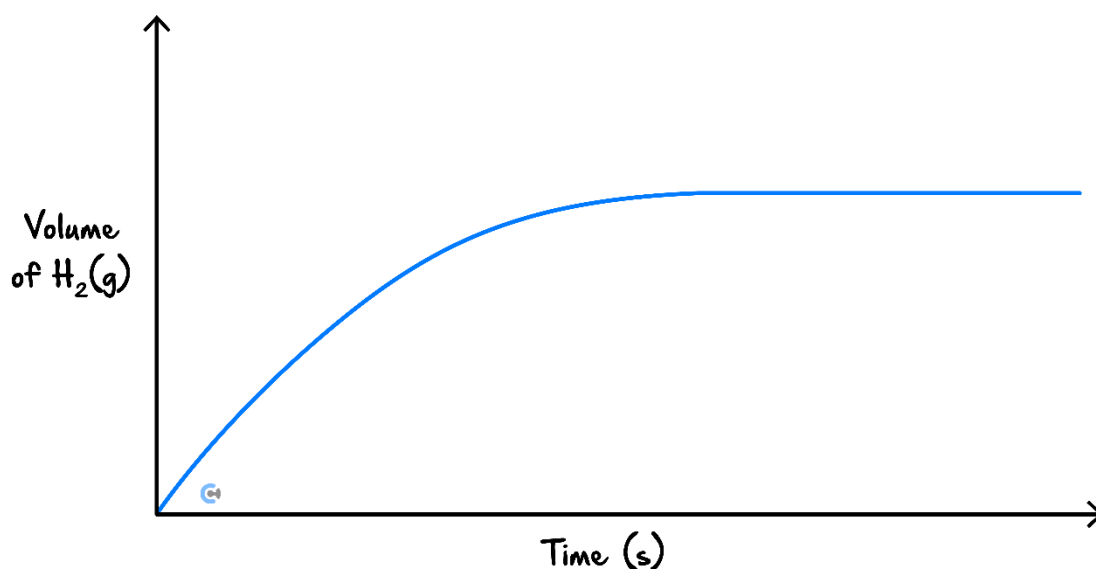
Question 9 (3 marks)



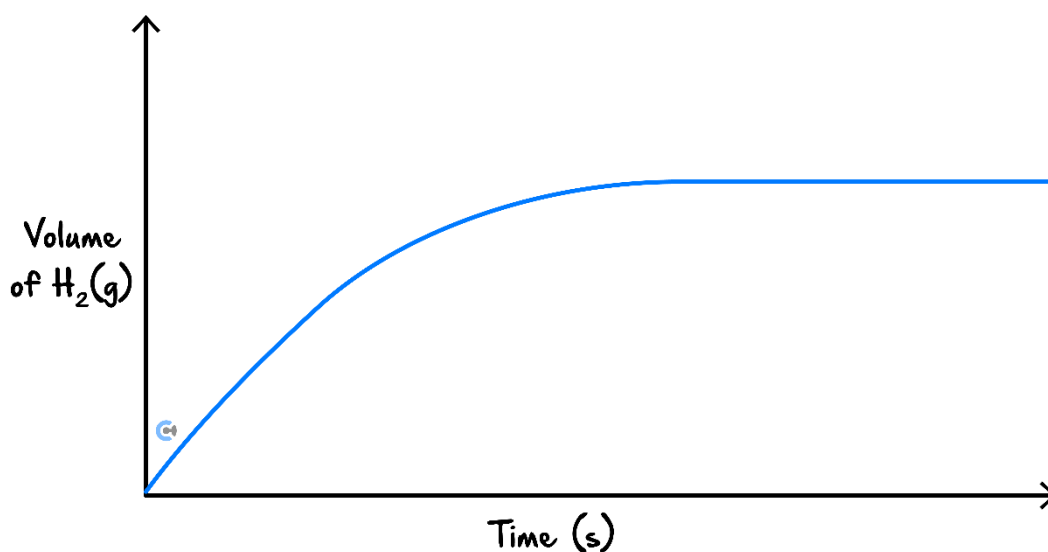
A graph has been provided below, showing how hydrogen gas is formed from a reaction between water and 2.0 g magnesium metal.



- 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)

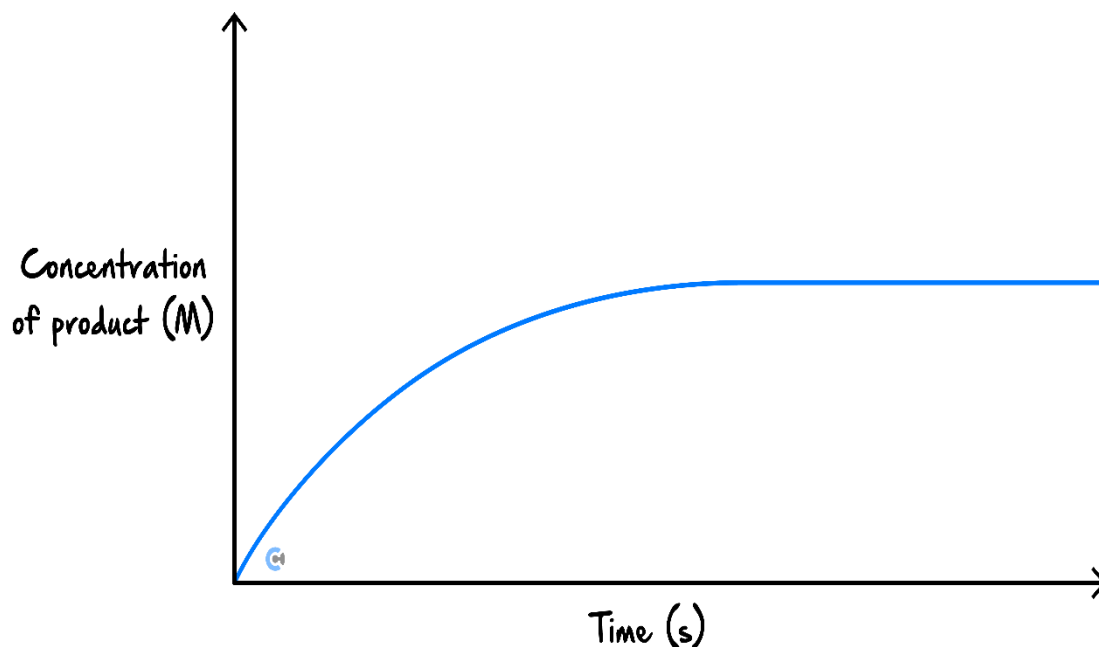




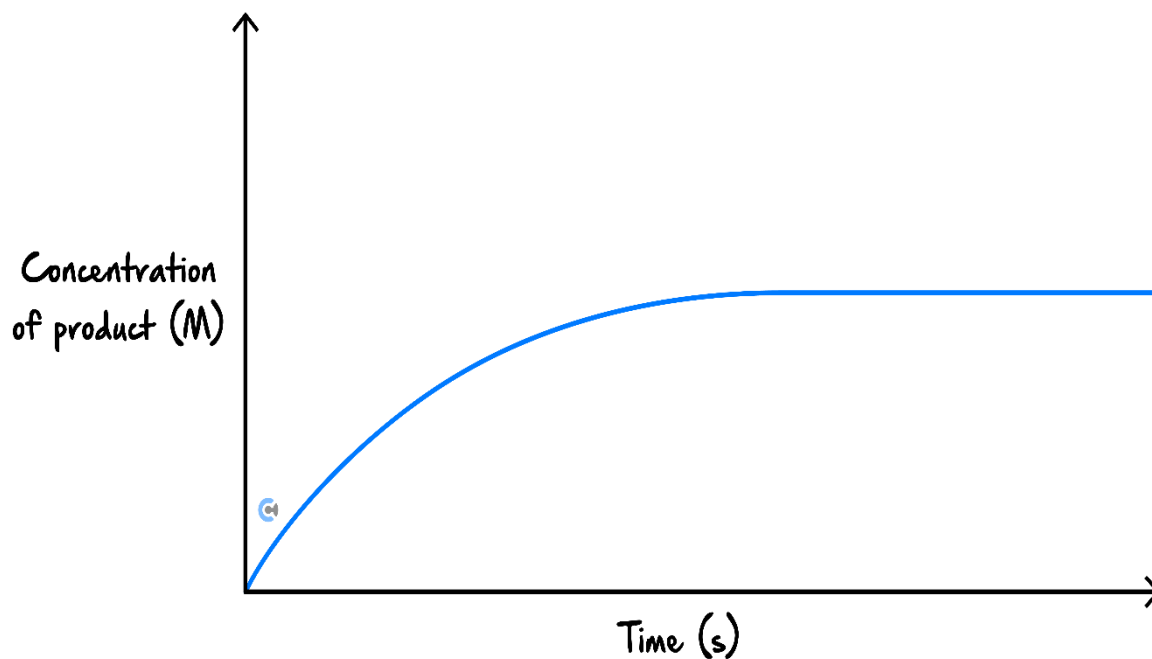
Question 10 (2 marks)

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)



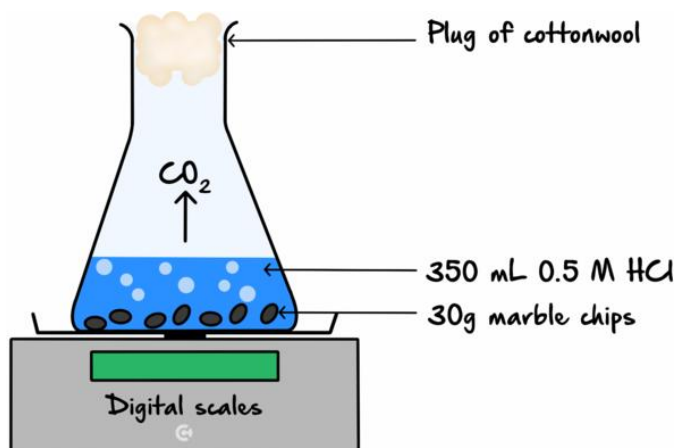
Space for Personal Notes



Question 11 (10 marks)

