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VCE Chemistry ¾
Le Chatelier's Principle [2.8]
Test Solutions

20 Marks. 1 Minute Reading. 17 Minutes Writing.

Results:

Test Questions	_____/ 15
Extension	_____/ 5

Section A: Test Questions (15 Marks)

Question 1 (3 marks)

Tick whether the following statements are **true** or **false**.

Statement	True	False
a. According to Le Chatelier's Principle, a system at equilibrium can completely offset any changes imposed.		✓
b. When ions are added to an aqueous equilibrium mixture, there may be an effect on the concentration of some pre-existing species within the system.	✓	
c. If one of the reactants is added to a system already at equilibrium, the forwards reaction will always be favoured.	✓	
d. Both Le Chatelier's Principle and a comparison between Q_c and K_c can be used at any point in time for an equilibrium system to determine which reaction is being favo		✓
e. When there is a change in volume, the initial change in concentration of the species is dependent on the stoichiometric ratios present in the balanced equation.		✓
f. When a reversible equation has the same number of particles on both sides of the equation, an overall pressure change will not change the position of equilibrium.	✓	

LCP cannot be used unless a change was instantiated; if the system is just reacting and not yet at equilibrium, we can only use Q_c vs K_c analysis.

Space for Personal Notes

Question 2 (1 mark)

In which one of the following would the position of the equilibrium not be affected by a volume change at constant temperature?

A. $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$

B. $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

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

D. $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$

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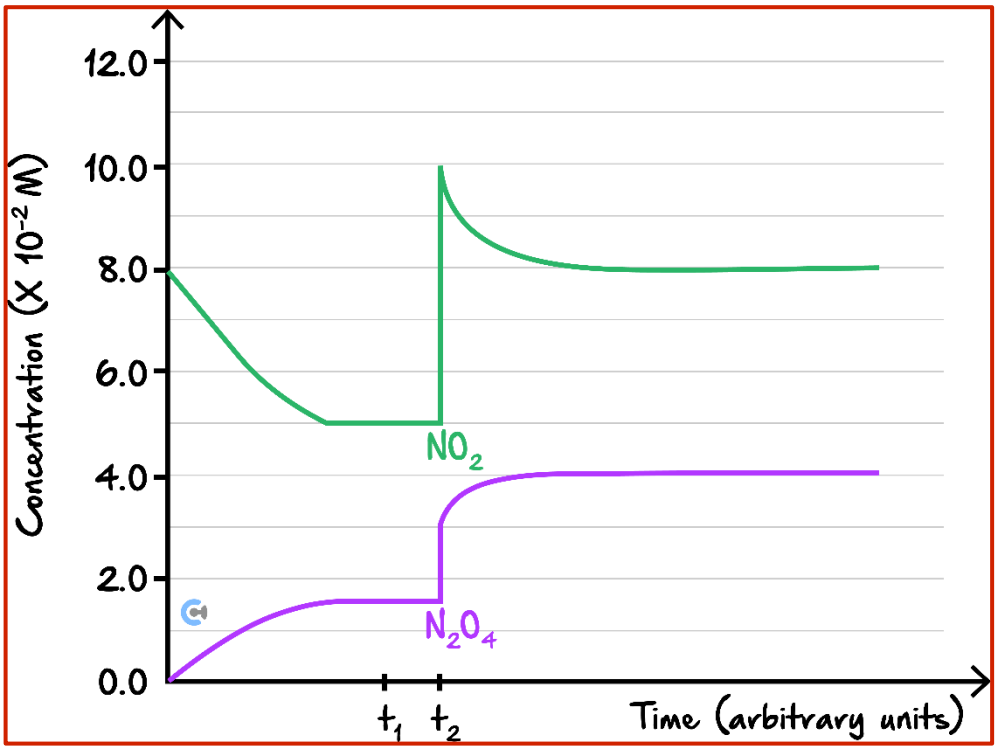
Question 3 (5 marks)

A student is investigating the following reaction system:

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H < 0$$

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



a. Time t_1 is shown in the graph above. Calculate the equilibrium constant at a time t_1. (2 marks)

$K = [N_2O_4] / [NO_2]^2$

$= 1.5 \times 10^{-2}/(5.0 \times 10^{-2})^2$

$= 6.0\ M^{-1}$

Marks	0	1	2	Average
%	22	48	30	1.1

Most students identified the equilibrium law but many either misread the concentrations from the graph or did not include the appropriate unit for the value of the equilibrium constant. The ability to read graphical data accurately is a fundamental skill.

b. 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)

Marks	0	1	2	3	Average
%	30	28	20	21	1.4

Students were awarded one mark each for:

- showing $[NO_2]$ doubled to $10.0(\times10^{-2})$ M and $[N_2O_4]$ doubled to $3.0(\times10^{-2})$ M
- showing subsequent adjustments in correct directions, NO_2 decrease and N_2O_4 increase
- showing change in $[NO_2]$ double that of N_2O_4 during return to equilibrium.

