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VCE Chemistry ¾
Rate-Yield Conflict [2.9]
Homework

Admin Info & Homework Outline:

Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2-Pg 18
Supplementary Questions	Pg 19-Pg 26

## Section A: Compulsory Questions (64 Marks)

Sub-Section [2.9.1]: Explain Effects of Temperature, Inert Gas or Catalyst on Equilibrium System

Question 1 (2 marks)

a. An inert gas is added to a gaseous equilibrium system. The temperature is then increased, and dynamic equilibrium is re-established. Which of the following is incorrect? (1 mark)

A. The concentrations of the reactants and products have changed.

B. The rate of the forward reaction is greater than the rate of the reverse reaction.

C. The inert gas causes no change to the system.

D. The increase in temperature causes the rate of the forward and reverse reaction to increase.

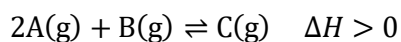b. In the following equilibrium system, methane can decompose in the following manner:

$$2CH_4(g) \leftrightarrow C_2H_2(g) + 3H_2(g) \quad \Delta H = +300 \; kJ \; mol^{-1}$$
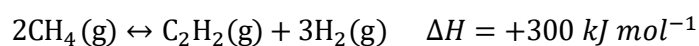
State how the system will respond to a temperature decrease. (1 mark)

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Question 2 (6 marks)

The following equilibrium system is investigated.

$$2A(g) + B(g) \rightleftharpoons C(g) \quad \Delta H > 0$$

a. Explain the effect of subsequently adding an inert gas on:

    i. The equilibrium constant K_c. (1 mark)

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   ii. The concentration of the product. (1 mark)

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b. Explain the effect of adding a catalytic powder to this equilibrium system. (2 marks)

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c. Explain the effect of increasing temperature on the system. (2 marks)

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Question 3 (5 marks)

A student removes an ampule of a colourless gas X(g) from a cold storage container and notices that it immediately begins to turn orange. The student knows that X(g) takes part in the following equilibrium reaction.

$$Y(g) + W(g) \rightleftharpoons X(g)$$
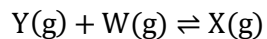
a.   State whether the above reaction is endothermic or exothermic. Justify your answer. (3 marks)

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b.   Explain the effect of this change on the equilibrium constant K_c. (2 marks)

