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VCE Chemistry ¾
AOS 2 Revision II [0.21]
Workshop

Error Logbook:

New Ideas/Concepts	Didn't Read Question
Pg / Q #: _____ Notes:	Pg / Q #: _____ Notes:
Algebraic/Arithmetic/ Calculator Input Mistake	**Working Out Not Detailed Enough**
Pg / Q #: _____ Notes:	Pg / Q #: _____ Notes:

Section A: Warm Up (10 Marks)

INSTRUCTION: 10 Marks. 7 Minutes Writing.

Question 1 (6 marks)

Complete the following table by drawing an arrow indicating whether there is a forward, reverse or no change for equilibrium shift, and decreases, increases or remains the same for the concentration of reactants and products and the value of K.

$$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g) \quad \Delta H = -286\ kJ/mol$$

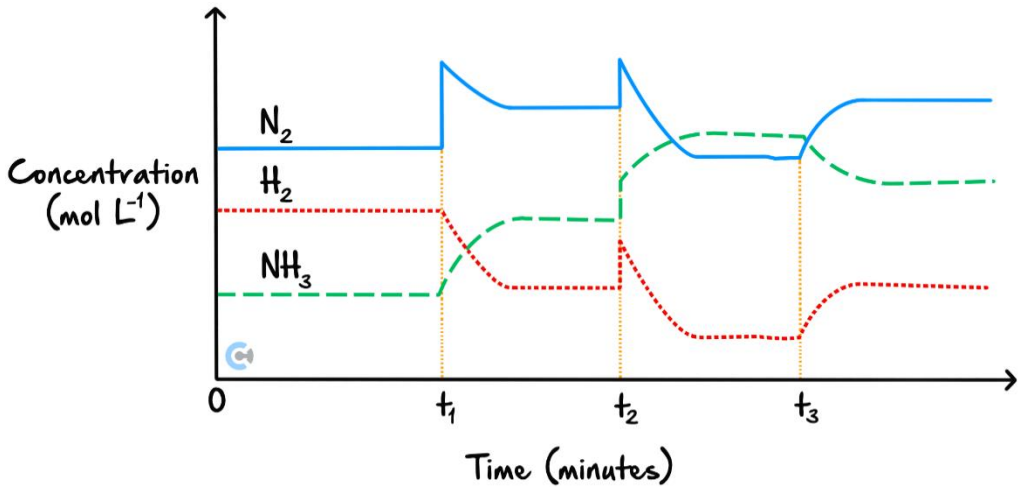
Action	**Equilibrium shift**	$[\mathbf{H_2}]$	$[\mathbf{O_2}]$	$[\mathbf{H_2O}]$	$\boldsymbol{K}$
Add H_2					
Add H_2O					
Remove O_2					
Increase temperature					
Increase pressure					
Add catalyst					

Space for Personal Notes

Question 2 (1 mark)

The reaction between nitrogen gas and hydrogen gas to produce ammonia is exothermic.

The graph below shows the changes that occur to an equilibrium mixture of hydrogen, nitrogen and ammonia when the system is removed from equilibrium:



Which of the following events occurred at the indicated times?

	t_1	t_2	t_3
A.	N_2 was added	N_2 and H_2 were added	Temperature increased
B.	NH_3 was added	N_2 and H_2 were added	Temperature decreased
C.	N_2 was added	Volume was decreased	Temperature increased
D.	N_2 was added	Volume was decreased	Temperature decreased