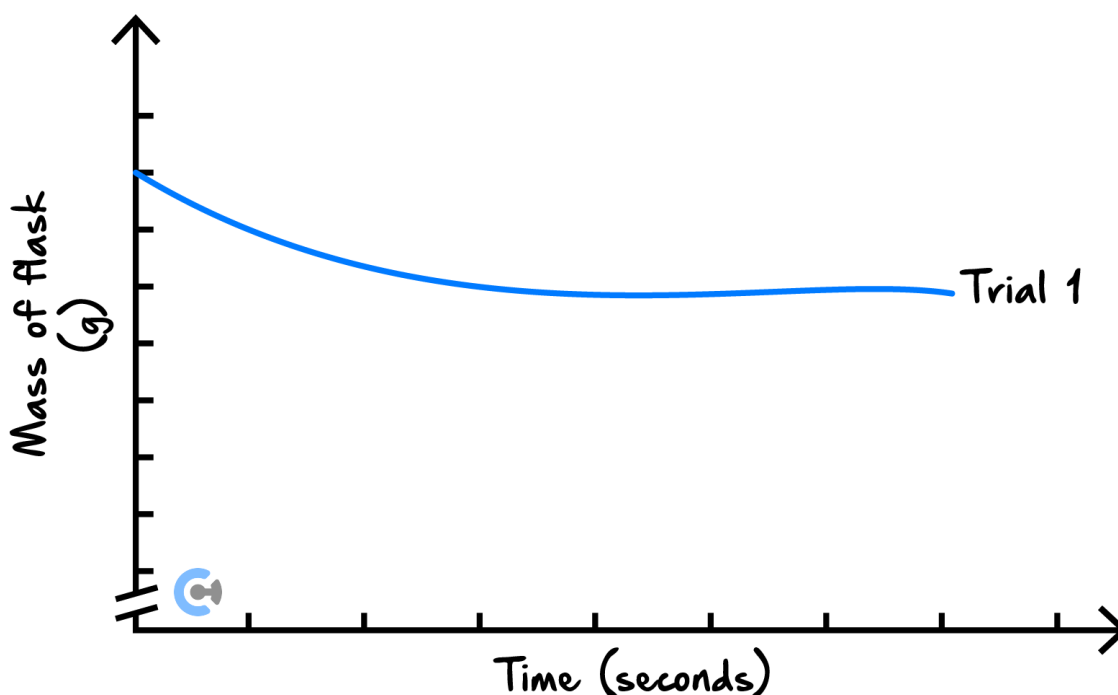
A student set up an experiment to test the effect of different factors on the rate and extent of the reaction between a strong acid and marble chips (Calcium Carbonate, CaCO_3). In each trial, the mass of the flask and its contents was measured every 30 seconds, from the instant the reactants were mixed.

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

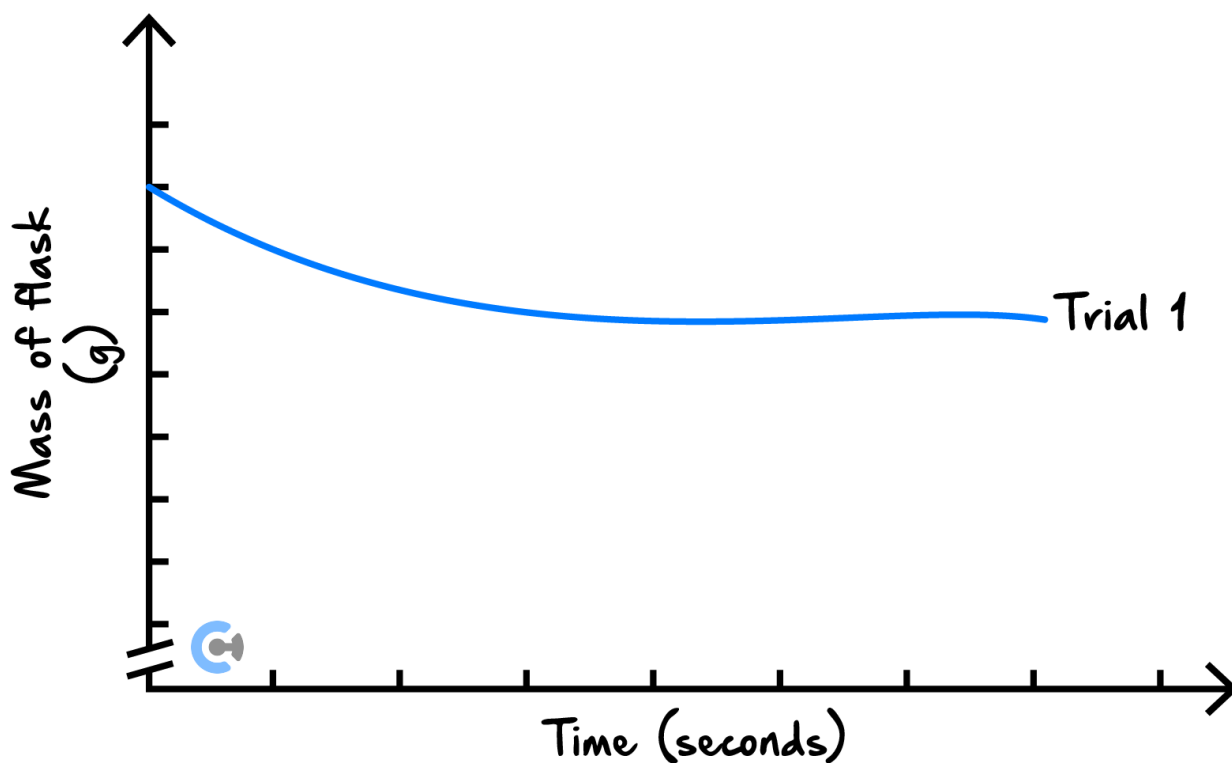


The student then goes about making several changes to the experimental design. Assume trial 1 is the condition of the experiment as shown above.

- 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)

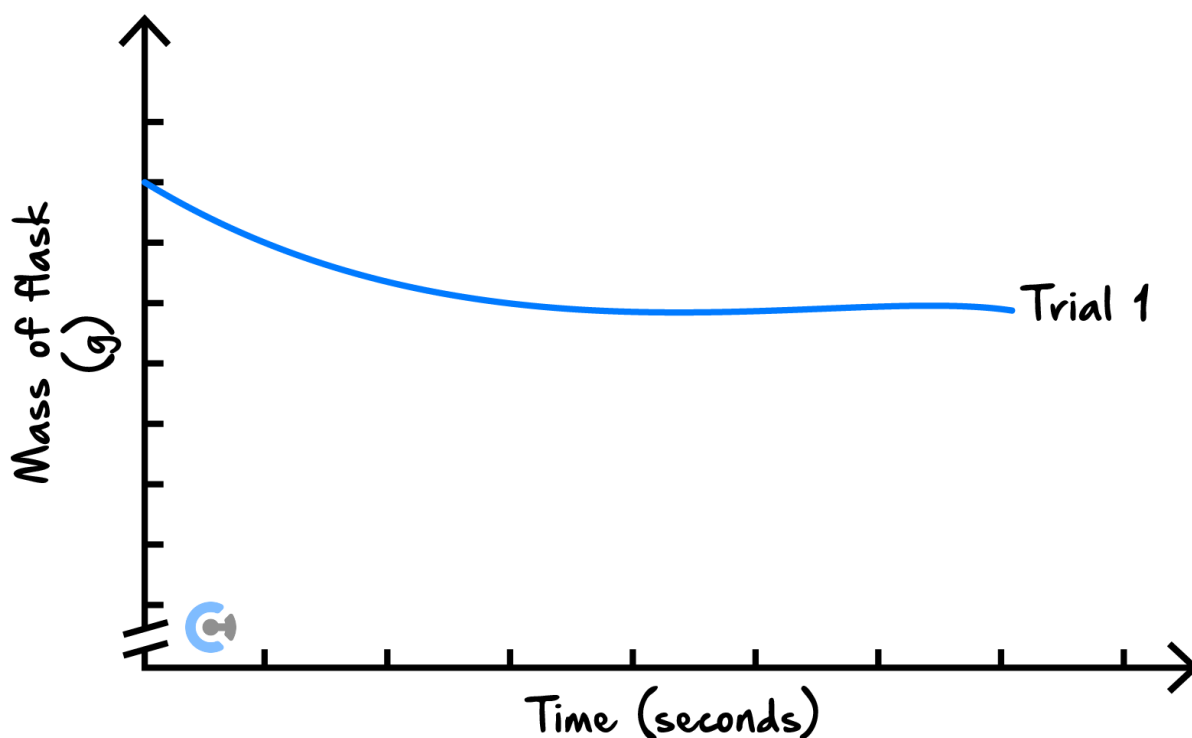


- b. The student then crushes the 30 g of marble chips and conducts another trial. Draw what would be expected from the trial on the graph below. (2 marks)



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)

Space for Personal Notes

Section B: [2.7] - Equilibrium (Checkpoints) (68 Marks)

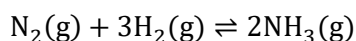
Sub-Section [2.7.1]: Write Equilibrium Constant Expression & Find its Value (Including Units)



Question 12 (4 marks)



Medha is interested in the Haber process, for which the chemical equation is shown below:



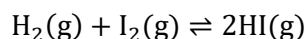
- a. In one experiment, at equilibrium, there is 2.15 *mol* of nitrogen gas, 2.5 *mol* of hydrogen gas and 4.55 *mol* of ammonia gas in a 2.0 *L* beaker.

- i. Write the K_c expression. (1 mark)

- ii. Find the K_c value. (1 mark)

- b. In another experiment, at equilibrium, Medha finds 3.25 *mol* of nitrogen gas, 1.25 *mol* of hydrogen gas and 3.20 *mol* of ammonia gas in a 4.00 *L* beaker. Find the K_c value.

- c. Medha's friend, Nawid, is experimenting with the equation shown below:

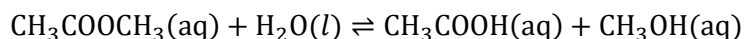


Nawid finds that at equilibrium, 1.05 mol of hydrogen gas, 2.10 mol of iodine gas and 1.50 mol of hydrogen iodide remain in a 3.00 L beaker. Find the K_c value. (2 marks)

Question 13 (4 marks)



Ester hydrolysis is used commercially for methanol production to be used in fuels. One instance of this is the hydrolysis of methyl ethanoate in the presence of water to form ethanoic acid and methanol. The chemical equation is provided below.



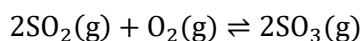
At equilibrium, Hitani finds that 3.5 mol of methyl ethanoate, 3.25 mol of ethanoic acid and 1.05 mol of methanol remains all dissolved in 4.00 L of water.

- a. Calculate the K_c value. (2 marks)

- b. At a different temperature, Hinati finds that the equilibrium constant is 5.50 M . The 3.125 L vessel contains 1.5 mol of methyl ethanoate, 4.4 mol of water, 2.20 mol of ethanoic acid at equilibrium. Find the concentration of methanol, in M , in the vessel. (2 marks)

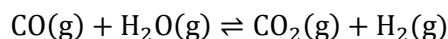
Question 14 (5 marks)


- a. Lachlan is investigating the following reaction:



In a 4.5 L vessel at equilibrium, the K_c value is 3.5 M^{-1} and there remains 2.5 mol of $\text{SO}_2(\text{g})$ and 1.25 mol of $\text{O}_2(\text{g})$ respectively. Find the concentration of sulphur trioxide ($\text{SO}_3(\text{g})$). (2 marks)

- b. Lachlan's friend, Harsh, is interested in the following reaction:



In a 10.5 L vessel at equilibrium, the K_c value is 6.3 (no unit) and there remains 1.5 mol of CO(g), 1.25 mol of H₂O(g) and 2.125 mol of H₂(g) respectively. Find the amount, in mol, of carbon dioxide (CO₂(g)). (3 marks)

Question 15 (6 marks)



Raph reacts nitrogen gas with hydrogen gas to form ammonia gas.

