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VCE Chemistry ¾

AOS 2 Revision (Rates & Equilibrium) [2.0]

SAC 2

51 Marks. 13 Minutes Reading. 76.5 Minutes Writing.

Section A: Multiple Choice Questions (5 Marks)

Question 1 (1 mark)

The reaction shown below is a reversible one:

$$2COF_2(g) \rightleftarrows CO_2(g) + CF_4(g)$$

A change in temperature to an equilibrium mixture causes the amount of CO_2 present to decrease from 1.2 mol to 0.9 mol. When this occurs, the:

A. Amount of CF_4 decreases by 0.3 and the amount of COF_2 increases by 0.6 mol.

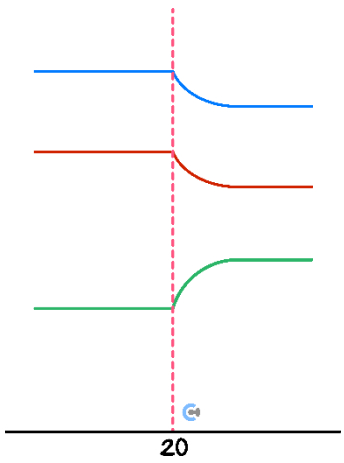
B. Amount of CF_4 decreases by 0.3 and the amount of COF_2 increases by 0.3 mol.

C. Amount of CF_4 decreases by 0.9 and the amount of COF_2increases by 1.8 mol.

D. Amount of CF_4 decreases by 1.2 and the amount of COF_2increases by 2.4 mol.

Question 2 (1 mark)

At the 20-minute mark, a change is made to an equilibrium mixture. The effect on the concentrations of this change is shown in the graph below:



The change at the 20-minute mark was:

A. A change in the temperature.

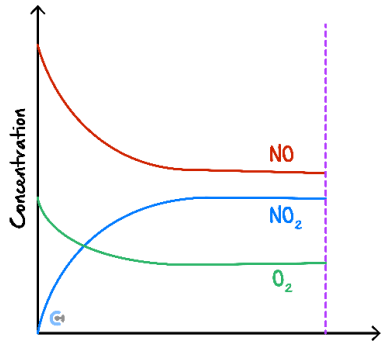
B. The addition of a catalyst.

C. A decrease in volume.

D. A decrease in pressure.

Question 3 (1 mark)

The concentrations of the components of an equilibrium system are shown in the graph below:



The equation for the reaction is:

A. $2NO_2(g) \rightleftarrows 2NO(g) + O_2(g)$

B. $NO(g) + O_2(g) \rightleftarrows NO_2(g)$

C. $2NO(g) + O_2(g) \rightleftarrows 2NO_2(g)$

D. $2NO_2(g) + O_2(g) \rightleftarrows 2NO(g)$

Question 4 (1 mark)

The manufacture of sulphuric acid requires the conversion of SO_2 to SO_3:

$$2SO_2(g) + O_2(g) \rightleftarrows 2SO_3 \qquad \Delta H = -300\ kJ\ mol^{-1}$$

I. Increase in pressure.

II. Addition of a catalyst.

III. Use of extra oxygen.

IV. Increase in temperature.

Which of the above changes will lead to an improved yield of SO_3?

A. I only.

B. I and II only.

C. II and IV only.

D. I, III and IV.

Question 5 (1 mark)

Hydrogen iodide can be formed from the reaction between hydrogen and iodine:

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

A sharp decrease in volume is applied to an equilibrium mixture of these gases. This change will cause:

A. No change to the equilibrium mixture.

B. The concentrations of each species drop, but there is no change in the position of equilibrium.

C. No change in the value of K but it will favour the forward reaction.

D. The pressure of iodine increases.

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Section B: Short Answer Questions (46 Marks)

Question 6 (6 marks)

A red complex, $FeSCN^{2+}(aq)$, is formed from the reaction between iron ions and thiocyanate ions:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftarrows FeSCN^{2+}(aq)$$

a. Water is added to an equilibrium mixture. Explain the impact this has on the intensity of the red colour. (2 marks)