Students were not expected to determine the exact concentrations at which the system returned to equilibrium.

Space for Personal Notes

Question 4 (6 marks)

The way in which equilibrium responds to changes is being investigated by making multiple changes to the system involving the dissociation of carbonic acid:

$$H_2CO_3(aq) \rightleftharpoons 2H^+(aq) + CO_3^{2-}(aq)$$

a. If water were added to the system above - which is already at equilibrium - explain what would happen to the concentration of CO_3^{2-} from immediately after the change up until equilibrium is re-established. (3 marks)

Concentration of all species, including CO_3^{2-}, decrease, as the system is diluted. (1)

Le Chatelier's Principle states that the system will try to oppose this change by partially opposing it by increasing overall concentration. (2)

Therefore, the forwards reaction will be favoured (more particles), increasing $[CO_3^{2-}]$, but it is still lower than the original $[CO_3^{2-}]$ as the change was only partially opposed. (3)

b. If a solution of sodium hydroxide, NaOH(aq) were added to the system, explain what would happen to the concentration of H^+ from immediately after the change up until equilibrium is re-established, and consequently, to the overall effect on the pH as a result. (3 marks)

Concentration of H^+ decreases as it will react with the OH^- and be consumed. (1)

Le Chatelier's Principle states that the system will try to oppose this change by partially opposing it by increasing $[H^+]$. (2)

Therefore, the forwards reaction will be favoured, increasing $[H^+]$ but it is still lower than the original $[H^+]$ as the change was only partially opposed → less acidic → pH will increase. (3)

Space for Personal Notes

Section B: Extension (5 Marks)

Question 5 (5 marks)

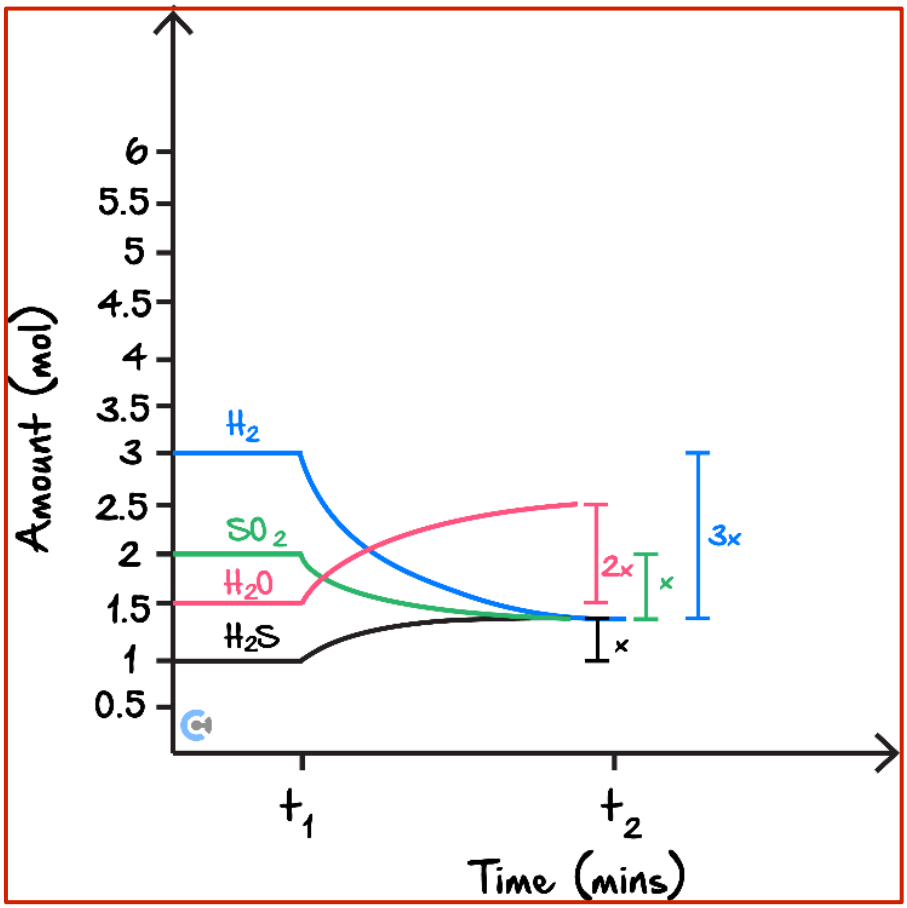
Aliya is investigating the following homogenous equilibrium system:

$$H_2S(g) + 2H_2O(g) \rightleftharpoons SO_2(g) + 3H_2(g) \qquad K_c = 23.9\,M$$

Once equilibrium is established, Aliya tampers with the system by halving the volume of the vessel. Assume there is no effect on the temperature of the system.