- a. Express the chemical reaction for this scenario. (1 mark)

- b. Provide the units of K_c for this reaction. (1 mark)

- c. Write the equilibrium expression for this reaction. (1 mark)

- d. In an experiment, 1.20 mol of hydrogen gas, 3.64 mol nitrogen gas and 2.10 mol of ammonia gas was formed at equilibrium in a 2.0 L container at 120°C . Find the equilibrium constant. (3 marks)

Space for Personal Notes

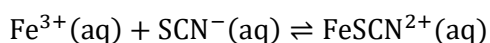


Sub-Section [2.7.2]: Identify the Extent of Reaction

Question 16 (3 marks)



Consider the following chemical reaction:



- a. If the K_c value is $1.50 \times 10^6 \text{ M}^{-1}$, state the extent of the reaction. (1 mark)

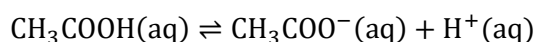
- b. If the K_c value is $9.50 \times 10^{-7} \text{ M}^{-1}$, state the extent of the reaction. (1 mark)

- c. If the K_c value is 1.0 M^{-1} , state the extent of the reaction. (1 mark)

Question 17 (3 marks)



Brooke is experimenting with the following reaction.



At equilibrium in a 10.5 L container, he finds 1.5 mol of CH_3COOH , 1.25 mol of $\text{CH}_3\text{COO}^{-}$ and 10.5 mol of H^{+} ions.

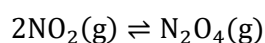
- a. Calculate the K_c value. (2 marks)

b. Hence, determine the extent of the reaction. (1 mark)

Question 18 (1 mark)



When the following reaction reaches equilibrium, it is found that there is a low concentration of nitric dioxide (NO_2) remaining.



Hence, predict the magnitude of the equilibrium constant.

Question 19 (1 mark)

The value of the equilibrium constant, K_c , for a reaction is 1.0×10^{14} . Which statement about the extent of the reaction is correct?

- A. The reaction hardly proceeds.
- B. The reaction goes almost to completion.
- C. The products have a lower concentration than the reactants.
- D. The concentrations of reactants and products are the same.

Space for Personal Notes

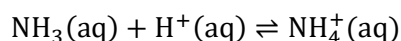


Sub-Section [2.7.3]: Find Equilibrium Constant When Equation is Changed

Question 20 (3 marks)



Dai is investigating the following reaction. The equilibrium constant at 25.0°C is 10.6 M^{-1} .



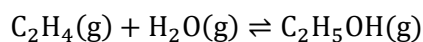
For the following reactions, state the equilibrium constant at 25.0°C.

Chemical Equation	K_c value at 25°C
a. $2\text{NH}_3(\text{aq}) + 2\text{H}^+(\text{aq}) \rightleftharpoons 2\text{NH}_4^+(\text{aq})$	
b. $\frac{1}{2}\text{NH}_3(\text{aq}) + \frac{1}{2}\text{H}^+(\text{aq}) \rightleftharpoons \frac{1}{2}\text{NH}_4^+(\text{aq})$	
c. $\text{NH}_4^+(\text{aq}) \rightleftharpoons \text{NH}_3(\text{aq}) + \text{H}^+(\text{aq})$	

Question 21 (3 marks)



Joanne is investigating the following reaction. The equilibrium constant at 35.0°C is 11.6 M^{-1} .

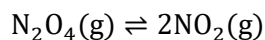


For the following reactions, state the equilibrium constant at 35.0°C.

Chemical Equation	K_c value at 25°C
a. $\frac{1}{2}\text{C}_2\text{H}_5\text{OH}(\text{g}) \rightleftharpoons \frac{1}{2}\text{C}_2\text{H}_4(\text{g}) + \frac{1}{2}\text{H}_2\text{O}(\text{g})$	
b. $2\text{C}_2\text{H}_5\text{OH}(\text{g}) \rightleftharpoons 2\text{C}_2\text{H}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g})$	
c. $3\text{C}_2\text{H}_4(\text{g}) + 3\text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{C}_2\text{H}_5\text{OH}(\text{g})$	


Question 22 (4 marks)

Consider the following equilibrium reaction:



- a. Write the equilibrium expression for this reaction, including its unit. (1 mark)

- b. Given that at a certain temperature, the equilibrium constant for this reaction is $K_c = 50 \text{ M}$, determine the equilibrium constants for the following modified reactions at the same temperature:

- i. $\frac{1}{2}\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$. (1 mark)

- ii. $2\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 4\text{NO}_2(\text{g})$. (1 mark)

- iii. $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$. (1 mark)

Space for Personal Notes

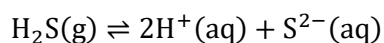


Sub-Section [2.7.4]: Apply Q_c to Find the Direction of the Equilibrium Shift

Question 23 (3 marks)



Naomi is investigating the following reaction. At 25°C, the system has an equilibrium constant of 35.0 M^2 .



Determine the direction of equilibrium shift when:

- a. $Q_c = 34 M^2$. (1 mark)

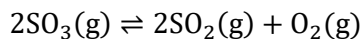
- b. $Q_c = 105 M^2$. (1 mark)

- c. $Q_c = 35 M^2$. (1 mark)

Space for Personal Notes

Question 24

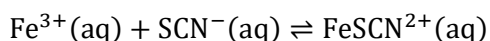

Claire is interested in the following reaction occurring in a 3.5 L container. She knows that at equilibrium at 26°C, $K_c = 0.1 M$.



She adds 2.0 mol of oxygen gas, 1.5 mol of $\text{SO}_2(\text{g})$ and 2.25 mol of $\text{SO}_3(\text{g})$. Calculate Q_c and hence predict the direction of the equilibrium shift.

Question 25 (3 marks)


Jasmine is investigating the following equation occurring in a 10.0 L vessel:



Her laboratory technician tells her that at 24°C, $K_c = 30.5 M$. Jasmine adds 2.0 mol of Fe^{3+} , 10.1 mol of FeSCN^{2+} and an unknown amount of SCN^{-} . Given that the equilibrium shifts backwards, calculate the SCN^{-} concentration, in M, which she must have been added.

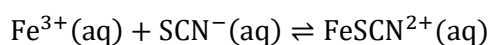


Sub-Section [2.7.5]: Apply RICE Tables to Find K_c

Question 26 (3 marks)



Hayley is running an experiment with the following reaction in a 1.0 L reaction vessel.



She adds 1.0 mol of Fe^{3+} and 1.355 mol of SCN^{-} into an empty reaction vessel. After the system reaches equilibrium, she notes that 0.125 mol of FeSCN^{2+} has been produced. Calculate the K_c value.

Space for Personal Notes


Question 27 (11 marks)

Clara adds 0.30 mol nitrogen monoxide to 0.40 mol oxygen gas, producing nitrogen dioxide in a 3.0 L vessel in an experiment at school.

- a.** State the chemical equation for this reaction. (1 mark)

- b.** Clara conducts the experiment and finds that at equilibrium, 0.165 mol of NO remains.

- i.** Find the concentration of nitrogen dioxide at equilibrium. (4 marks)

- ii.** Find the equilibrium constant at 15°C . (2 marks)

- c. Another student in Clara's class is conducting the same experiment under the same conditions (15°C , 3.0 L vessel). At one point during the chemical reaction, he notes that there is 0.251 mol of NO , 0.754 mol of O_2 and 1.230 mol of NO_2 .

- i. Find the reaction quotient. (2 marks)

- ii. Comment on the relative rate of production/consumption of reactants and products. Explain how the system will return back to reaching the equilibrium constant. (2 marks)

Space for Personal Notes



0.500 mol nitrogen gas and 0.400 mol hydrogen gas is added to a 4.0 L vessel, producing ammonia gas.

- a.** Express the chemical equation for this reaction. (1 mark)

- b.** If the equilibrium constant is known to be 10.65 M^{-2} at 100°C ,

- i. Express the equilibrium expression. (1 mark)

- ii.** Find the equilibrium concentration of ammonia gas. (4 marks)

Space for Personal Notes


Question 29 (5 marks)

Hydrogen peroxide can be produced from the reversible reaction between hydrogen and oxygen:

- a. Write the equilibrium chemical equation. (1 mark)

- b. 0.85 mol of hydrogen and 0.4 mol of oxygen are added to an empty 1.00 L reactor. When equilibrium is reached, the amount of hydrogen peroxide present is 0.2 mol. Determine the value of K_c . (4 marks)

Space for Personal Notes

Section C: [2.8] - Le Chatelier's Principle (Checkpoints) (33.5 Marks)

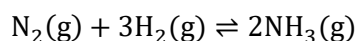
Sub-Section [2.8.1]: Explain the Effects of Addition/Removal of Substances or Pressure/Volume Changes on Equilibrium System



Question 30 (2.5 marks)



Precious is experimenting with changes made to a sealed reaction vessel containing the following reaction:



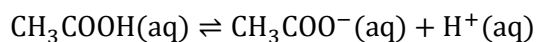
In the table below, predict the direction in which the equilibrium system will shift (using a left or right arrow, or a dash for no change) when the following changes are made:

S. no	Change	Shift
a.	$\text{N}_2(\text{g})$ is removed.	
b.	$\text{H}_2(\text{g})$ is added.	
c.	$\text{NH}_3(\text{g})$ is removed.	
d.	Volume of the vessel is doubled.	
e.	100 ml of water is removed.	

Space for Personal Notes

Question 31 (2 marks)

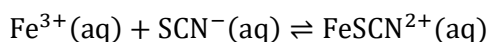

Melody is interested in the following reaction:



Explain the direction in which the equilibrium system will shift if she removes a small amount of ethanoic acid (CH_3COOH).

Question 32 (3 marks)


Shiven sets up the following reaction in a 2.0 L vessel, which is half full, and allows it to reach equilibrium.

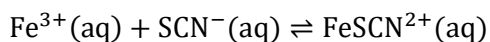


Given that Shiven adds 1000 mL of water to the reaction, explain whether the rate of the forward reaction will be greater, equal to, or less than the rate of the reverse reaction.

