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VCE Chemistry ¾
AOS 2 Revision (Rates & Equilibrium) [2.0]
SAC 1

50 Marks. 12 Minute Reading. 75 Minutes Writing.

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Section A: Multiple Choice Questions (5 Marks)

The following information applies to the two questions that follow.

The equation for the reaction between ethyne and hydrogen is:

$$C_2H_2(g) + 2H_2(g) \rightleftarrows C_2H_6(g) \qquad \Delta H = -355 \; kJ \; mol^{-1}$$
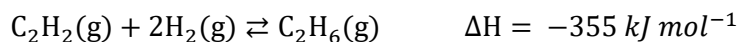
At 150°C, the value of K is $248 \; M^{-2}$.

Question 1 (1 mark)

A sample of C_2H_6 is added to an empty reactor.

Select the correct alternative for the concentrations when the mixture comes to equilibrium at 150°C.

A. $[H_2] > [C_2H_6]$

B. $[H_2] = 2[C_2H_6]$

C. $[H_2] = [C_2H_2]$

D. $[H_2] < [C_2H_6]$

Question 2 (1 mark)

The temperature of an equilibrium mixture of the three gases is increased. As a consequence, the:

A. Amount of C_2H_6 will increase.

B. Amount of H_2 will increase by twice the amount of C_2H_2.

C. Amount of H_2 will increase by the same amount as the C_2H_2.

D. Amount of H_2 will increase by the amount that the C_2H_6 drops by.

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Question 3 (1 mark)

The gases W and X were placed in a sealed container and allowed to reach equilibrium in an exothermic reaction by the equation $W(g) + X(g) \rightleftharpoons 3Y(g) + Z(g)$. The graph below shows the concentration of gases W and Y throughout the reaction.
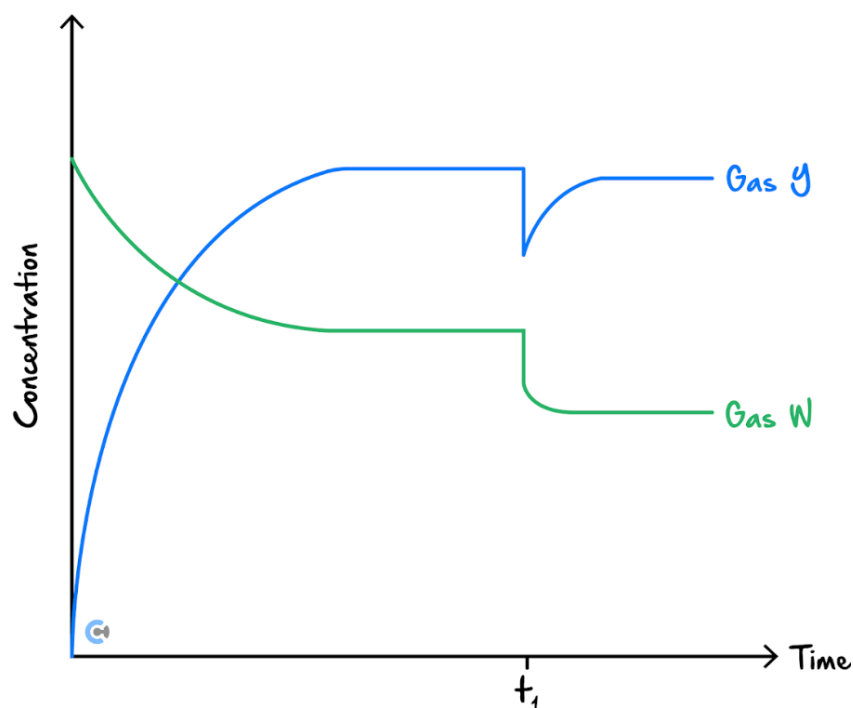
Which one of the following most likely occurred at t_1?