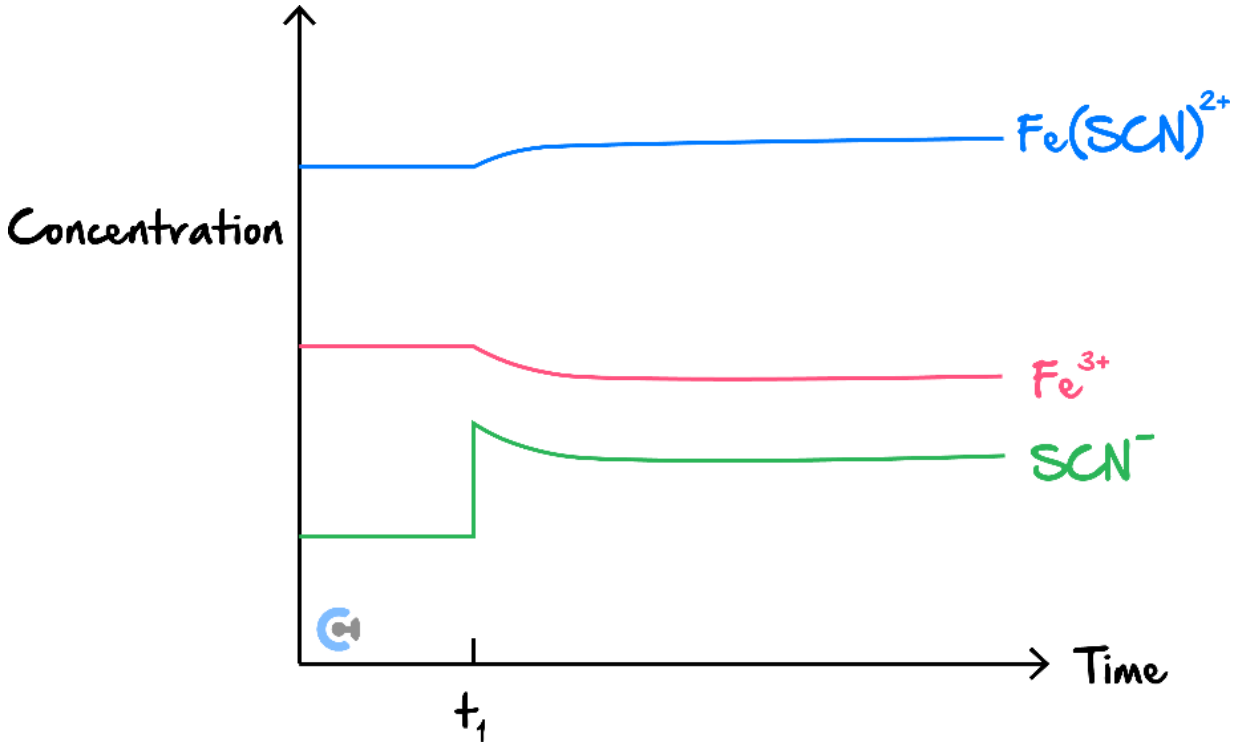
Space for Personal Notes

The following information applies to the two questions that follow.

$$\underset{\text{Yellow}}{Fe^{3+}(aq) + SCN^{-}(aq)} \rightleftharpoons \underset{\text{Deep red}}{Fe(SCN)^{2+}(aq)}$$

Question 3 (1 mark)

The concentration profile below represents a change to the above equilibrium system at a time t_1:



Which one of the following would account for the changes in concentration at a time t_1?

A. The addition of SCN^-.

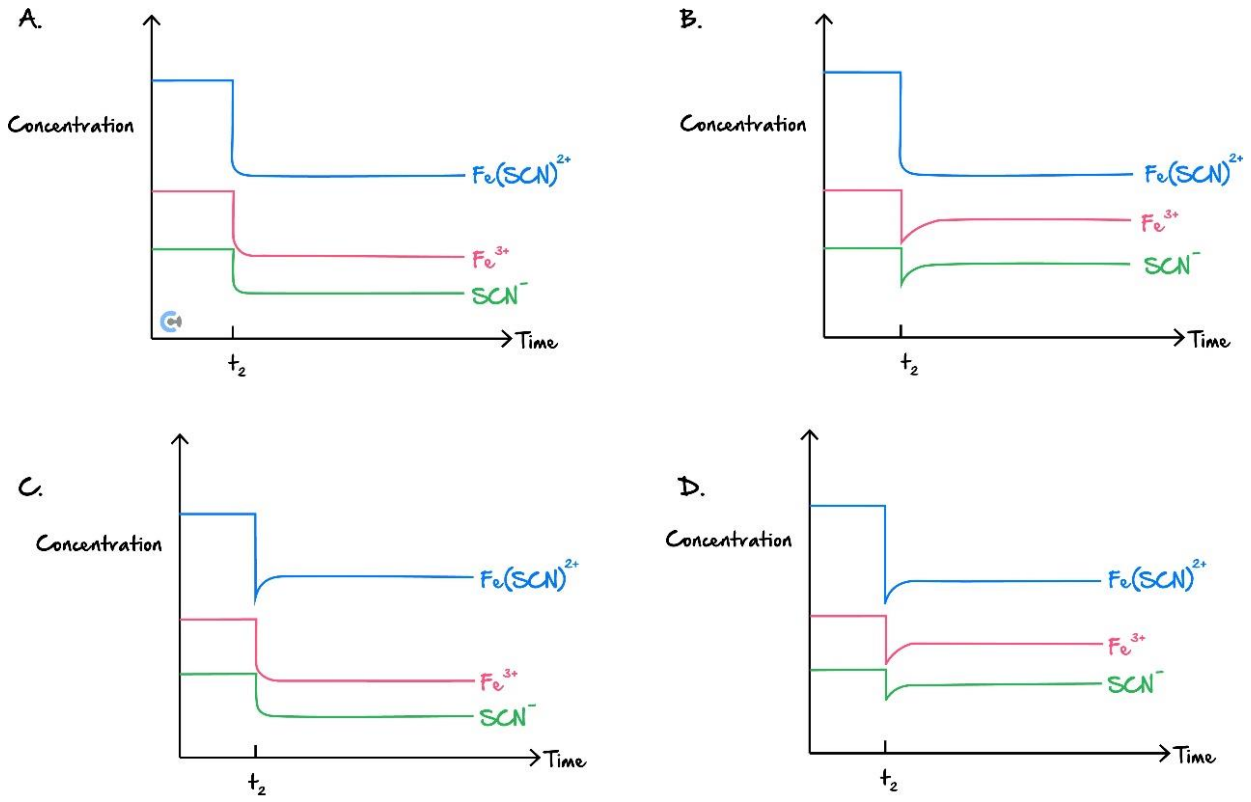
B. The removal of $Fe(SCN)^{2+}$.

C. An increase in temperature.

D. A decrease in temperature.

Question 4 (1 mark)

Which one of the following best represents the changes in concentration when the equilibrium mixture is diluted at a time t_2?



Question 5 (1 mark)

Which of the following will shift the position of equilibrium to the right in the Haber process?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = 92.6\ kJ$$

I. Decreasing the concentration of $NH_3(g)$.

II. Decreasing the temperature.

III. Increasing the pressure.

A. I and II only.

B. I and III only.

C. II and III only.

D. I, II and III.

Section B: Ramping Up (12 Marks)

INSTRUCTION: 12 Marks. 9 Minutes Writing.