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b. A few drops of KSCN are added to an equilibrium mixture.

i. Explain the impact of this change on the equilibrium constant value. (1 mark)

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ii. State how the final concentration of SCN^{-} compares to the original concentration. (1 mark)

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c. An equilibrium mixture is heated, and the intensity of the red increases. Is this reaction exothermic or endothermic? Explain your answer. (2 marks)

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Question 7 (6 marks)

The equation for the decomposition of nitrosyl bromide is:

$$2\text{NOBr(g)} \rightleftarrows 2\text{NO(g)} + \text{Br}_2\text{(g)}$$

The equilibrium constant at $350°\text{C}$ is $0.032\ M$

a. Determine the value of K for each of the following reactions:

i. $4\text{NOBr(g)} \rightleftarrows 4\text{NO(g)} + 2\text{Br}_2\text{(g)}$. (1 mark)

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ii. $\text{NO(g)} + \frac{1}{2}\text{Br}_2\text{(g)} \rightleftarrows \text{NOBr(g)}$. (1 mark)

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b. A 2.0 L reactor contains 4 mol of NOBr, 4 mol of NO and 2 mol of Br_2. Which way does the reaction have to favour for equilibrium to be reached, or is the mixture already at equilibrium? (2 marks)

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c. 5.0 mol of NOBr is introduced to an empty reactor.

i. Will 2.5 mol of Br_2 form? Explain your answer. (1 mark)

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ii. If the amount of NO to form was found to be 0.20 mol, what amount of Br_2 was formed? (1 mark)

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Question 8 (6 marks)

The equilibrium reaction of ammonia with oxygen is shown below by the equation:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Exactly 5.00 mol of ammonia and 10.00 mol of oxygen are heated in a closed 2.00 L sealed container. The reaction reaches equilibrium after 4.0 min.

a. If the reaction mixture contained exactly 2.50 mol of $NO(g)$ when the system first reaches equilibrium, calculate the value of the equilibrium constant (K_c) at this temperature. (4 marks)

b. Temperature is decreased at 8.0 min. State the effect this has on the K_c value. Justify your answer. (2 marks)

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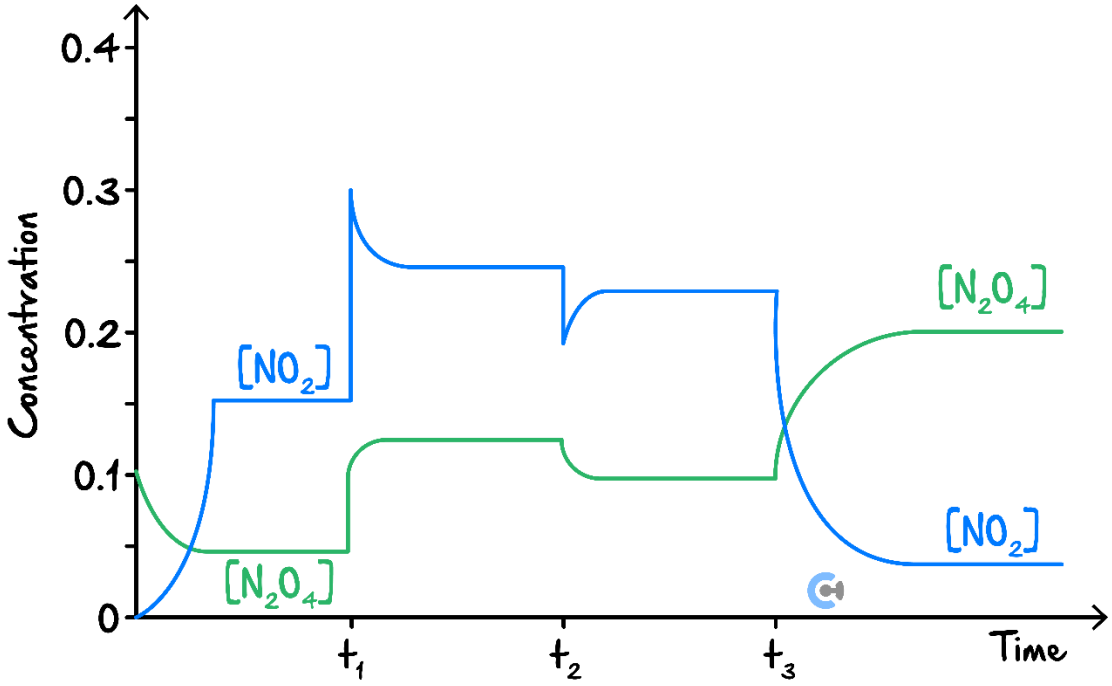
Question 9 (11 marks)