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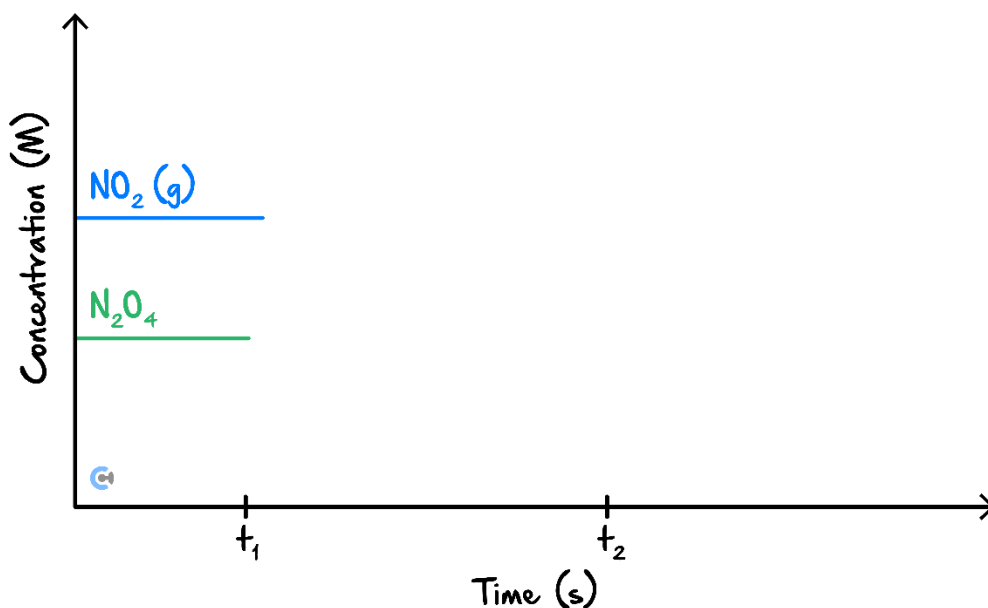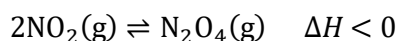## Sub-Section [2.9.2]: Graph Effects of Temperature, Inert Gas Catalyst on Equilibrium Systems
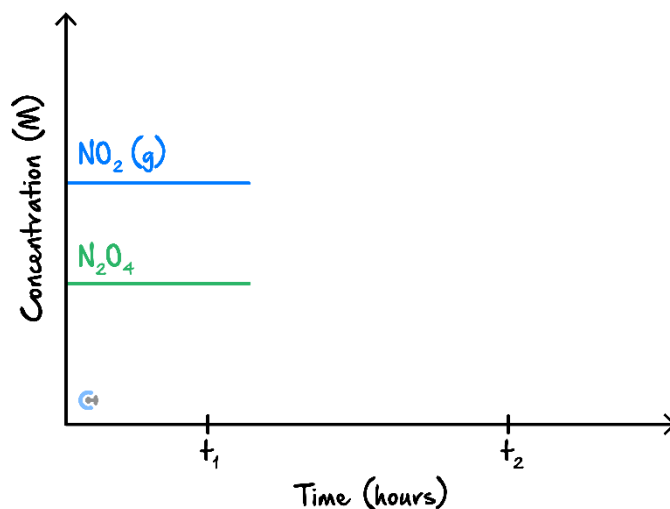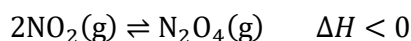
Question 4 (3 marks)

a. The temperature in the following system is increased at t_1. Sketch the shift in the equilibrium position, given that equilibrium is re-established at t_2. (2 marks)

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \quad \Delta H < 0$$

b. Neon gas is added to the following equilibrium system. Sketch the shift in the equilibrium position. (1 mark)

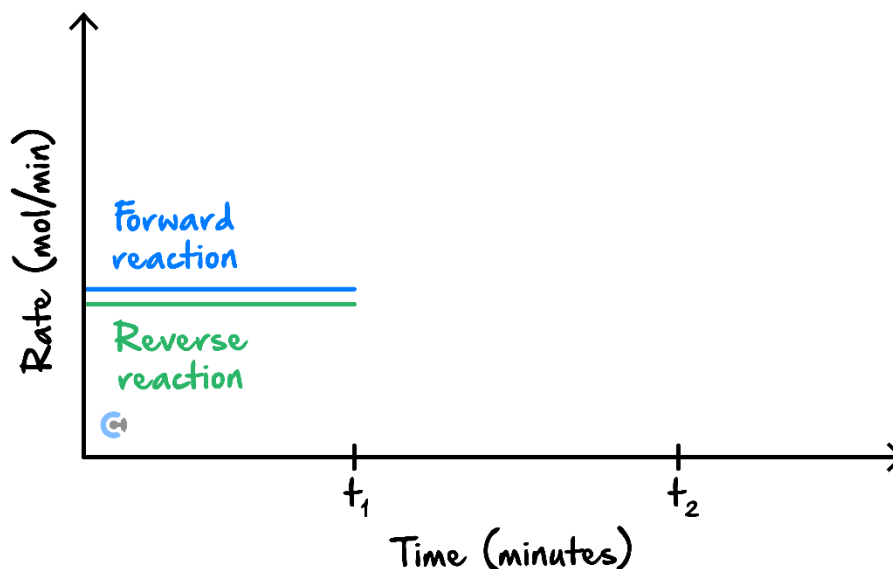$$2NO_2(g) \rightleftharpoons N_2O_4(g) \quad \Delta H < 0$$

Question 5 (3 marks)