Space for Personal Notes


Question 33 (4 marks)

Olivia observes the reaction shown below:



She is informed that the FeSCN^{2+} ions produced a distinct red colour whilst all other ions in the system are colourless. At equilibrium, she finds there is 1.5 mol of Fe^{3+} , 1.0 mol of SCN^{-} and 0.75 mol of FeSCN^{2+} present within the 1.0 L vessel.

Olivia adds 0.5 mol of $\text{Fe}^{3+}(\text{aq})$ to the system.

When adding iron (III) ions to the solution, she notices that the solution within the vessel increases in intensity to a darker red. Explain this observation.

Space for Personal Notes

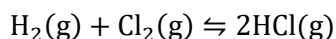


Sub-Section [2.8.2]: Graph Effects of Addition/Removal of Substances or Pressure/Volume Changes on Equilibrium System

Question 34 (3 marks)



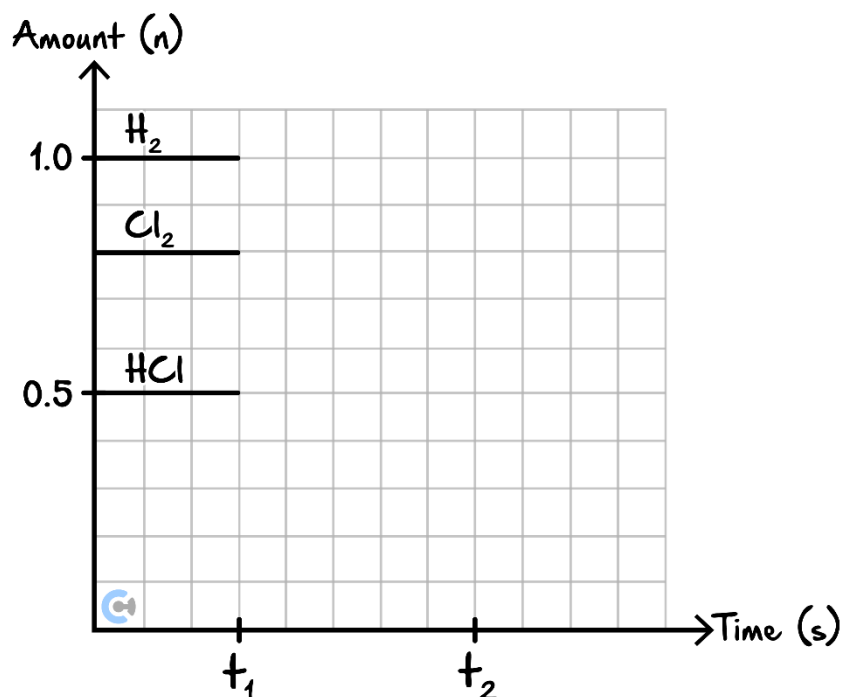
Merna allows the following reaction to reach equilibrium.



She adds 0.20 mol of HCl from the vessel.

- a. Determine the direction in which the system shifts. (1 mark)

- b. Graph how the amounts of the species change with time. Assume HCl is removed at t_1 , and equilibrium is re-established at t_2 . (2 marks)

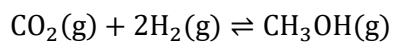


Space for Personal Notes



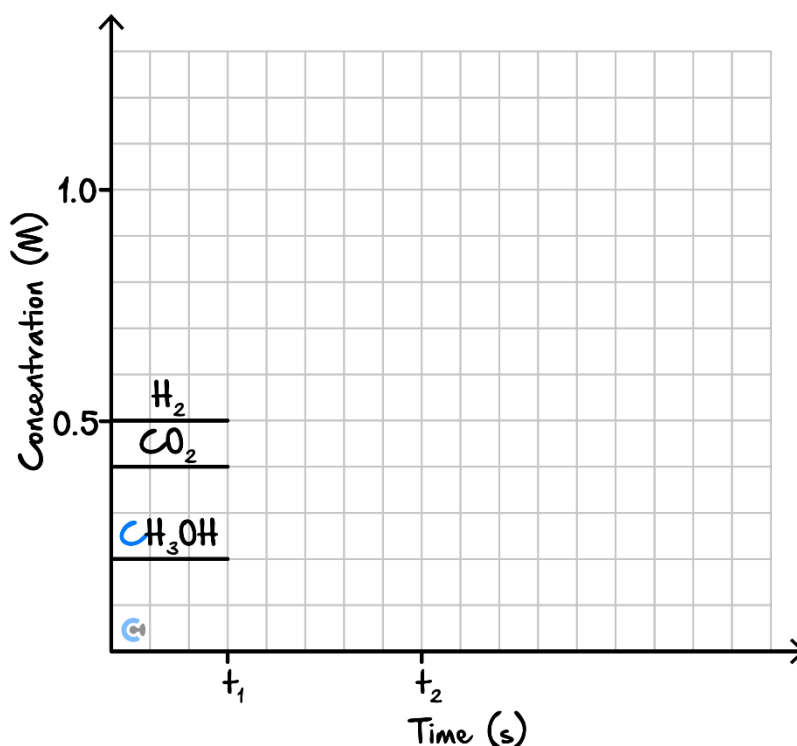
Question 35 (4 marks)

The following reaction is allowed to reach equilibrium in a 2.0 L vessel.



Katie halves the volume of the container.

- a. Graph how the concentrations of the species change with time. Assume the volume is halved at t_1 , and equilibrium is re-established at t_2 . (2 marks)



- b. When the volume is halved:

- i. State the change in the amount of H_2 at t_1 . (1 mark)

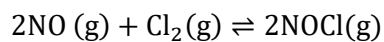
- ii. State the change in the amount of CO_2 at t_2 . (1 mark)

Space for Personal Notes



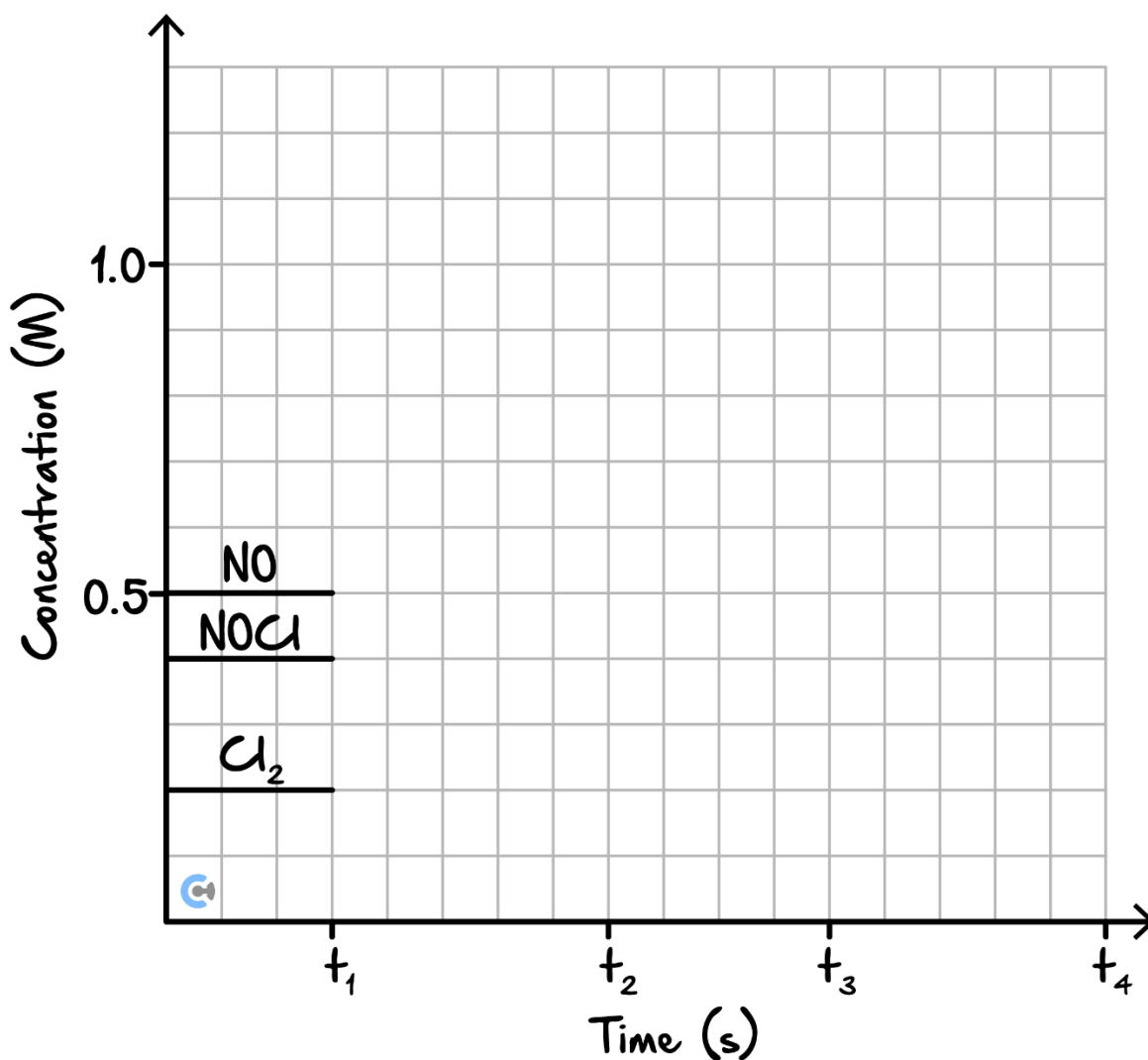
Question 36 (6 marks)

The following reaction is allowed to reach equilibrium in a 3.0 L container.



Nour halves the volume of the container.

- a. Graph how the concentrations of the species change with time. Assume the volume is halved at t_1 , and equilibrium is re-established at t_2 . (2 marks)



Nour then removes 0.3 mol of chlorine gas (Cl₂) from the system.

- b. Graph how the concentration of the species changes with time. Assume the chlorine gas is removed at t_3 , and equilibrium is re-established at t_4 . (2 marks)

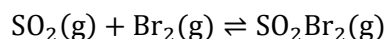


Sub-Section [2.8.3]: Apply Partial Opposition during Equilibrium to the Effects on Amount, Concentration & Colour of Substance

Question 37 (3 marks)



Claire sets up the following reaction, allowing it to reach equilibrium.

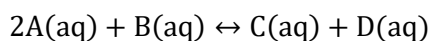


Claire removes 0.2 mol of Br_2 from the system. Given that the colour of Br_2 is brown, explain what happens to the intensity of the solution when equilibrium is re-established.