Dinitrogen tetroxide, N_2O_4, decomposes to form nitrogen dioxide, NO_2, as described by the chemical equation:

$$N_2O_4\ (g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +\ 57\ kJ\ mol^{-1}$$

A sample of pure dinitrogen tetroxide, with a concentration of $0.12\ M$, was placed in a flask and allowed to reach equilibrium. The graph below shows how the concentrations of the two gases vary when some changes were made to the equilibrium system:



a. How many times did the system reach equilibrium? (1 mark)

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b.

i. State the change was made to the system at t_1. (1 mark)

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ii. Give an explanation of how this change affected the position of the equilibrium. (1 mark)

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c.

i. State the change that was made to the system at t_2. (1 mark)

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ii. Explain how this change affects the rate of production of N_2O_4. (2 marks)

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d.

i. State the change was made to the system at t_3. (1 mark)

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ii. Give an explanation of how this change affected the position of the equilibrium. (1 mark)

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e.

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

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ii. Calculate the K_C value just before the t_3 change. (1 mark)

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iii. Which change at t_1, t_2 or t_3 will lead to a different value of K_C? (1 mark)

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Question 10 (2 marks)

Given the following information:

$$Cl_2(g) \rightleftharpoons 2Cl(g) \quad K = 1.13 \times 10^{-6}\ M \text{ at } 1100°C$$

For the following reaction:

$$2Cl(g) \rightleftharpoons Cl_2(g)$$

State the numerical value of the equilibrium constant for the reaction at the same temperature.

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Question 11 (7 marks)

Consider the combustion of methane in oxygen in a 1 L container at a total pressure of 100 kPa. The temperature in the container is kept at a constant 400 K.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

a. Could measuring the total pressure inside the container throughout the reaction indicate the reaction rate? Explain your answer. (2 marks)

The reaction is repeated using the same amounts of oxygen and methane at 400 K, except a 0.5 L container is used.

b. State the pressure, in kPa, inside this new container. (1 mark)

c. Using collision theory, explain whether the reaction rate is higher, lower or the same. (2 marks)

Hydrogen can react with ethane to form ethane using a palladium (Pd) catalyst in the following reaction:

$$C_2H_4(g) + H_2(g) \xrightarrow{Pd(s)} C_2H_6(g)$$

d. Use collision theory to explain fully how adding a catalyst affects the rate of production of ethane. (2 marks)

Question 12 (8 marks)

Sulphur dioxide (SO_2) can react reversibly with oxygen (O_2) to form sulphur trioxide (SO_3), as per the following reaction equation:

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

The equilibrium constant (K) of this reaction is $10.3\ M^{-1}$.

a. Write an expression for the equilibrium constant (K) of the above reaction. (1 mark)

A $1.00\ L$ vessel containing a mixture of SO_2, O_2 and SO_3 is at equilibrium. It is found that the container has $0.132\ mol$ of O_2 and $0.100\ mol$ of SO_2.

b. Determine the amount, in mol, of SO_3 in the container at equilibrium. (1 mark)

To this container, 0.100 mol of SO_2 was added.

c.

i. In which direction will the equilibrium shift? Circle your answer. (1 mark)

Forwards Backwards No change

ii. Explain your answer to part **c. i.** using **reaction rates.** (2 marks)

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d. Calculate the value of the reaction quotient/concentration fraction (Q) as soon as the 0.100 mol of SO_2 was added. Explain briefly how the value of Q subsequently changes over time. (3 marks)

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