A. Samples of gas W and gas Y were added to the container.

B. The gases in the container were heated to a higher temperature.

C. The volume of the container was increased at a constant temperature.

**D.** An inert gas was added to the mixture at a constant temperature.

Question 4 (1 mark)

If the reaction quotient Q has a larger value than the related equilibrium constant K then:

A. The reaction is at equilibrium.

B. The reaction is not at equilibrium and will make more products at the expense of the reactants.

C. The reaction is not at equilibrium and will make more reactants at the expense of the products.

D. The value of K will increase until it reaches the Q value.

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Question 5 (1 mark)

Write an expression for the equilibrium constant for this reaction.

$$Ti(s) + 2Cl_2(g) \rightleftharpoons TiCl_4(l)$$
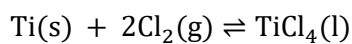
A. $\dfrac{1}{[Cl_2]}$

B. $\dfrac{[TiCl_4]}{[Ti][Cl_2]^2}$

C. $\dfrac{1}{[Cl_2]^2}$

D. $\dfrac{[TiCl_4]}{[Ti][Cl_2]}$

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Section B: Short Answer Questions (45 Marks)

Question 6 (9 marks)

The reaction between hydrochloric acid and oxygen is a reversible, exothermic reaction:

$$4HCl(g) + O_2(g) \rightleftarrows 2H_2O \ (g) + 2Cl_2(g) \qquad \Delta H = -29 \ kJ \ mol^{-1}$$
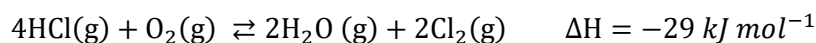
Consider the impact of the following changes on an equilibrium mixture of the above gases.

a. The volume of an equilibrium mixture is doubled. Explain the impact on

    i. The value of K. (1 mark)

_____

    ii. The concentration of oxygen. (1 mark)

_____

b. Oxygen is added to an equilibrium mixture. Explain the impact this has on the final concentration of oxygen. (2 marks)

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c. The temperature of an equilibrium mixture is decreased. Explain the impact on the value of K_c, and the concentration of HCl. (3 marks)

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d. A catalyst is added to a sample of HCl and oxygen. Explain how the system will respond compared to the original. (1 mark)

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e. Argon gas is added to the system. State the effect this has on the concentration of hydrogen gas present in the same volume container. (1 mark)

_____

Question 7 (9 marks)

Chlorine and fluorine gases react to form the compound, ClF_3. The reaction is:

$$Cl_2(g) + 3F_2(g) \rightleftarrows 2ClF_3(g)$$
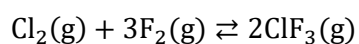
a. Write the expression for the equilibrium constant. (1 mark)

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b.

i. At a particular temperature, an equilibrium mixture in a 5.00 L reactor contains the following.

1.4 mol Cl_2 $\qquad$ 1.2 mol F_2 $\qquad$ 2.2 mol ClF_3

Calculate the equilibrium constant value for this reaction. (1 mark)

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ii. State whether the extent of the reaction is small, medium or large. Explain your answer. (1 mark)

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iii. At the same temperature, a different equilibrium mixture is found to have a concentration of Cl_2 of 0.42 M and a ClF_3 concentration of 0.71 M. Find the concentration of F_2 gas. (1 mark)

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c. At a new temperature, 0.54 mol of ClF_3 is added to an empty 1.0 L reactor. When equilibrium is reached, the amount of ClF_3 is found to be 0.40 mol. Calculate the equilibrium constant value at this new temperature. (3 marks)

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d. A mixture of the above gases is at equilibrium. If the volume of the reactor is now halved, explain how this affects the amount of fluorine gas present. (2 marks)

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Question 8 (8 marks)

The graph below is related to the formation of nitrogen dioxide from dinitrogen tetroxide.