Question 38 (6 marks)



Consider the following reaction where substance B is dark blue.



a. If A is removed, state the change: (2 marks)

i. In the intensity of blue:

Increased Stay the same Decreased

ii. In the amount of A:

Increased Stay the same Decreased

iii. In the amount of C:

Increased Stay the same Decreased

b. If B is added, state the change: (2 marks)

i. In the intensity of blue:

Increased

Stay the same

Decreased

ii. In the amount of A:

Increased

Stay the same

Decreased

iii. In the amount of C:

Increased

Stay the same

Decreased

c. If water is added, state the change: (2 marks)

i. In the intensity of blue:

Increased

Stay the same

Decreased

ii. In the amount of A:

Increased

Stay the same

Decreased

iii. In the amount of C:

Increased

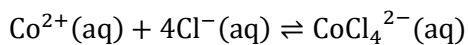
Stay the same

Decreased

Space for Personal Notes


Question 39

The following reaction is allowed to reach equilibrium. $\text{Co}^{2+}(\text{aq})$ is pink in colour.



Place ticks in appropriate boxes to indicate the effect of each change once a new equilibrium has been established.

Change at Equilibrium	Colour at New Equilibrium Compared with Initial Equilibrium		$[\text{CoCl}_4]^{2-}$ at New Equilibrium Compared with Initial Equilibrium	
	Less Pink	More Pink	Decreased	Increased
Sample 1: 1 drop of AgNO_3 solution is added, forming an AgCl precipitate.				
Sample 2: 1 drop of NaCl solution is added.				
Sample 3: A large volume of water is removed.				
Sample 4: A drop of K_2Co is added.				

Space for Personal Notes

Section D: [2.9] - Rate Yield Conflict (Checkpoints) (28 Marks)

Sub-Section [2.9.1]: Explain the Effects of Temperature, Inert Gas, or Catalyst on an Equilibrium System

Question 40 (1 mark)



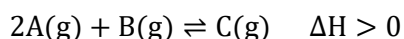
An inert gas and a catalyst are added to an equilibrium system simultaneously. What is the effect on the equilibrium system?

- A. The rates of the forward and reverse reaction remain the same and the concentrations of all reagents increase.
- B. The rates of the forward and reverse reactions increase and the concentration of the reagents remains the same.
- C. The rate of the forward reaction increases and the concentration of the products increases.
- D. Only the rate of the reverse reaction increases and the concentration of the reagents remains the same.

Question 41 (4 marks)



Consider the following equilibrium system.

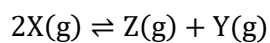


- a. Explain the effect of increasing the temperature of the system. (2 marks)

- b. Explain the effect of adding a catalytic powder to the system while increasing the temperature. (2 marks)


Question 42 (4 marks)

The following equilibrium system is used in ColdGlow glow sticks.



ColdGlow glow sticks get brighter based on how cold their surroundings are. Both Z and Y are colourless gases, whereas X has a distinct fluorescent red colour.

- a.** State whether the above reaction is endothermic or exothermic. Justify your answer. (2 marks)

- b.** The volume of the glow sticks is decreased and the temperature can be assumed to be constant. Describe and explain any observable effects on the system. (2 marks)

Space for Personal Notes

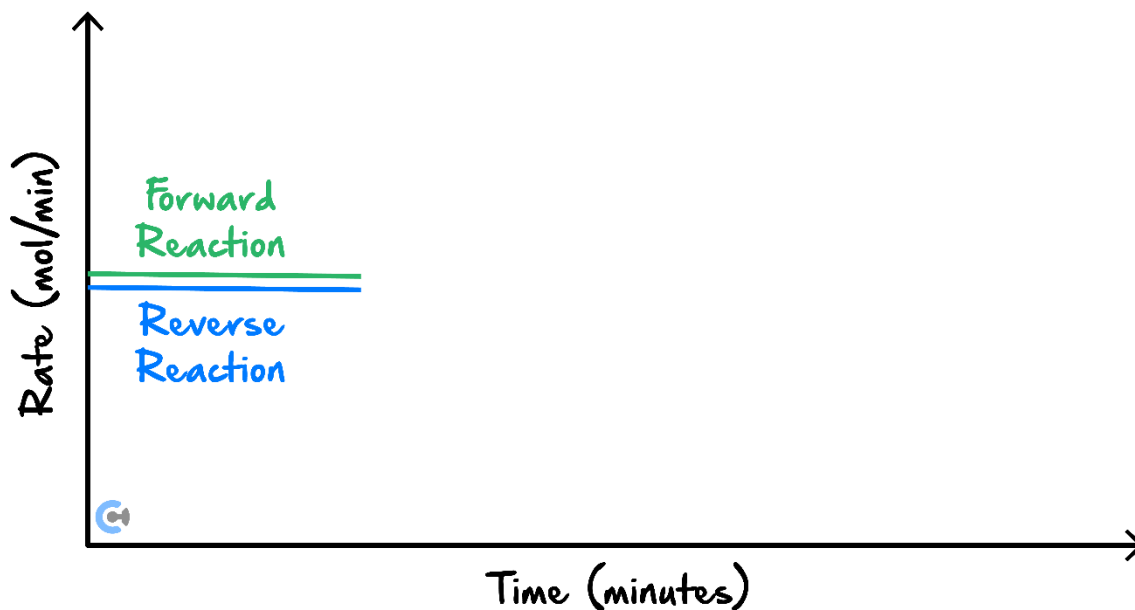


Sub-Section [2.9.2]: Graph Effects of Temperature, Inert Gas, or Catalyst on Equilibrium Systems

Question 43 (1 mark)



A noble gas is added to an equilibrium system. Sketch the change to the system.



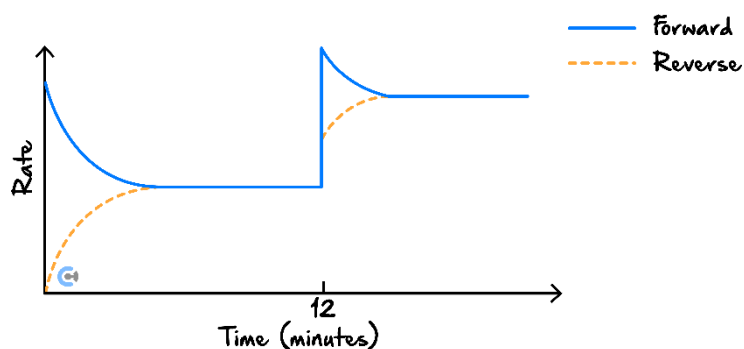
Space for Personal Notes

Sub-Section [2.9.3]: Find the Change made to the System from an Equilibrium Graph



Question 44 (1 mark)

A change is made to a gaseous equilibrium system at 12 minutes after the system is set up. The effect of the change is shown.



The change made to the system could be:

- A. Reactants were added to the system.
- B. The temperature was decreased.
- C. A catalyst was added to the system.
- D. The volume of the system was increased.

Space for Personal Notes



Sub-Section [2.9.4]: Find Equilibrium Constant changes due to Temperature

Question 45 (1 mark)



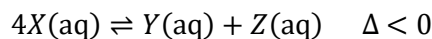
Consider an endothermic equilibrium system for which the equation is unknown. The temperature of the system is increased. Which of the following would be observed once the system re-established equilibrium?

- A. The rate of the reverse reaction only has decreased compared to before the temperature change.
- B. The concentration of the reactants has increased.
- C. The value of the equilibrium constant has increased.
- D. The system feels colder.

Question 46 (7 marks)



The following system has been allowed to reach equilibrium.



At equilibrium, there are 4.00 mol of X and 6.00 mol of Y in 2 litre of solution. The value of the equilibrium constant is 0.1875 M^{-2} .

- a. Calculate the concentration of Z. (2 marks)

The chemist decides to change the temperature of the system and measures the concentration of Z to be 1.10 M after the change in temperature.

b. Explain whether the chemist increased or decreased the temperature of the system. (2 marks)

c.

i. State the expression for the equilibrium constant. (1 mark)

ii. Calculate the new equilibrium constant. (2 marks)

Space for Personal Notes

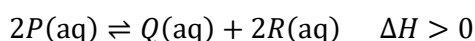


Sub-Section [2.9.5]: Find Optimum Operating Conditions in all Circumstances such as the Rate-Yield Conflict

Question 47 (1 mark)



A chemist is trying to maximise the yield of P in an industrial process involving the equilibrium system shown below.



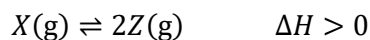
Which of the following could be applied to the system to maximise the yield of P ?

- A. Increasing the volume of the container.
- B. Increasing the temperature of the system.
- C. Reacting P with another species in a precipitate reaction.
- D. Removing products as they are produced.

Space for Personal Notes


Question 48 (8 marks)

A chemist is trying to increase the yield of Z in the following equilibrium system.



- a.** Explain the effect of decreasing the temperature of the system on the value of the equilibrium constant. (2 marks)

- b.** Compare the effect of decreasing the temperature of the system on the rate of the forward reaction at equilibrium and the rate of the reverse reaction at equilibrium. (2 marks)

- c.** Explain why increasing the volume of this system is not optimal for increasing the rate and yield of Z with explicit reference to collision theory and Le Chatelier's principle. (4 marks)

Space for Personal Notes

Section E: [2.6 - 2.9] - Overall (VCAA Qs) (57 Marks)

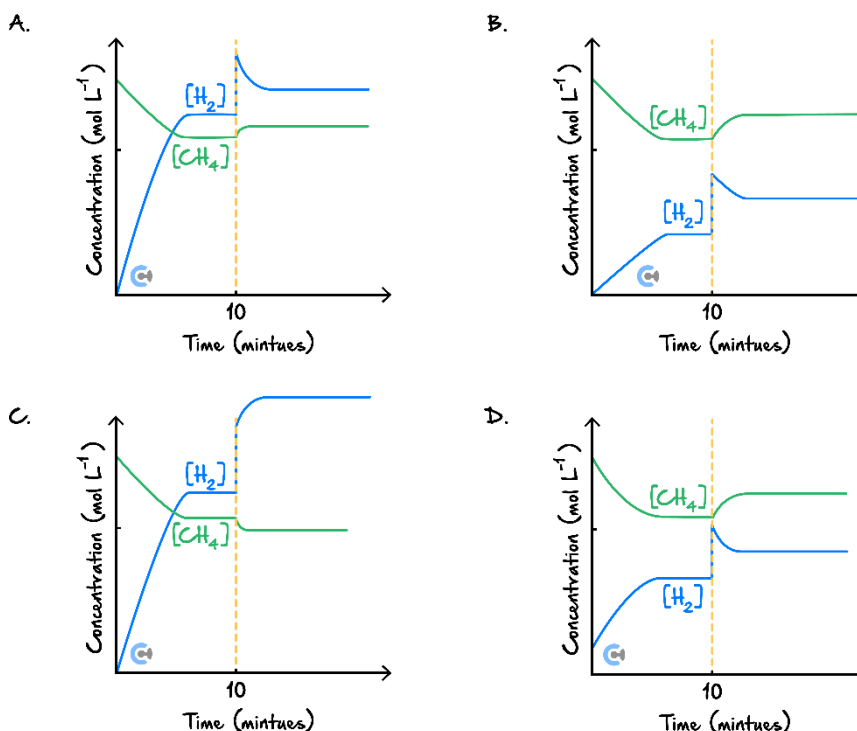
Question 49 (1 mark)



Inspired from VCAA CHEMISTRY Exam 2008

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008chem2-w.pdf#page=3>

Equal amounts of $\text{CH}_4(\text{g})$ and $\text{H}_2\text{O}(\text{g})$ are added to a reaction vessel and allowed to react. After 10 minutes, equilibrium has been reached. At that time, some H_2 is added to the mixture and equilibrium is re-established. Which one of the following graphs best represents the changes in the amounts of CH_4 and H_2 in the reaction mixture?



