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VCE Chemistry ¾
AOS 2 Revision II [2.10]
Test Solutions

20 Marks. 1 Minute Reading. 16 Minutes Writing

Results:

Test Questions	_____ / 15
Extension Questions	_____ / 5

Section A: Test Questions (15 Marks)

Question 1 (3 marks)

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

Statement	True	False
a. Adding a catalyst increases the rate of reaction by increasing the frequency of total collisions and thus the frequency of successful collisions.		✓
b. Adding an inert gas to a vessel increases the overall pressure and the frequency of total collisions, but does not impact the rate of reaction.	✓	
c. At equilibrium, the concentrations of all species are equal to one another and remain constant.		✓
d. If $Q_c = K_c$, the rates of the forward and reverse reactions are equal at this point in time.	✓	
e. If an inert gas is added to a system at equilibrium, there is no effect on the position of equilibrium.	✓	
f. When the temperature is increased to a system at equilibrium, it will partially oppose the change by favouring the exothermic reaction.		✓

Space for Personal Notes

Question 2 (6 marks)

A deadly, toxic gas, phosgene, with the chemical formula, $COCl_2$, can be produced via the reversible reaction between chlorine and carbon monoxide as such:

$$Cl_2(g) + CO(g) \rightleftharpoons COCl_2(g) \qquad \Delta H = -220\ kJ/mol$$

a. Explain how the use of a catalyst would affect the **yield** of phosgene. (2 marks)

Yield would be unaffected. (1)
This is because catalysts increase the rates of both forwards and reverse reactions by the same amount. (2)

b.

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

$$K_c = \frac{[COCl_2]}{[Cl_2][CO]}$$

ii. Hence, if the equilibrium constant for this reaction is $20\ M^{-1}$ at SLC, and at a certain point in time, the concentrations of the species are: $[Cl_2] = 2.3\ M, [CO] = 21.2\ M, [COCl_2] = 319\ M$, determine whether the system is at equilibrium. If it is not, state how the position of equilibrium would shift. (2 marks)

$Q_c = \frac{319}{2.3 \times 21.2} = 6.5\ M^{-1}$ (2 s.f.)

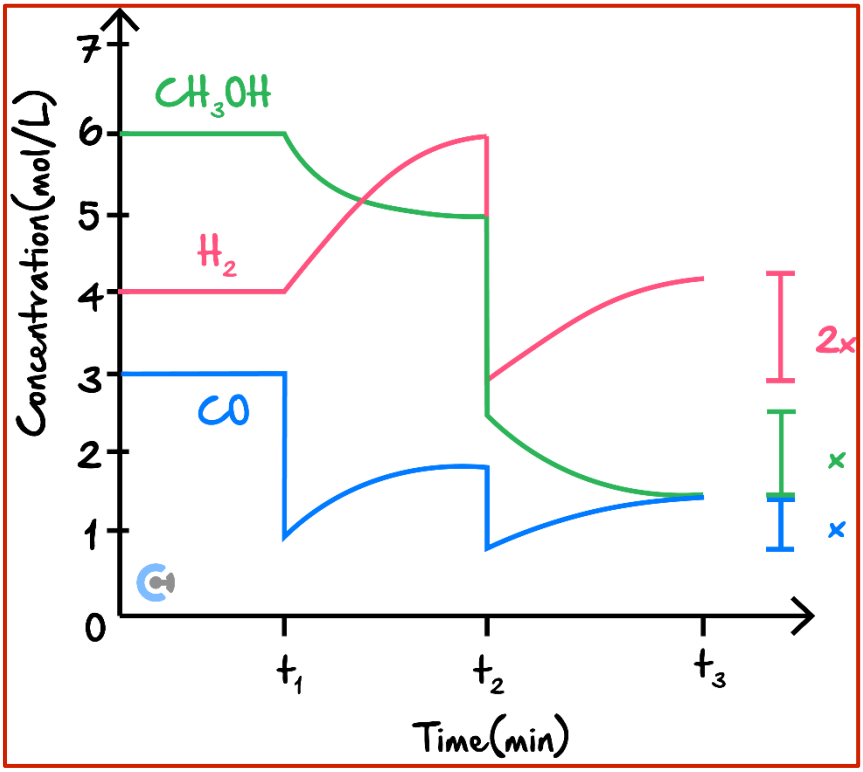
Since $Q_c \neq K_c$, system is not @ equilibrium. Since $Q_c < K_c$, the system will shift to the right

c. Based on the equilibrium constant for this reaction at SLC mentioned in **part b.ii.,** briefly comment on its extent of reaction. (1 mark)

As $10^{-4} < K_c < 10^{4}$, there is a moderate extent of reaction; there is a substantial amount of both reactants and products at equilibrium.