$$N_2O_4(g) \rightleftarrows 2NO_2(g) \qquad \Delta H = +173 \, kJ \, mol^{-1}$$
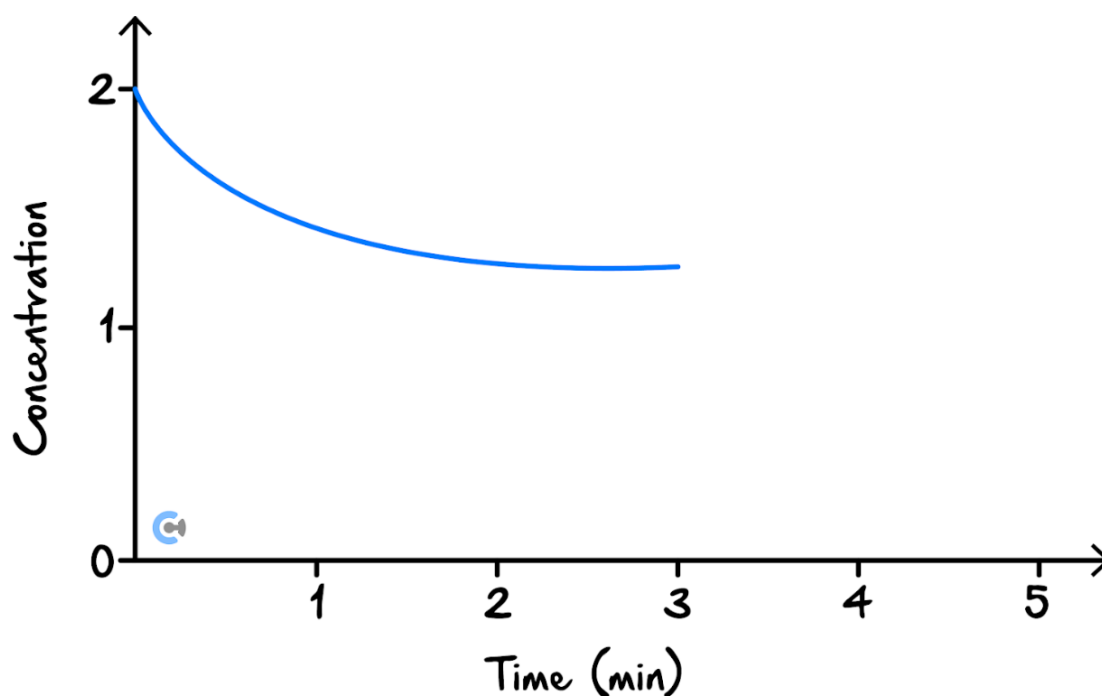
a. N_2O_4 is added to an empty reactor. Its concentration is shown on the graph. Draw on the same graph, the graph for the NO_2 concentration. (1 mark)

b. Calculate the K_c value at 3 minutes. (2 marks)

_____

_____

c. At the 3-minute mark, the temperature of the mixture is increased. Use the graph to draw how the concentrations of the two chemicals will change after the temperature increases, given that equilibrium is re-established at 5 minutes. (2 marks)

d. NO_2 is brown in colour. The volume of an equilibrium mixture is halved and the system is allowed to establish a new equilibrium.

Explain how the brown colour of the mixture changes during this reaction. (3 marks)

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Question 9 (7 marks)

The reaction between bromine gas and methanoic acid is:

$$Br_2(aq) + HCOOH(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

Br_2 gas has a brown colour but Br^- ions are colourless.

a. A 1.0-mole sample of bromine is reacted with a 0.8-mole sample of methanoic acid.

    i. The brown intensity of colour is seen to decrease over time but varies in the rate at which it decreases. Describe how the intensity of brown colour decreases over time, and state the final colour at the end of the reaction. (2 marks)

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    ii. The reaction is repeated with the same amount of chemicals but this time with an added catalyst. Compare the change in brown intensity of this reaction with the first reaction. (1 mark)

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b.

   i.   The reaction is repeated in a flask that is sitting on a balance. Draw in the shape of the graph for the mass change of the flask. (1 mark)

Mass of flask ↑

→ Time

   ii.   Calculate the final mass loss of the flask. (1 mark)

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   iii.   Describe how the pH of the reaction mixture changed with time. (1 mark)