Question 6 (5 marks)

Chlorine trifluoride, ClF_3, is used in the electronics industry to clean electronic circuit boards during their manufacture. It is produced by reacting chlorine and fluorine gases according to the following equation:

$$Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g) \quad \Delta H = -160\ kJ\ mol^{-1}$$

a.

i. Write an equilibrium constant expression for this reaction. (1 mark)

_____

ii. A reaction mixture is allowed to reach equilibrium at 400°C. It is determined that the equilibrium concentrations are $[Cl_2] = 0.173\ M$, $[F_2] = 0.419\ M$ and $[ClF_3] = 1.059\ M$.

Calculate the magnitude of the equilibrium constant at 400°C. (1 mark)

_____

_____

b. The manufacturers of chlorine trifluoride wish to maximise both the rate and the extent of the reaction as economically as possible. They decide to use higher temperatures, higher gas pressure and a suitable catalyst to achieve their aims.

Complete the table below by indicating whether or not the changes introduced to the reaction conditions would be successful. (3 marks)

	Improvement in rate? (yes or no)	**Improvement in extent? (yes or no)**
Increase in temperature		
Increase in pressure		
Addition of a catalyst		

Question 7 (7 marks)

Methanol can be manufactured from carbon monoxide and hydrogen. The reaction is a reversible one.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH \quad K = 3.4\,M^{-2} \text{ at } 440°C$$

Methanol is added to a 1 litre reactor at 440°C. The system is allowed to reach equilibrium, where the concentration of methanol is found to be $0.32\,M$.

a. Determine the carbon monoxide concentration. (3 marks)

_____

_____

_____

_____

_____

b. An equilibrium mixture of the three gases is at 440°C. The volume of the reactor is halved. Explain the impact of this change on each of the following:

i. The value of the equilibrium constant: _____. (1 mark)

ii. The position of equilibrium: _____. (1 mark)

iii. The amount of carbon monoxide: _____. (1 mark)

iv. The concentration of the carbon monoxide: _____. (1 mark)

Space for Personal Notes

Section C: Getting Trickier I (12 Marks)

INSTRUCTION: 12 Marks. 10 Minutes Writing.

The following information applies to the three questions that follow.

The following gaseous equilibrium is established at high temperature in the presence of a finely divided nickel (Ni) catalyst.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206\ kJ\ mol^{-1}$$

Question 8 (1 mark)

A particular reaction is carried out using equal amounts of $CH_4(g)$ and $H_2O(g)$.

Which one of the following sets of changes in conditions would lead to the most significant increase in the proportion of the reactants converted to products?

	Volume of reaction vessel	Temperature
A.	Increased	Increased
B.	Increased	Decreased
C.	Decreased	Increased
D.	Decreased	Decreased

Question 9 (1 mark)

This reaction occurs at a measurable rate only when the finely divided catalyst is present.

This catalyst increases the reaction rate because:

A. It strongly attracts the reaction products, driving the reaction to the right.

B. The reactants can become attached to its surface, where they can meet and undergo a reaction.

C. It provides energy to the reactants when their molecules bounce off it, increasing the proportion of molecules in the gas state with the required activation energy.

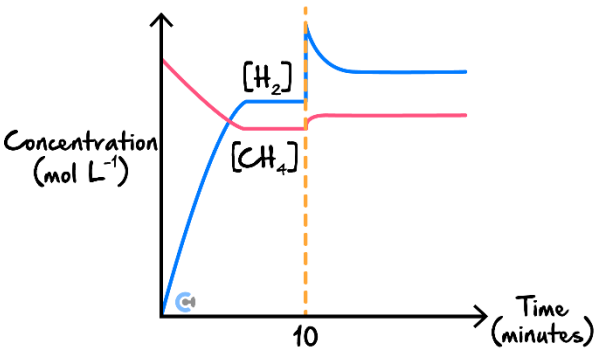
D. It increases the equilibrium constant of the reaction, causing an increase in the proportion at equilibrium.

Question 10 (1 mark)

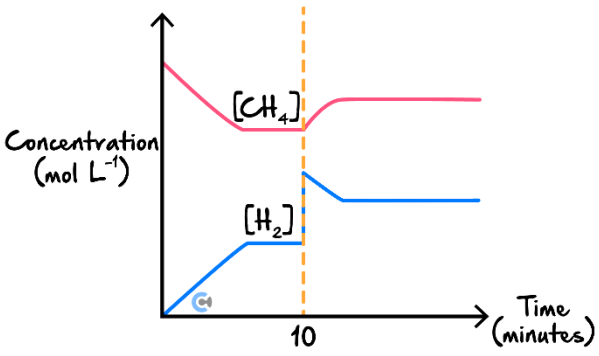
Equal amounts of $CH_4(g)$ and $H_2O(g)$ are added to a reaction vessel and allowed to react. After 10 minutes, equilibrium has been reached. At that time, some H_2 is added to the mixture, and equilibrium is re-established.

Which one of the following graphs best represents the changes in the amounts of CH_4 and H_2 in the reaction mixture?

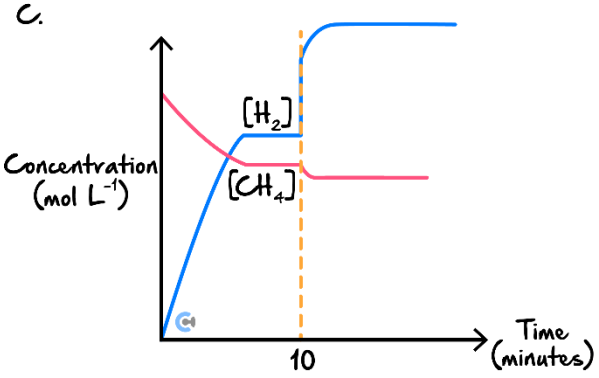
A.