Question 50 (1 mark)



Inspired from VCAA CHEMISTRY Exam 2008

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008chem2-w.pdf#page=3>

The rate of a reaction generally increases with temperature.

The factor that has the **biggest effect** on the increase in reaction rate is that, with increasing temperature:

- A. The activation energy of the reaction increases.
- B. The activation energy of the reaction decreases.
- C. The number of collisions between particles increases.
- D. The proportion of particles with high kinetic energy increases.


Question 51 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2023

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf#page=4>

At 327°C, the equilibrium constant for the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ is 4.10 M^{-2} .
What is the equilibrium constant at 327°C for the reaction $2\text{N}_2(\text{g}) + 6\text{H}_2(\text{g}) \rightleftharpoons 4\text{NH}_3(\text{g})$?

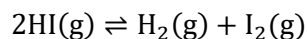
- A. 8.20 M^{-2}
- B. 8.20 M^{-4}
- C. 16.8 M^{-2}
- D. 16.8 M^{-4}


Question 52 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2022

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/NHT/2022ChemistryNHT-w.pdf#page=4>

Hydrogen iodide, HI, can decompose to form hydrogen, H_2 , and iodine, I_2 . The equation for this reaction is given below.



Which one of the following statements about collision theory is correct for this reaction?

- A. The frequency of collisions is independent of the temperature.
- B. The frequency of collisions depends on the orientation of the molecules.
- C. The chance of a collision resulting in a reaction depends on the orientation of the molecules.
- D. The chance of a collision resulting in a reaction depends only on the kinetic energy of the molecules.

Space for Personal Notes



Question 53 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2021

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/NHT/2021chem-nht-w.pdf#page=4>

A student investigated the rate of reaction between dilute hydrochloric acid, HCl, and calcium carbonate, CaCO₃. The student performed two experiments using two pieces of CaCO₃ of different shapes.

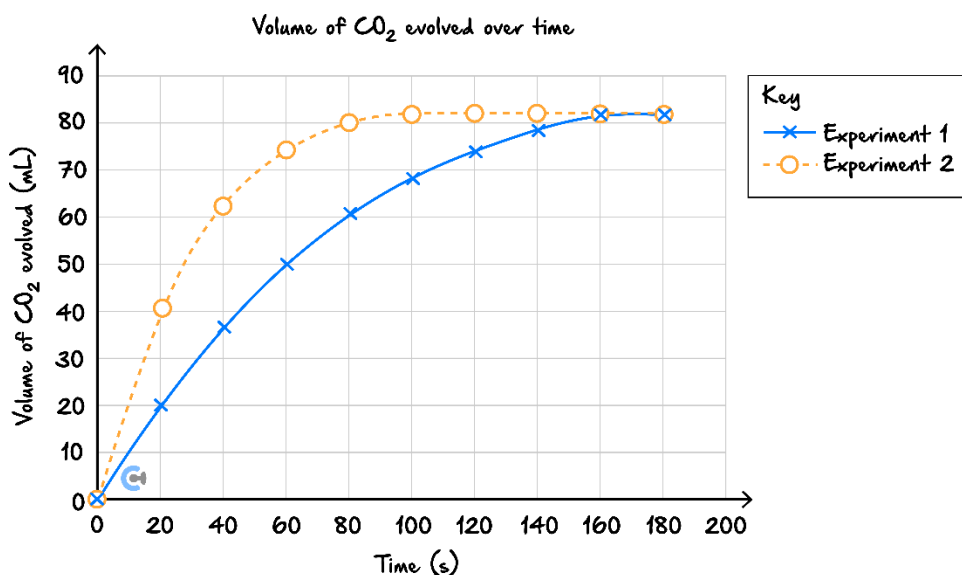
In each experiment, Experiment 1 and Experiment 2, 0.34 g of CaCO₃ and 12.0 mL of 0.50 M HCl was used and the volume of gas produced at SLC was measured at 10 s intervals.

The following reaction takes place:



The molar mass of CaCO₃ is 100.1 g mol⁻¹.

The student plotted the results and produced the graph shown below.



At 160 s, the two lines meet.

This is because:

- A. Both reactions have reached equilibrium.
- B. The CaCO₃ has completely reacted and there is some acid remaining.
- C. The acid has completely reacted and there is some CaCO₃ remaining.
- D. Both reactions have stopped because all reactants have been consumed.

Space for Personal Notes


Question 54 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2018

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2018/nht/2018chem-nht-w.pdf#page=3>

Consider the following reaction.



Which one of the following statements are correct?

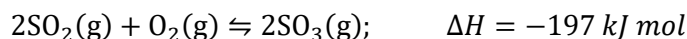
- A. K_c is very large; the reaction is reversible.
- B. Changing the pressure will affect the value of K_c .
- C. K_c is very large; the reaction is effectively irreversible.
- D. Changing the temperature will not affect the value of K_c .


Question 55 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2023

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/NHT/2023chem-nht-w.pdf#page=3>

Sulphur trioxide, SO_3 , can be produced from oxygen, O_2 , and sulphur dioxide, SO_2 in the following equilibrium reaction.



Consider the following statements about the production of SO_3 in a closed system.

- I. Increasing the temperature of the system will increase both the reaction rate and the equilibrium constant.
- II. Increasing the volume of the system will reduce the reaction rate and reduce the equilibrium yield of SO_3 .
- III. Increasing the pressure of the system by adding nitrogen gas, N_2 , will increase the equilibrium yield of SO_3 .
- IV. Adding a suitable catalyst to the system will have no effect on the equilibrium constant.

Which of the statements above is correct?

- A. I and II only.
- B. I and III only.
- C. II and IV only.
- D. III and IV only.

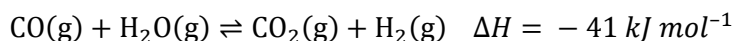


Question 56 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2012

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2012/2012chem2-w.pdf#page=6>

The following reaction is used in some industries to produce hydrogen.



Carbon monoxide, water vapour, carbon dioxide, and hydrogen were pumped into a sealed container that was maintained at a constant temperature of 200°C. After 30 seconds, the concentration of gases in the sealed container was found to be $[\text{CO}] = 0.1 \text{ M}$, $[\text{H}_2\text{O}] = 0.1 \text{ M}$, $[\text{H}_2] = 2.0 \text{ M}$, $[\text{CO}_2] = 2.0 \text{ M}$.

The equilibrium constant at 200°C for the above reaction is, $K = 210$.

Which one of the following statements about the relative rates of the forward reaction and the reverse reaction at 30 seconds is true?

- A. The rate of the forward reaction is greater than the rate of the reverse reaction.
- B. The rate of the forward reaction is equal to the rate of the reverse reaction.
- C. The rate of the forward reaction is less than the rate of the reverse reaction.
- D. There is insufficient information to allow a statement to be made about the relative rates of the forward and reverse reactions.

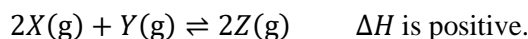


Question 57 (1 mark)

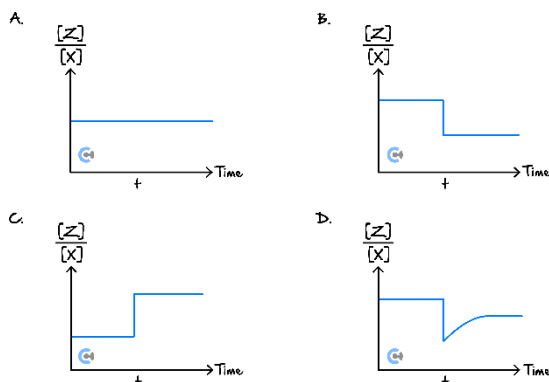
Inspired from VCAA CHEMISTRY Exam 2011

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2011chem2-w.pdf#page=2>

Consider the following equilibrium.



A catalyst is added to the equilibrium mixture at time, t . The temperature and volume of the mixture remain constant. Which one of the following graphs best represents the change in the equilibrium ratio $\frac{[\text{Z}]}{[\text{X}]}$?





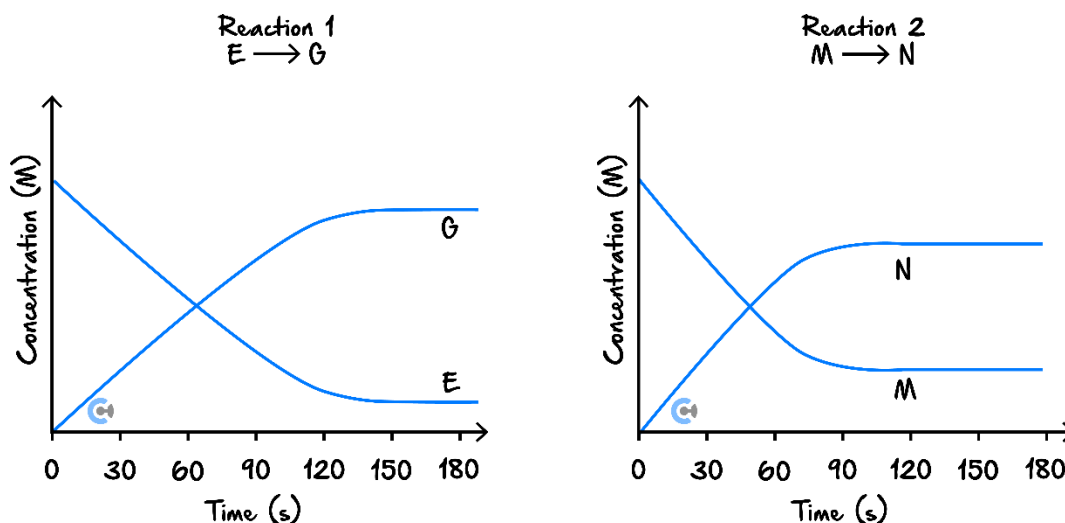
Question 58 (1 mark)

Inspired from VCAA CHEMISTRY Exam 2019

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT/2019chem-nht-w.pdf#page=8>

The diagrams below show the concentration versus time graphs for two different reactions under identical conditions.