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c. The graph below shows the volume of CO_2 produced in the reaction between $1.0\ mol$ of Br_2 and $1.0\ mol$ of methanoic acid in $1.00\ L$ of water.
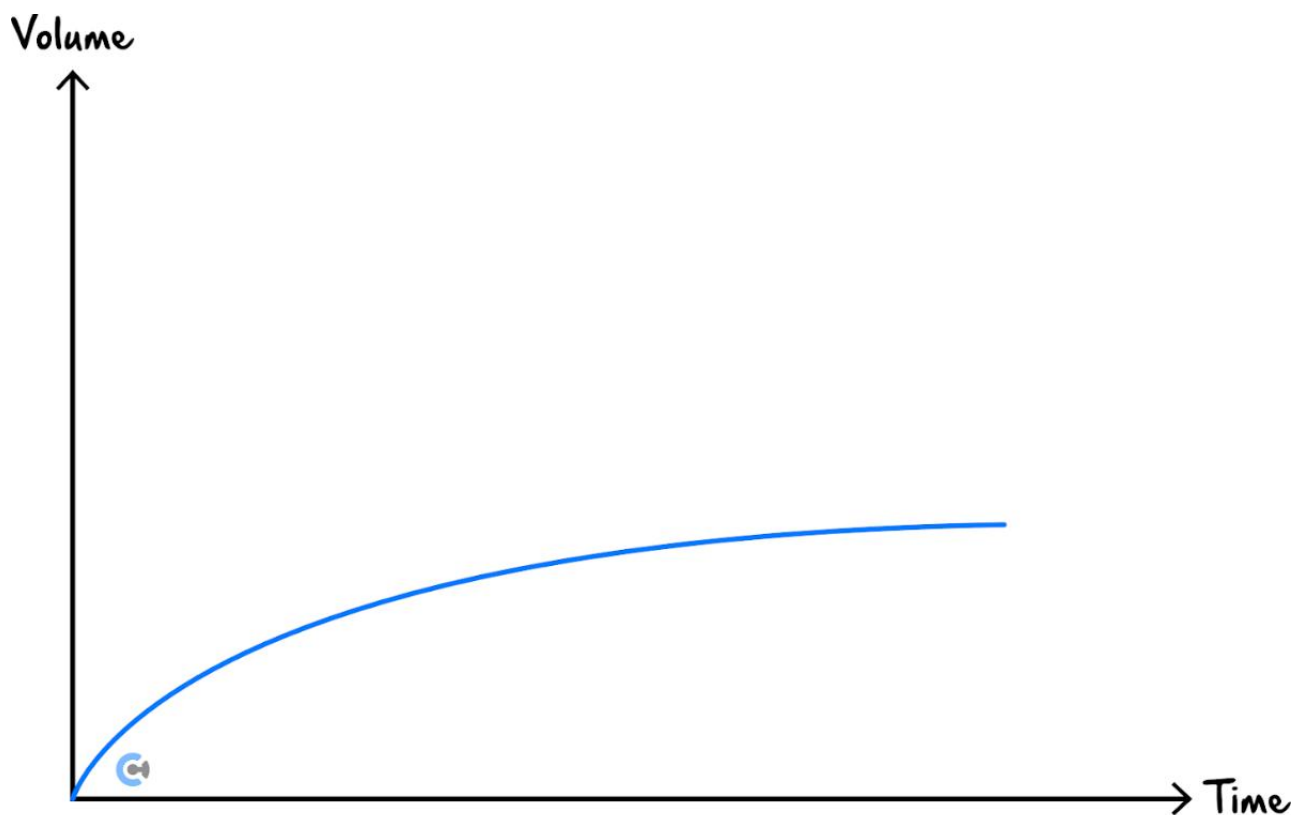
The reaction is now repeated but the amount of Br_2 is doubled in the $1.00\ L$ sample of water. Draw on the graph above the graph of the CO_2 produced from this reaction. (1 mark)

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Question 10 (6 marks)

Consider a solution in which the following equilibrium is established:

$$Br_2(aq) + 2OH^-(aq) \rightleftharpoons OBr^-(aq) + Br^-(aq) + H_2O(l); \Delta H = +15 \; kJ \; mol^{-1}$$

The molecular bromine (Br_2) gives the aqueous solution a reddish-brown colour. All the other species present are colourless.

The following tests are carried out on separate samples of the solution.

Test 1 A few mL of a concentrated solution of sodium bromide are mixed into the solution.

Test 2 A few mL of a concentrated HCl solution is mixed into the solution.

Test 3 The solution is heated from room temperature to 40°C.

For each of the above tests, predict whether the mixture would become darker or lighter in colour by ticking the appropriate box and, in each case, give a reason for your prediction in the adjoining box. (6 marks)

	Test Result		Explanation of test result
	Darker	**Lighter**	
Test 1			_____ _____ _____ _____
Test 2			_____ _____ _____ _____
Test 3			_____ _____ _____ _____

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Question 11 (6 marks)

Consider the following reaction shows the reaction during the hydration of ethene.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad \Delta H = -45.5 \; kJ \; mol^{-1}$$

a. Explain the effect of increasing temperature on the rate of production of ethanol. (3 marks)

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b. Considering both the rate of production of ethanol and the equilibrium yield of ethanol achieved, state the optimum temperature conditions that should be used to maximise both rate and yield. Justify your answer. (2 marks)

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c. State the optimum pressure conditions used to maximise both rates of production and equilibrium yield of ethanol. (1 mark)

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