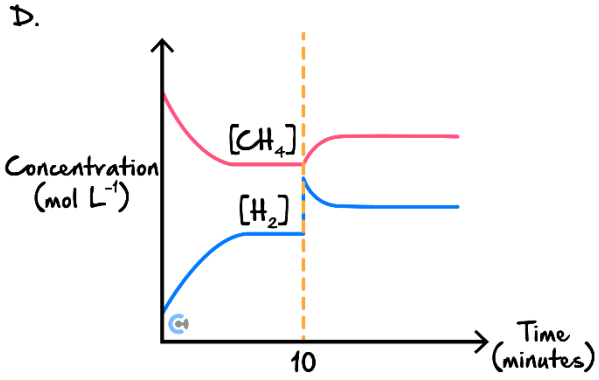
B.



C.



D.



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Question 11 (9 marks)

Inspired from VCAA Chemistry Exam 2021
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/NHT/2021chem-nht-w.pdf#page=24

5.0 mol of oxygen, O_2, and 10.0 mol of sulphur dioxide, SO_2 are injected into a 5.0 L evacuated and sealed container at standard laboratory conditions (SLC) and allowed to achieve equilibrium. The equation for this reaction is given below:

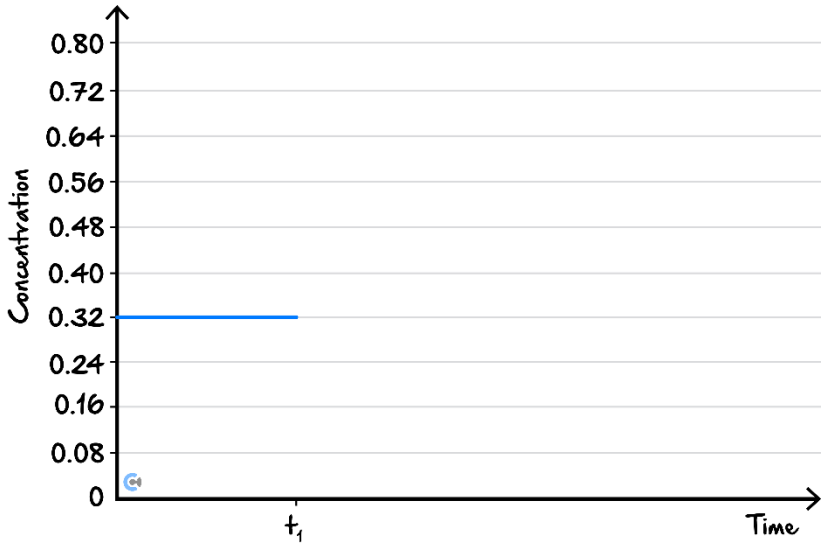
$$O_2(g) + 2SO_2(g) \rightleftharpoons 2SO_3(g)$$

a. At equilibrium, the concentration of O_2 is 0.32 M.

Calculate the equilibrium constant, K_c. (3 marks)

b. At time t_1 after equilibrium has been achieved, the volume of the container is expanded to $10.0\ L$ at constant temperature.

i. On the graph below, draw the concentration of O_2 after time t_1 until equilibrium is re-established. (2 marks)



ii. Justify your answer to **part b. i.** using Le Chatelier's principle. (2 marks)

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iii. What is the effect of the expansion of the container on the rate of the forward reaction? Give your reasoning using collision theory. (2 marks)

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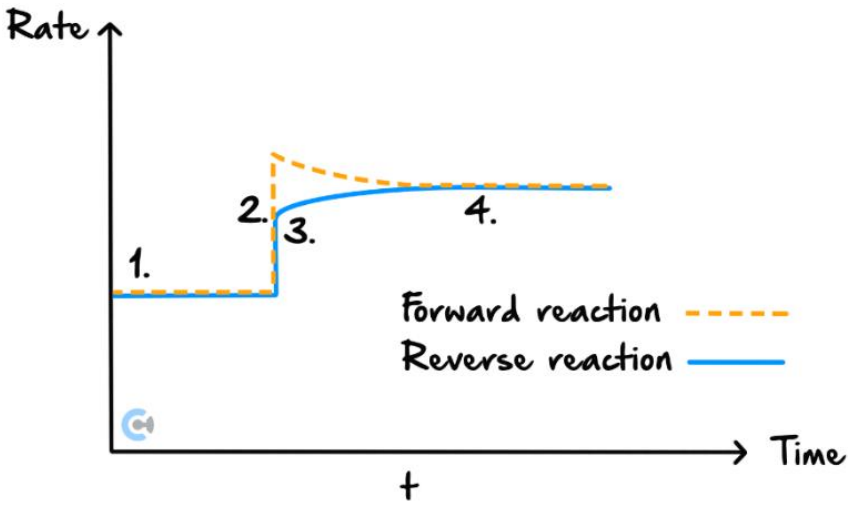
Section D: Getting Trickier II (8 Marks)

INSTRUCTION: 8 Marks. 7 Minutes Writing.

The following information applies to the two questions that follow.