Question 3 (6 marks)

For the system, $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$, the following concentration-time graph is provided:



a. State what change must have been made at the time t_1. (1 mark)

Removal of $CO(g)$.

b. Complete the graph from time t_2 until the equilibrium is re-established at time t_3, if the volume of the vessel is doubled at t_2. (2 marks)

c.

i. If a third change was made at t_3 – a decrease in temperature – resulting in an increase in the amount of $CH_3OH(g)$, explain what the enthalpy of the forward reaction must be. (2 marks)

Decrease in T → system will partially oppose this by increasing the temperature, and as such, will favour the exothermic reaction. Since $n(CH_3OH)$ increased, the forwards reaction must have been favoured, and thus, the forwards reaction must be the exothermic one.

ii. Hence, explain what temperature conditions should be used in industry for this reaction so as to optimise the amount of CH_3OH, as well as the speed at which it is evolved. (1 mark)

Moderate temperatures should be used to deal with rate-time conflict → High T for rate, low T for yield, so we need to meet in the middle.

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Section B: Extension Questions (5 Marks)

Question 4 (5 marks)

Harrison is investigating the following equilibrium system in solution:

$$HCN(aq) \rightleftharpoons H^+(aq) + CN^-(aq)$$

a. If the solution is diluted by adding water, explain the effect on the:

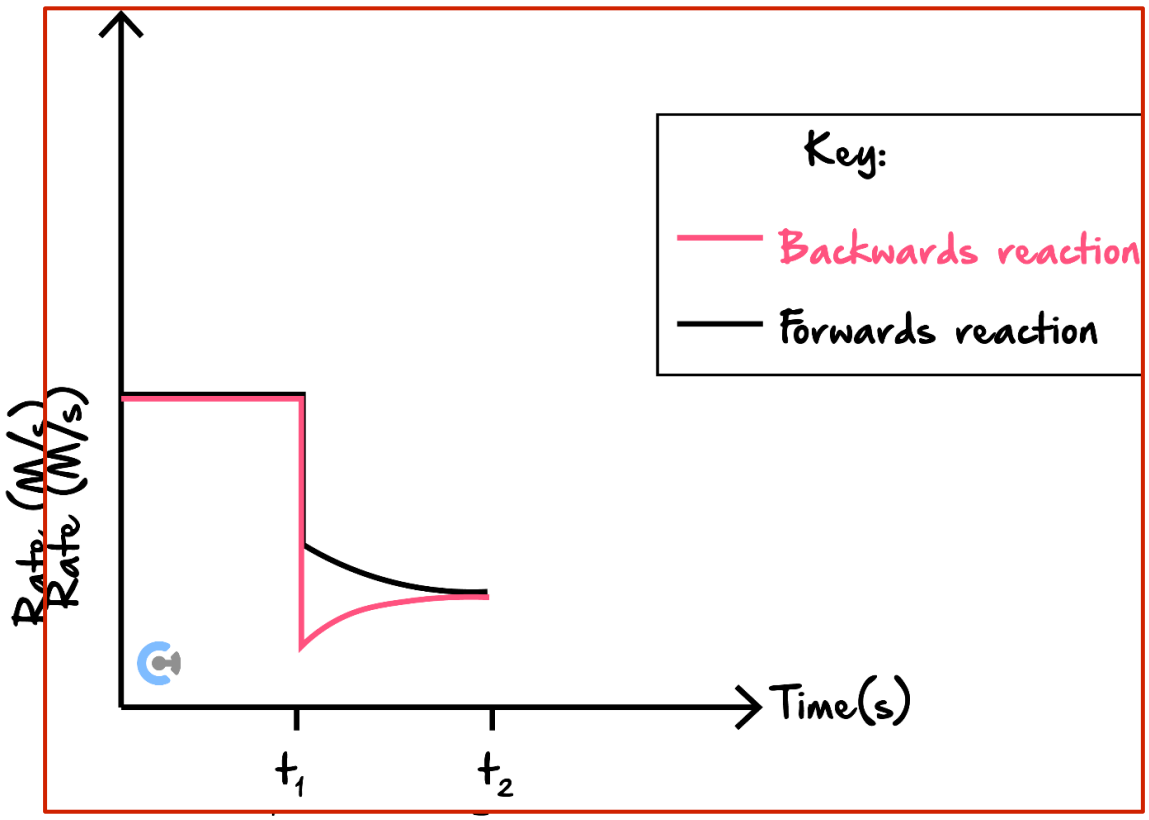
i. Amount of $H^+(aq)$. (2 marks)

No initial effect on $n(H^+)$. To oppose the decrease in concentration, the system will partially oppose the change by increasing concentration by favouring the side with more particles (products). As such, $n(H^+)$ increases.

ii. Concentration of $CN^-(aq)$. (2 marks)

Initially, $[CN^-]$ will drop. To oppose the decrease in concentration, the system will partially oppose the change by increasing concentration by favouring the side with more particles (products). As such $[CN^-]$ partially increases, **but is still lower than before the change.**

b. Draw the effect on the rates of the forward and reverse reactions on the set of axes below, when the volume of solution is increased via the addition of water at t_1. (1 mark)



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