Consider the following equilibrium system:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

a. Catalytic pebbles are added to the system. Sketch the change to the system from t_1 to when the system re-establishes equilibrium at t_2. (1 mark)

Forward reaction
Reverse reaction

Rate (mol/min)

t_1 t_2

Time (minutes)

b. The temperature of an identical system is increased. Sketch the change to this system from t_1 to when the system re-establishes equilibrium at t_2. (2 marks)

Forward reaction
Reverse reaction

Rate (mol/min)

t_1 t_2

Time (minutes)
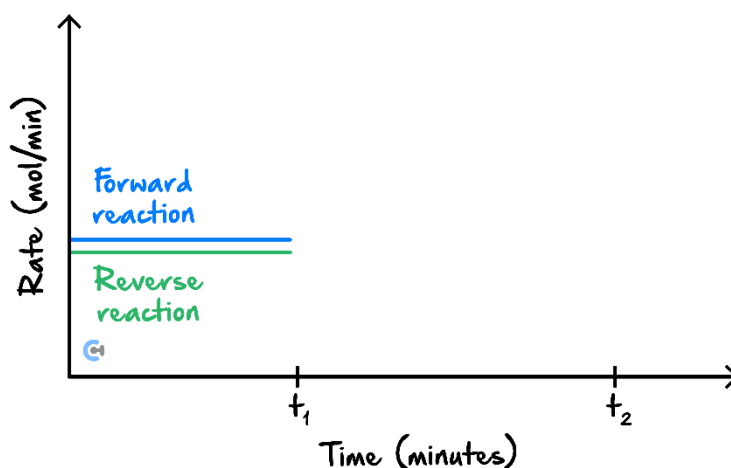
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Question 6 (4 marks)

A chemical engineer is designing a process for the synthesis of a chemical X(g) using the equilibrium system below.

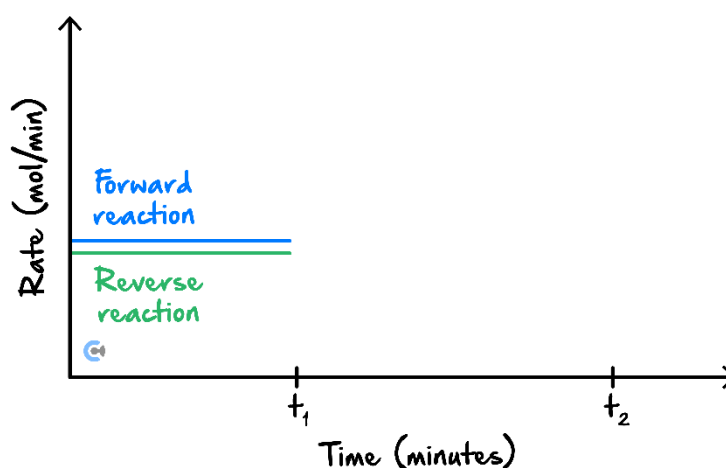$$A(g) + Y(g) \rightleftharpoons C(g) + X(g) \qquad \Delta H < 0$$
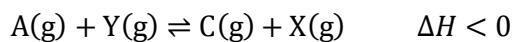
The engineer increases the temperature of the system.

a. Sketch the change in the equilibrium system on the graph below from t_1 to when the system re-establishes equilibrium at t_2. (2 marks)
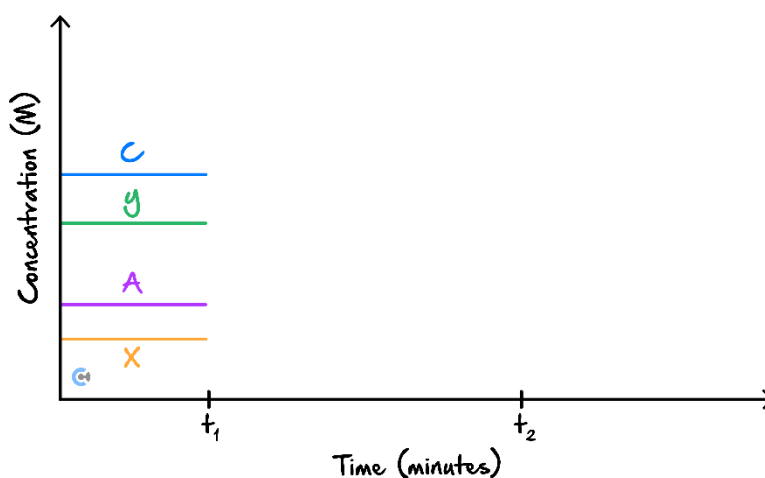
b. Sketch the change in the rate of the system below from t_1 to when the system establishes re-equilibrium at t_2. (2 marks)