The diagram below shows a rate-time graph for an equilibrium reaction:



Question 12 (1 mark)

The change in the rates at time ***t*** could be due to:

A. The addition of more reactant(s).

B. A temperature decrease.

C. The removal of some product(s).

D. A volume decrease.

Question 13 (1 mark)

To which of the following equilibria could the above rate-time graph apply?

A. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

B. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

C. $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$

D. $C_4H_{10}(g) \rightleftharpoons C_2H_4(g) + C_2H_6(g)$

Question 14 (6 marks)

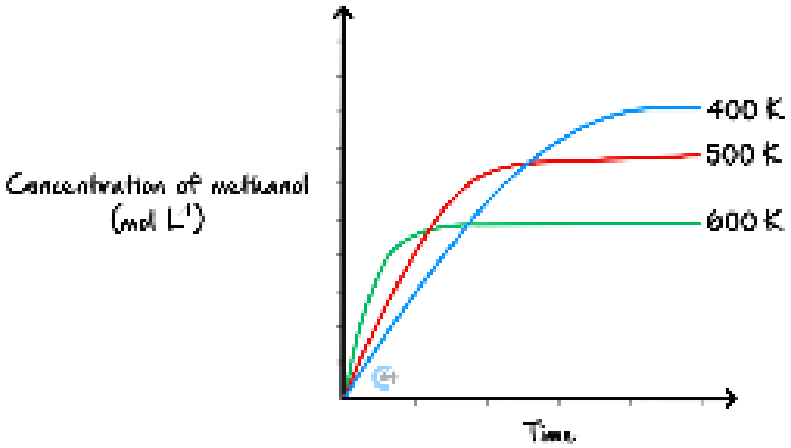
Methanol is produced on an industrial scale by the catalytic conversion of a mixture of hydrogen and carbon monoxide gases at a temperature of 520 K and a pressure of 50 to 100 atmospheres.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

a. Carbon monoxide gas and hydrogen gas are mixed in a reaction vessel, and equilibrium is established.

The graph below shows how the concentration of methanol in this vessel changes with time at three different temperatures.

The pressure is the same at each temperature.



i. Is the reaction exothermic or endothermic? Explain your answer. (2 marks)

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ii. Explain why a moderately high temperature of 520 K is used although the equilibrium concentration of methanol is greater at a low temperature. (1 mark)

_____

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iii. Explain why, at a given temperature, the use of high pressures results in a greater equilibrium concentration of methanol. (2 marks)

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b. A catalyst consisting of a mixture of copper, zinc and aluminium is used to increase the rate of this reaction. Explain how a catalyst can increase the reaction rate. (1 mark)

_____

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_____

Let's take a BREAK!

Space for Personal Notes

Section E: VCAA-Level Questions I (8 Marks)

INSTRUCTION: 8 Marks. 30 Seconds Reading. 8 Minutes Writing.

Question 15 (8 marks)

Inspired from VCAA Chemistry Exam 2017
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2017/2017chem-w.pdf#page=21

Sulphur trioxide, SO_3, is made by the reaction of sulphur dioxide, SO_2, and oxygen, O_2, in the presence of a catalyst, according to the equation below:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$

In a closed system in the presence of the catalyst, the reaction quickly achieves equilibrium at 1000 K.

a. A mixture of 2.00 mol of $SO_2(g)$ and 2.00 mol of $O_2(g)$ was placed in a 4.00 L evacuated, sealed vessel and kept at 1000 K until equilibrium was reached. At equilibrium, the vessel was found to contain 1.66 mol of $SO_3(g)$. Calculate the equilibrium constant, K_c, at 1000 K. (4 marks)

b. A manufacturer of SO_3 investigates changes to the reaction conditions used in **part a.** in order to increase the percentage yield of the product in a closed system, where the volume may be changed, if required. What changes would the manufacturer make to the temperature and volume of the system in order to increase the percentage yield of SO_3? Justify your answer. (4 marks)

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Space for Personal Notes

Section F: Multiple Choice Questions (10 Marks)

INSTRUCTION: 10 Marks. 10 Minutes Writing.

Question 16 (1 mark)

The equilibrium between nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4, is shown below:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad K_c = 0.01$$

What happens when the volume of a mixture at equilibrium is decreased at a constant temperature?

I. The value of K_c increases.

II. More N_2O_4 is formed.

III. The ratio of $\frac{[NO_2]}{[N_2O_4]}$ decreases.

A. I and II only.

B. I and III only.

C. II and III only.

D. I, II and III.

Question 17 (1 mark)

Consider the following reaction:

$$4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + Cl_2(g) \qquad \Delta H < 0$$

Which of the following steps would increase the yield of chlorine gas from this reaction?

A. Increasing the temperature.

B. Adding an inert gas such as argon.

C. Adding a suitable catalyst.

D. Increasing the gas pressure.

Question 18 (1 mark)

Consider the equilibrium system $N_2O_4\,(g) \rightleftharpoons 2NO_2(g)$.