The graphs can be used to determine whether each reaction is reversible or irreversible and which reaction has a faster rate of reaction.



Which of the following conclusions matches the data presented in the graphs?

	Reaction 1	Rate of reaction
A.	Reversible.	Reaction 1 is slower than Reaction 2.
B.	Effectively irreversible.	Reaction 1 is faster than Reaction 2.
C.	Effectively irreversible.	Reaction 1 is slower than Reaction 2.
D.	Reversible.	Reaction 1 is faster than Reaction 2.

Space for Personal Notes

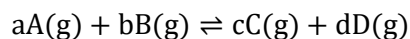


The following information applies to the two questions that follow.

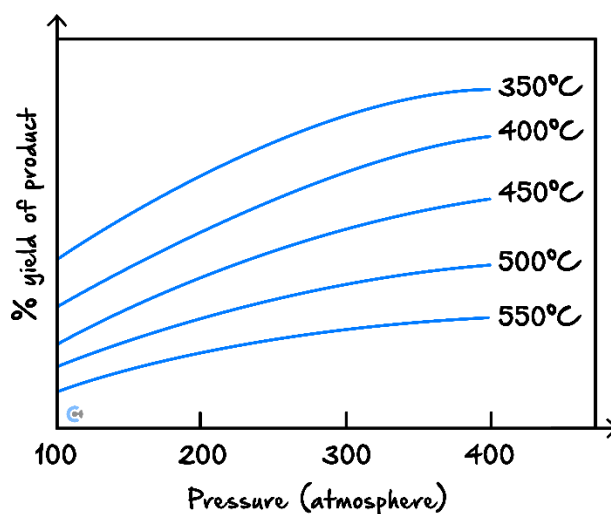
Inspired from VCAA CHEMISTRY Exam 2010

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2010chem2-w.pdf#page=5>

The graph below refers to the following gaseous reaction.



The effect of increasing pressure and temperature on the equilibrium yield of the products is shown in the graph below.



Question 59 (1 mark)

Which one of the following statements about the relative number of reactant and product molecules in the balanced equation is true?

- A. The number of reactant molecules is equal to the number of product molecules.
- B. The number of reactant molecules is greater than the number of product molecules.
- C. The number of reactant molecules is less than the number of product molecules.
- D. The relative number of reactant and product molecules cannot be determined from the data provided.

Question 60 (1 mark)

Which one of the following statements about this gaseous reaction is true?

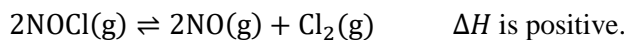
- A. The reaction is exothermic because the yield increases as the temperature increases.
- B. The reaction is endothermic because the yield increases as the temperature increases.
- C. The reaction is exothermic because the yield decreases as the temperature increases.
- D. The reaction is endothermic because the yield decreases as the temperature increases.



The following information applies to the two questions that follow.

Inspired from VCAA CHEMISTRY Exam 2013

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2013/2013chem-w.pdf#page=8>



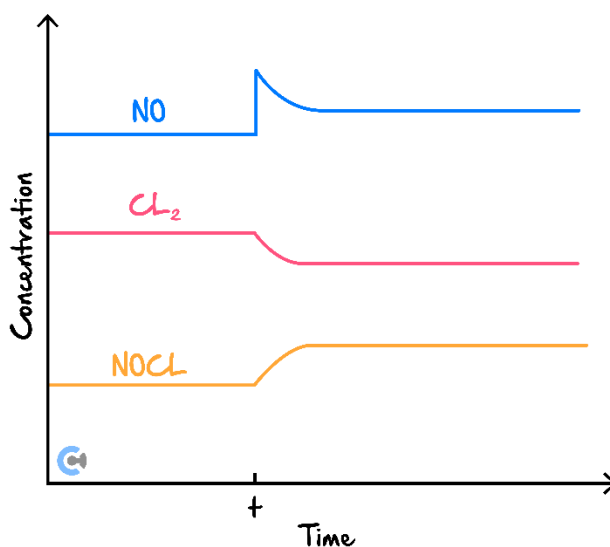
Question 61 (1 mark)

The equilibrium expression for this reaction is:

- A. $\frac{2[\text{NO}][\text{Cl}_2]}{2[\text{NOCl}]}$
- B. $\frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{NOCl}]^2}$
- C. $\frac{2[\text{NOCl}]}{2[\text{NO}][\text{Cl}_2]}$
- D. $\frac{[\text{NOCl}]^2}{[\text{NO}]^2[\text{Cl}_2]}$

Question 62 (1 mark)

A concentration-time graph for this system is shown below.



What event occurred at time, t , to cause the change in equilibrium concentrations?

- A. The pressure was decreased at a constant temperature.
- B. The temperature was increased at a constant volume.
- C. A catalyst was added at a constant temperature and volume.
- D. Additional NO gas was added at a constant volume and temperature.

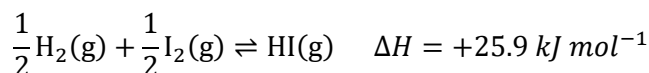


The following information applies to the two questions that follow.

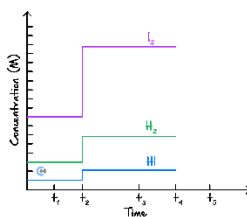
Inspired from VCAA CHEMISTRY Exam 2021

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf#page=8>

Hydrogen, H_2 , and iodine, I_2 , react to form hydrogen iodide, HI.



The graph shows the concentrations H_2 , I_2 , and HI in a sealed container. One change was made to the equilibrium system at time, t_2 .



Question 63 (1 mark)

Which one of the following statements is correct?

- A. A catalyst was added at time t_2 .
- B. The amount of HI is greater at time t_3 compared with time t_1 .
- C. The rate of reaction producing HI is the same at time t_1 and time t_3 .
- D. The rate of production of HI at time t_3 is double the rate of production of H_2 at time t_3 .

Question 64 (1 mark)

One change was made to the equilibrium system at time t_4 , which altered the equilibrium constant. Equilibrium was re-established at time t_5 . The rate of the reverse reaction at time t_5 was higher than at time t_3 .

Which of the following options correctly shows the change in the equilibrium system from time t_3 to time t_5 ?

Change from time t_3 to time t_5		
	Equilibrium Constant	Total Chemical Energy
A.	Increase	Increase
B.	Increase	Decrease
C.	Decrease	Increase
D.	Decrease	Decrease



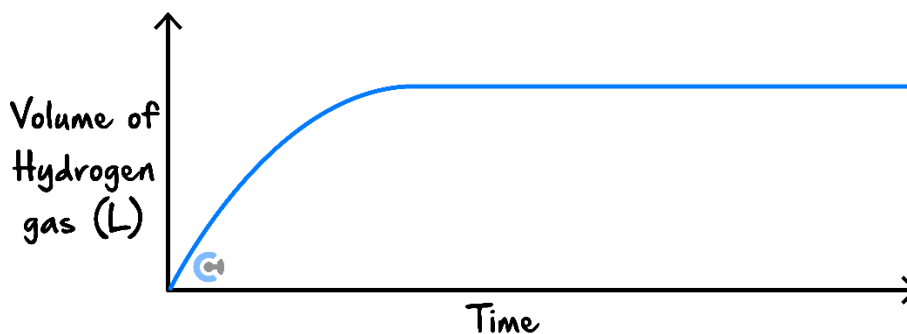
Question 65 (4 marks)

Inspired from VCAA CHEMISTRY Exam 2008

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008chem2-w.pdf#page=11>

A 2.0 g piece of magnesium ribbon was added to a known volume of 2.0 M hydrochloric acid. The volume of hydrogen gas produced during the reaction was measured and recorded.

The graph below shows the result of this experiment.



- a. Write an equation for the reaction between magnesium and hydrochloric acid. (2 marks)

- b. In a second experiment, 2.0 g of magnesium **powder** was added to the same volume of 2.0 M hydrochloric acid as used in the first experiment.

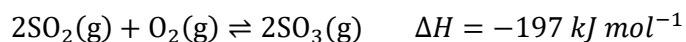
On the axes above, sketch the expected graph of the volume of hydrogen against time for this second experiment. Give an explanation for the shape of your graph. (2 marks)

Space for Personal Notes


Question 66 (7 marks)

Inspired from VCAA CHEMISTRY Exam 2021
<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf>

The reaction for the oxidation of sulphur dioxide, SO_2 , is shown below.



- a. 1.00 mol of SO_2 and 1.00 mol of oxygen, O_2 , are placed into an evacuated, sealed 3.00 L container at 100°C. After the reaction reaches equilibrium, the container contains 20.0 g of sulfur trioxide, SO_3 .

Calculate the equilibrium constant, K_c , for this reaction at 100°C. (4 marks)

- b. The volume of the closed container is doubled.

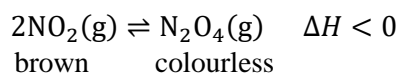
Describe the effect that this has on the concentration of SO_2 from the time just before the volume was changed until after the system re-established its equilibrium. (3 marks)


Question 67 (8 marks)

Inspired from VCAA CHEMISTRY Exam 2018

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2018/2018chem-w.pdf>

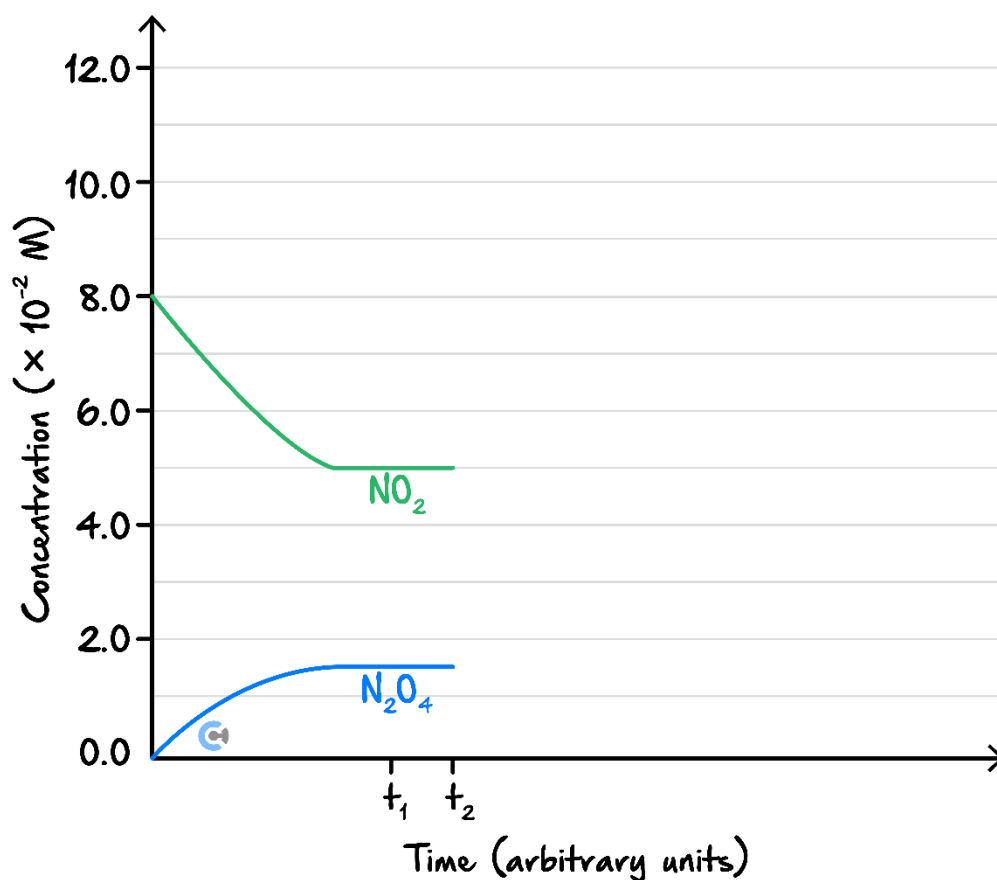
A student is investigating the following reaction system.