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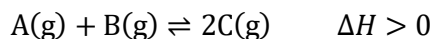VCE Chemistry ¾ Questions? Message +61 440 137 304

Sub-Section [2.9.3]: Find the Change Made to System from Equilibrium Graph

Question 7 (4 marks)

Several changes have been made to the equilibrium system below.

$$A(g) + B(g) \rightleftharpoons 2C(g) \qquad \Delta H > 0$$

The concentrations are recorded and graphed as shown.
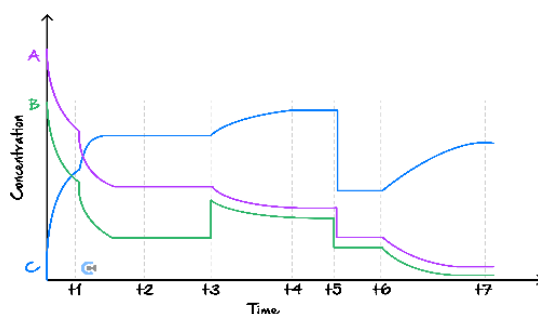
What change was made to the system between:

a. t_1 and t_2? (1 mark)

    A. A noble gas has been added to the system.

    B. The temperature of the system has been increased.

    C. $1.0 \, mol$ of $C(g)$ has been added to the system.

    D. The temperature of the system has been decreased.

b. t_2 and t_3? (1 mark)

    A. A catalyst has been added to the system.

    B. $1.0 \, mol$ of $B(g)$ has been added to the system.

    A. The temperature of the system has been decreased.

    B. $1.0 \, mol$ of $A(g)$ has been taken out of the system.

c. t_3 and t_4? (1 mark)

    A. The temperature of the system has been increased.

    B. A noble gas has been added to the system.

    C. The volume of the system has been decreased.

    D. $1.0 \, mol$ of $B(g)$ has been added to the system.

d. t_5 and t_6? (1 mark)

    A. The volume of the system has been increased.

    B. $1.0 \, mol$ of $C(g)$ has been added to the system.

    C. A noble gas has been added to the system.

    D. The temperature of the system has been decreased.

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Question 8 (4 marks)

A chemist attempting to maximise the yield of $NH_3(g)$, makes two changes to an equilibrium system as shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$
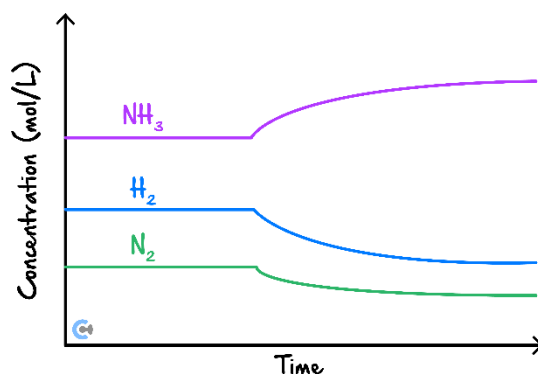
a. Describe the changes made to the system. Justify your response. (2 marks)
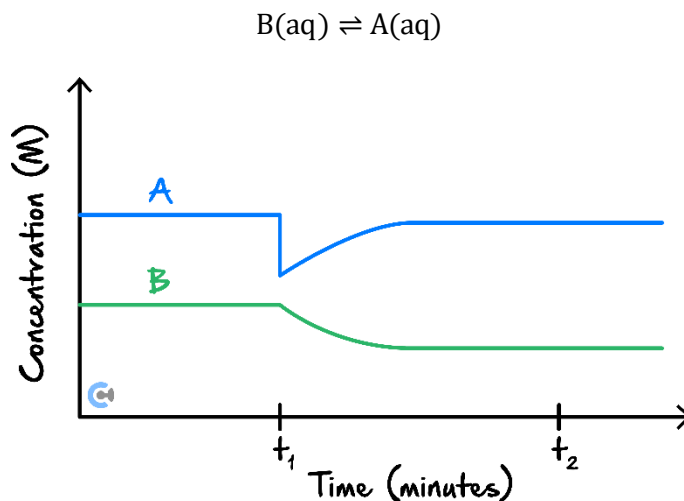
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b. Explain why the **two** of the changes described in **part a.** are made in conjunction with reference to the rate-yield conflict. (2 marks)