a.

i. Sketch the amount-time graph below, where t_1 represents the point in time where Aliya halved the volume, and t_2 represents the point at which equilibrium is re-established. (2 marks)

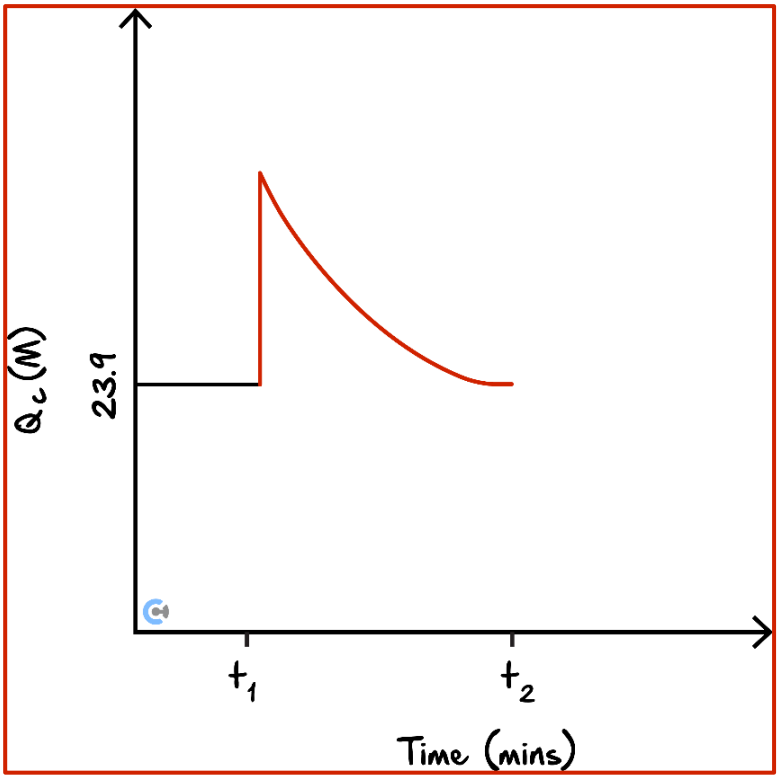


ii. Hence, or otherwise, outline what effect the imposed change had on the overall yield of hydrogen gas. (1 mark)

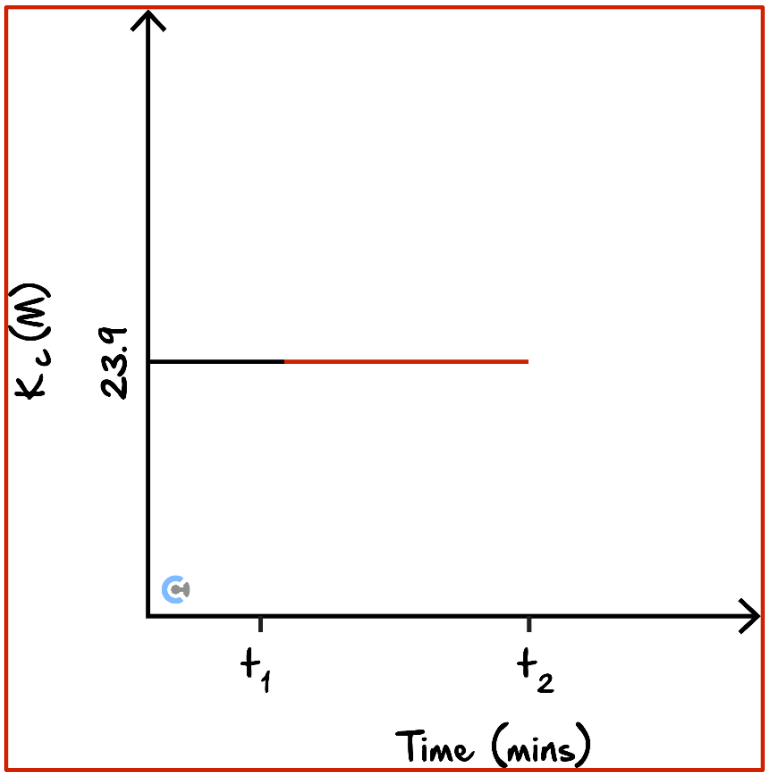
Decreased. The change did nothing to $n(H_2)$, but the change caused $n(H_2)$ to decrease since the reverse reaction was favoured.

b. For the same change described above, graph the following relationships.

i. Q_c against time. (1 mark)



ii. K_c against time. (1 mark)



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