If the volume of a sample of this equilibrium mixture was halved and the temperature restored to its original value, it would be expected that, when equilibrium was established in the smaller volume, the:

A. $[NO_2]$ would have increased, and the $m(NO_2)$ would have increased.

B. $[NO_2]$ would have increased even though the $m(NO_2)$ would have decreased.

C. $[NO_2]$ would have decreased, and the $m(NO_2)$ would have decreased.

D. $[NO_2]$ would have decreased even though the $m(NO_2)$ would have increased.

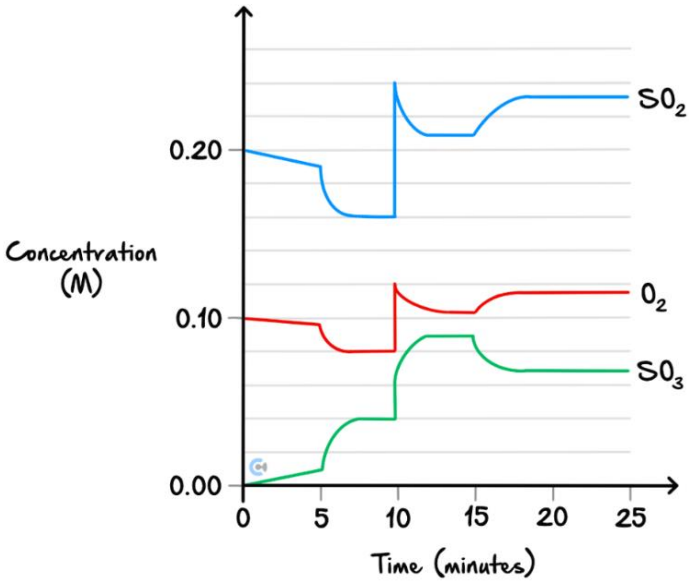
Space for Personal Notes

The following information applies to the two questions that follow.

Sulphur dioxide gas and oxygen were placed in a sealed container, and a reaction occurred according to the equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H \text{ is negative}$$

Various changes were made to the system at different times during the experiment, and the results were plotted as shown in the diagram below:



Question 19 (1 mark)

What change was made to the system at $t = 5$ minutes?

A. The volume of the container was decreased.

B. Heat was added to the system.

C. Some sulphur trioxide gas was removed.

D. A suitable catalyst was introduced.

Question 20 (1 mark)

Between the times 0 and 25 minutes, the equilibrium constant has:

A. Only one value.

B. Only two different values.

C. Only three different values.

D. More than three different values.

Question 21 (1 mark)

For which of the following reactions would an increase in temperature and volume improve the yield of the product?

A. $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$ $\Delta H = -564\ kJ\ mol^{-1}$

B. $C_3H_8(g) + 5O_2(g) \rightleftharpoons 3CO_2(g) + 4H_2O(g)$ $\Delta H = -2217\ kJ\ mol^{-1}$

C. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ $\Delta H = +125\ kJ\ mol^{-1}$

D. $CO_2(g) + 2H_2O(g) \rightleftharpoons CH_4(g) + 2O_2(g)$ $\Delta H = +868\ kJ\ mol^{-1}$

Question 22 (1 mark)

The anaesthetic, nitrous oxide, N_2O, decomposes to form an equilibrium mixture of N_2O, N_2 and O_2 according to the following equation:

$$2N_2O(g) \leftrightharpoons 2N_2(g) + O_2(g)$$

At 25°C, $K = 7.3 \times 10^{37}\ M$ and at 40°C, $K = 2.7 \times 10^{36}\ M$.

What valid conclusion can be made from this?

A. The equilibrium concentrations of N_2 and O_2 are equal to 25°C.

B. The equilibrium concentration of N_2O is higher at 25°C than at 40°C.

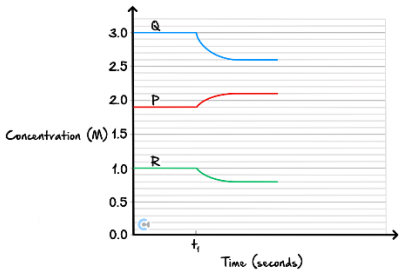
C. N_2O is less stable at higher temperatures.

D. The forward reaction is exothermic.

Space for Personal Notes

Question 23 (1 mark)

The following concentration-time graph refers to a mixture of three gases, P, Q and R, in an enclosed 5.0 L container. At time t_1 the mixture is heated.



The equilibrium system that represents the graph is:

A. $P(g) \rightleftharpoons 2Q(g) + R(g)$ and the forward reaction is exothermic.

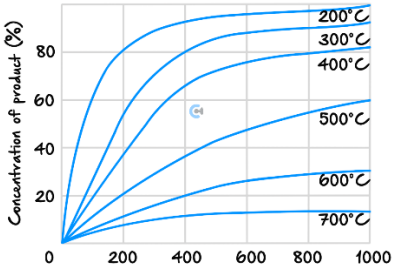
B. $2Q(g) \rightleftharpoons P(g) + R(g)$ and the forward reaction is endothermic.

C. $2Q(g) + R(g) \rightleftharpoons P(g)$ and the forward reaction is exothermic.

D. $P(g) + 2Q(g) \rightleftharpoons R(g)$ and the forward reaction is endothermic.

Question 24 (1 mark)

Temperature and pressure are key factors in the production of common chemicals via equilibrium reactions. The data below shows the relationships between the percentage yield of product, temperature and pressure for the industrial production of a particular chemical.