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Question 9 (3 marks)

A chemist makes a change to an equilibrium system in solution at t_2 as shown below. The temperature is kept constant.

$$B(aq) \rightleftharpoons A(aq)$$

a. Describe the change the chemist made. Justify your answer. (2 marks)

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b. Describe change in the equilibrium constant at t_3 compared to t_1 as a result of the change made at t_2. (1 mark)

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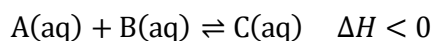VCE Chemistry ¾ Questions? Message +61 440 137 304

Sub-Section [2.9.4]: Find Equilibrium Constant Changes Due to Temperature

Question 10 (1 mark)

The temperature of the equilibrium system below is increased.

$$A(aq) + B(aq) \rightleftharpoons C(aq) \quad \Delta H < 0$$

Which of the following is true?

A. The value of the equilibrium constant stays the same.

B. The concentration of C(aq) increases.

C. The value of the equilibrium constant decreases.

D. The system is colder than before the change.

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Question 11 (4 marks)

A chemist is attempting to determine the thermochemical nature of the following equilibrium system; that is, whether the system is exothermic or endothermic.

$$W(g) \rightleftharpoons X(g) + Y(g)$$
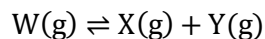
The chemist finds that the value of the equilibrium constant increases when the temperature of the system is decreased.

a. Explain what the increase in the value of the equilibrium constant indicates with reference to the reactants and products. (2 marks)

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b. Explain whether this system is exothermic or endothermic. (2 marks)

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Question 12 (7 marks)

The following system has been allowed to reach equilibrium.

$$2A(aq) \rightleftharpoons 3B(aq) + 2C(aq) \qquad \Delta < 0$$
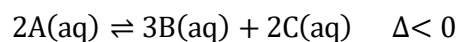
At equilibrium, there are $2.00\ mol$ of A and $1.00\ mol$ of B in 1 litre of solution. The value of the equilibrium constant is $4.00\ M^3$.

a. Calculate the concentration of C in the solution. (2 marks)

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A chemist decides to change the temperature of the system.

The chemist measures the concentration of C to be $3.50\ M$ after the change in temperature.

b. Explain whether the chemist increases or decreases the temperature of the system. (2 marks)

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c.

    i. State the expression for the equilibrium constant. (1 mark)

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    ii. Calculate the new equilibrium constant. (2 marks)

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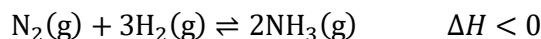
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Sub-Section [2.9.5]: Find Optimum Operating Conditions in All Circumstances Such as the Rate-Yield Conflict

Question 13 (2 marks)

A chemist is trying to increase the yield of NH_3 in the following equilibrium system.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

Suggest **one** change that could achieve this result and does not change the equilibrium constant. Justify your answer.