- a.** The reaction system can be observed in a sealed test tube, which allows the student to investigate the impact of temperature on the equilibrium position of the reaction.

State the colour change expected when the student places the sealed test tube of the gas mixture in a beaker of hot water. Explain why this colour change occurs. (3 marks)

- b. Below is the concentration versus time graph for the reaction system. The graph was produced using secondary data at a temperature of 22°C.



- i. Time t_1 , is shown in the graph above.

Calculate the equilibrium constant at time t_1 . (2 marks)

- ii. At time t_2 , the volume of the system was halved, keeping the temperature at 22°C.

Continue the graph to show how this change would affect the reaction system and how the system would respond to this change until equilibrium is restored. (3 marks)

Space for Personal Notes

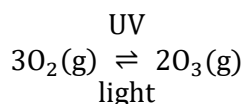


Question 68 (8 marks)

Inspired from VCAA CHEMISTRY Exam 2022

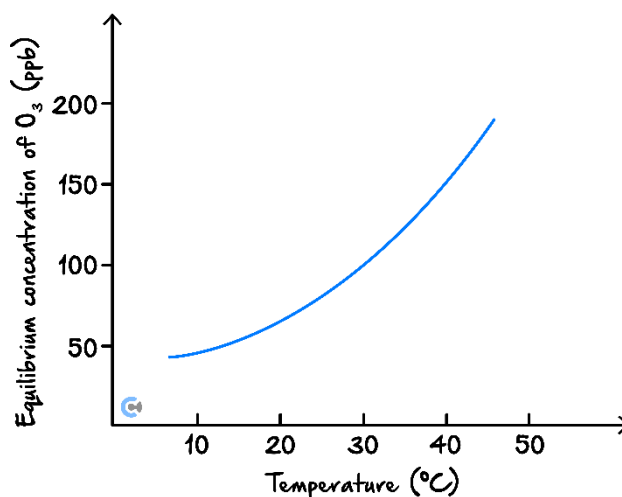
<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/NHT/2022ChemistryNHT-w.pdf#page=20>

In the upper atmosphere, ozone, $\text{O}_3(\text{g})$, is formed from oxygen, $\text{O}_2(\text{g})$, in the presence of ultraviolet (UV) light. An equation that represents this chemical reaction is given below.



Graph 1 shows the effect of temperature on the equilibrium concentration of $\text{O}_3(\text{g})$ in a sealed container containing only $\text{O}_2(\text{g})$ and $\text{O}_3(\text{g})$. The container is clear and exposed to UV light.

Graph 1



- a.
- i. With reference to Graph 1, state whether the forward reaction is endothermic or exothermic. (1 mark)

- ii. Explain your answer to **part a.i.** (2 marks)

- iii. Decomposition of O_3 to produce O_2 is the reverse reaction.

Sketch the energy profile for the decomposition of O_3 on the axes provided in Graph 2. (1 mark)

Graph 2 - Energy profile



- b. $7.50 \times 10^{-2} \text{ mol}$ of O_2 was placed in an evacuated and sealed 3.00 L container at 30°C . This clear container was exposed to UV light. At equilibrium, $1.56 \times 10^{-7} \text{ mol}$ of O_3 had formed in the container.

Calculate the equilibrium constant at 30°C . (4 marks)

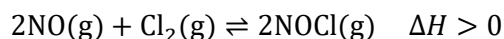
Space for Personal Notes


Question 69 (8 marks)

Inspired from VCAA CHEMISTRY Exam 2022

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/NHT/2022ChemistryNHT-w.pdf#page=20>

Nitrosyl chloride, NOCl, is a highly toxic gas used in the chemical industry as an oxidising agent. The formation reaction of NOCl from nitrogen monoxide, NO, and chlorine, Cl₂, is:



This reaction forms an equilibrium above 100°C.

A scientist conducted two experiments on the equilibrium reaction of NOCl. The initial experiments were conducted in evacuated and sealed 4 L containers at 150°C.

Experiment 1: 2 mol of NOCl was injected into a previously evacuated, sealed 4 L container.

Experiment 2: 4 mol of NOCl was injected into another previously evacuated, sealed 4 L container.

a.

- i.** Which experiment had the highest initial rate of production of Cl₂? Circle the correct response below. Justify your answer. (2 marks)

Experiment 1

Rates are equal

Experiment 2

- ii.** If, for Experiment 1, the concentrations of NOCl and NO were equal at equilibrium, [NOCl] = [NO], then what conclusion could be made about the relative concentrations of NOCl and NO in Experiment 2 at equilibrium? Justify your answer. (2 marks)

- b. 2 mol of an inert gas is injected into the container in Experiment 1. The temperature is kept at 150°C. What effect will this have on the rate of production of the Cl_2 in the container? Circle the correct response below. Justify your answer using collision theory. (2 marks)

Decrease No change Increase

- c. The temperature for Experiment 2 is increased to 200°C. Explain the effect on the equilibrium concentration of NOCl in the reaction. (2 marks)

Space for Personal Notes

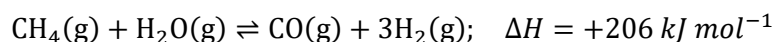


Question 70 (6 marks)

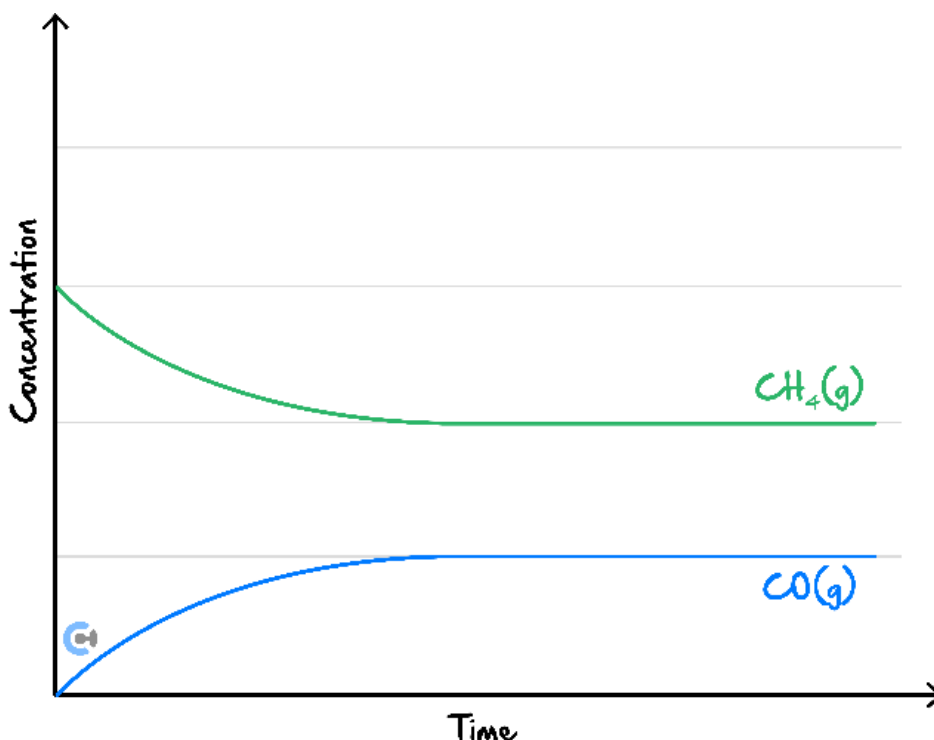
Inspired from VCAA CHEMISTRY Exam 2007

https://www.vcaa.vic.edu.au/Documents/exams/chemistry/chem1_exam_07.pdf#page=10

Carbon monoxide and hydrogen can be produced from the reaction of methane with steam according to the equation:



Some methane and steam are placed in a closed container and allowed to react at a fixed temperature. The following graph shows the change in concentration of methane and carbon monoxide as the reaction progresses.



- a.
- On the graph above, draw a line to show the change in concentration of hydrogen gas as the reaction progresses. **Label this line.** (1 mark)
 - On the graph above, draw a line to show how the formation of carbon monoxide would differ over time in the presence of a catalyst. **Label this line.** (1 mark)

- b.** The rates of chemical reactions may be explained using the collision theory model. Indicate whether the following statements about rates and the collision theory model are true or false by placing ticks in the appropriate boxes. (3 marks)

Statement	True	False
i. Endothermic reactions are always slower than exothermic reactions.		
ii. All particles have the same kinetic energy at a fixed temperature.		
iii. Reactant particles need to collide with sufficient energy to react.		
iv. The rate of a reaction at a constant temperature increases as the reaction proceeds.		
v. Increasing the temperature increases the fraction of collisions with energy above the activation energy.		

Space for Personal Notes



Website: contoureducation.com.au | Phone: 1800 888 300 | Email: hello@contoureducation.com.au

VCE Chemistry $\frac{3}{4}$

Free 1-on-1 Support



Be Sure to Make The Most of These (Free) Services!

- Experienced Contour tutors (45+ raw scores, 99+ ATARs).
- For fully enrolled Contour students with up-to-date fees.
- After school weekdays and all-day weekends.

1-on-1 Video Consults

- Book via bit.ly/contour-chemistry-consult-2025 (or QR code below).
- One active booking at a time (must attend before booking the next).

Text-Based Support

- Message [+61 440 137 304](tel:+61440137304) with questions.
- Save the contact as "Contour Chemistry".

Booking Link for Consults

bit.ly/contour-chemistry-consult-2025



Number for Text-Based Support

[+61 440 137 304](tel:+61440137304)