According to these data:

A. The forward reaction is exothermic, and the product is on the side with fewer particles.

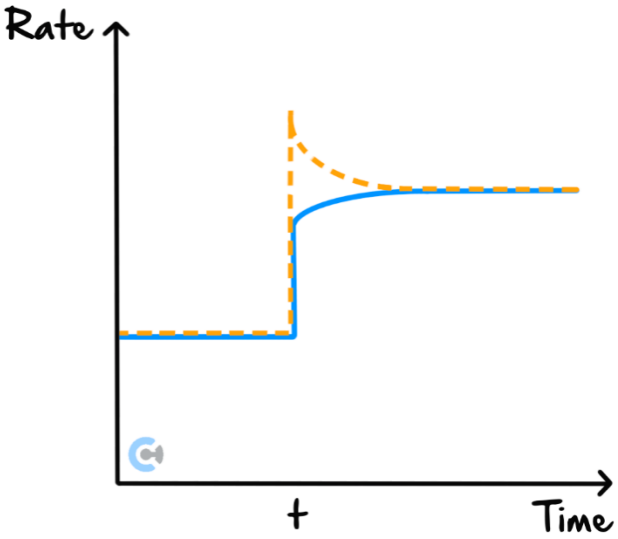
B. The forward reaction is endothermic, and the product is on the side with more particles.

C. The forward reaction is exothermic, and the product is on the side with more particles.

D. The forward reaction is endothermic, and the product is on the side with fewer particles.

Question 25 (1 mark)

The impact of a change imposed at time ***t***, on an $2NO_2(g) \rightleftharpoons N_2O_4(g)$ equilibrium mixture is shown on the rate-time graph below:



The change imposed on the system was:

A. Addition of $NO_2(g)$.

B. Addition of $N_2O_4(g)$.

C. Increase of container volume.

D. Decrease of container volume.

Space for Personal Notes

Section G: VCAA-Level Questions II (7 Marks)

INSTRUCTION: 7 Marks. 30 Seconds Reading. 7 Minutes Writing.

Question 26 (7 marks)

Consider the reaction shown in the following equation:

$$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g) \qquad \Delta H = -16.1\ kJ\ mol^{-1}, K_C = 1.3 \times 10^{-2} M^{-1} \text{ at } 1000\ K$$

a. Write an expression for the equilibrium constant for this reaction. (1 mark)

_____

_____

b. 10.0 mol of NOBr, 10.0 mol of NO and 5.0 mol of Br_2 are placed in a 1.0 L container at 1000 K.

Predict in which direction the reaction will proceed. Justify your answer. (3 marks)

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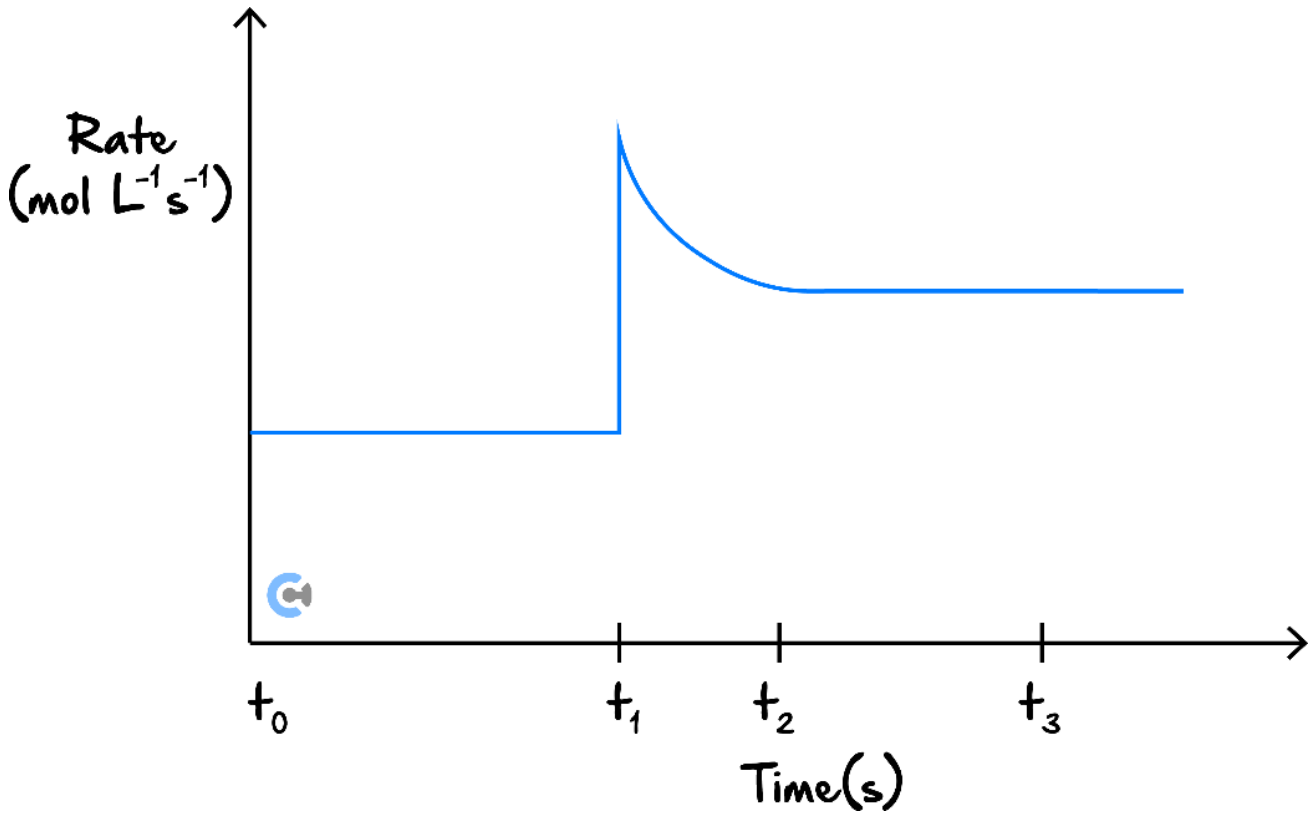
c. A mixture of NO, NOBr and Br_2 is initially at equilibrium.

The following graph shows how the **rate** of formation of NOBr in the mixture changes when the volume of the reaction vessel is decreased at time t_1.



Use collision theory and factors that affect the rate of a reaction to explain the shape of the graph at the time intervals indicated in the following table. (3 marks)

Time	Explanation
Between t_0 and t_1	
At t_1	
Between t_1 and t_2	

Section H: Extension Questions (14 Marks)

Question 27 (8 marks)

A mixture of hydrogen gas and iodine gas is injected into a vessel that is then sealed. The mixture will establish an equilibrium system as described by the following equation:

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$$

a. In an experiment, 3.00 mol of iodine and 2.00 mol of hydrogen was added to a 1.00 L reaction vessel. The amount of iodine present at equilibrium was 1.07 mol. A constant temperature was maintained in the reaction vessel throughout the experiment.

i. Write the expression for the equilibrium constant for this reaction. (1 mark)

_____

_____

ii. Determine the equilibrium concentrations of hydrogen and hydrogen iodide, and calculate the value of the equilibrium constant. (3 marks)

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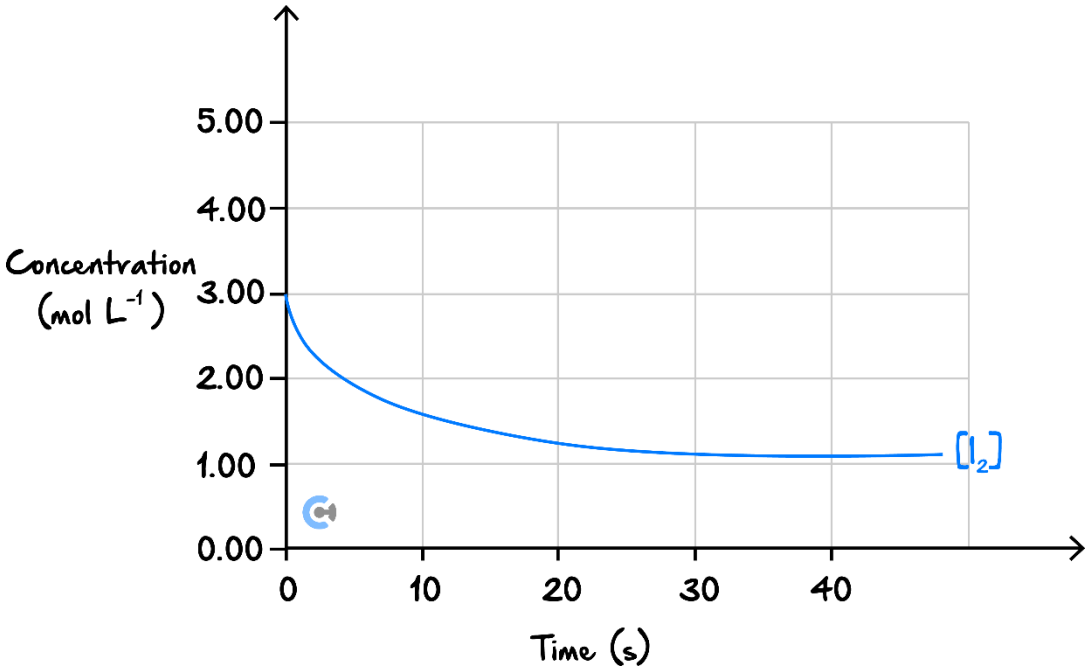
b. A graph of the decrease in the concentration of I_2 until equilibrium is effectively reached is shown in the figure below.

i. On the figure below, draw clearly labelled graphs to show how the concentrations of H_2 and HI changed over the same period of time. (2 marks)



ii. Indicate on the above figure, as well, how the I_2 concentration would have changed if a catalyst had been added to the vessel as well. Assume all other conditions remain the same. (2 marks)

Space for Personal Notes

Question 28 (6 marks)

Annual global methanol production exceeds 50 million tonnes. Each day, well over 100,000 tonnes of methanol are used as either chemical feedstock or fuel. Methanol is produced from a variety of feedstocks, including natural gas, coal and biomass. Production of methanol from natural gas requires the production of synthesis gas (a mixture of carbon monoxide and hydrogen). Methanol is produced from synthesis gas according to the equilibrium:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\ kJ\ mol^{-1}$$

The catalyst used is a mixture of copper, zinc oxide and alumina.

a. What are two advantages arising from the use of the catalyst in methanol production? (2 marks)

_____

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b. A sample of synthesis gas containing 0.240 mol of carbon monoxide and 0.380 mol of hydrogen was allowed to come to equilibrium in a 5.00 L reaction vessel. At equilibrium 0.170 mol of carbon monoxide was present. Determine the value of the equilibrium constant at the temperature of the equilibrium. (3 marks)

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c. When the temperature of the equilibrium established in **part b.** was altered, the value of the equilibrium constant was found to increase. Was the temperature increased or decreased? Explain your choice. (1 mark)

_____

_____

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- 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	Text-Based Support
➢ Book via bit.ly/contour-chemistry-consult-2025 (or QR code below). ➢ One active booking at a time (must attend before booking the next).	➢ Message +61 440 137 304 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