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Question 14 (4 marks)

A chemist is trying to increase the yield of NH_3 in the following equilibrium system.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

a. Explain the effect of decreasing the temperature of the system on the equilibrium position. (1 mark)

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b. Explain the effect of decreasing the temperature of the system on the rate of the forward reaction at equilibrium. (2 marks)

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c. Explain why decreasing the temperature of this system is not optimal for maximising production of NH_3. (1 mark)

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Question 15 (4 marks)

A chemical engineer is attempting to improve the yield of SO_3 for an industrial process. The following equilibrium system is used to produce SO_3.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$
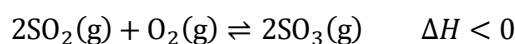
a. A civil engineer working on the project suggests decreasing the system's temperature to increase the yield of SO_3. Evaluate this suggestion with reference to both rate and yield. (3 marks)

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b. A "*simple and practical*" change is being proposed to improve the yield of SO_3. Suggest **one** change which can aid with this. (1 mark)
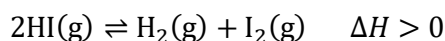
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Sub-Section: The 'Final Boss'

Question 16 (8 marks)

A chemist requires concentrated hydrogen iodide. Hydrogen iodide disassociates according to the following equation.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H > 0$$

The graph below shows the concentrations of each reacting reagent after the chemist's first attempts at mitigating the effects of disassociation.
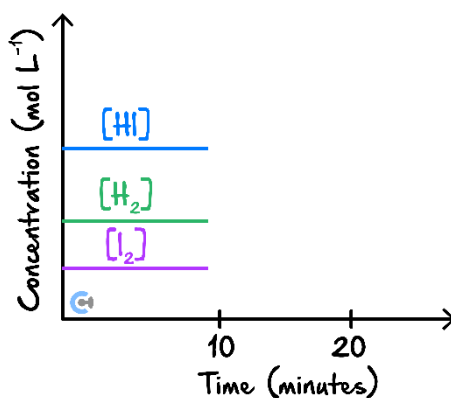
a. Suggest a change the chemist could have made to the system at 10 minutes. Justify your response. (2 marks)

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At 20 minutes, the chemist adds helium gas to the system.

b. Continue the graph on the axes provided above for $[H_2]$ and $[I_2]$ to represent this change. (1 mark)

At 30 minutes, the chemist finds that the concentration of H_2 is 1.00 M, the concentration of I_2 is 0.50 M and the concentration of HI is 3.00 M.

c. Calculate the equilibrium constant value. (1 mark)

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The chemist increases the temperature of the system.

d. Describe the change to the value of the equilibrium constant. Explain your answer. (2 marks)

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e. A colleague of the chemist argues that increasing the temperature of the system creates a rate-yield conflict. Evaluate the colleague's argument and state whether they are correct. (2 marks)

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Section B: Supplementary Questions (28 Marks)

Sub-Section [2.9.1]: Explain Effects of Temperature, Inert Gas or Catalyst on Equilibrium System

Question 17 (1 mark)

An inert gas and a catalyst are added to an equilibrium system simultaneously. What is the effect on the equilibrium system?

A. The rates of the forward and reverse reaction remain the same and the concentrations of all reagents increase.

B. The rates of the forward and reverse reactions increase and the concentration of the reagents remains the same.

C. The rate of the forward reaction increases and the concentration of the products increase.

D. Only the rate of the reverse reaction increases and the concentration of the reagents remains the same.

Question 18 (4 marks)

Consider the following equilibrium system.

$$2A(g) + B(g) \rightleftharpoons C(g) \quad \Delta H > 0$$
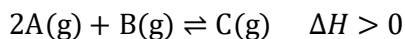
a. Explain the effect of increasing the temperature of the system. (2 marks)

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b. Explain the effect of adding a catalytic powder to the system while increasing the temperature. (2 marks)

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Question 19 (4 marks)

The following equilibrium system is used in ColdGlow glow sticks.

$$2X(g) \rightleftharpoons Z(g) + Y(g)$$
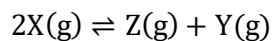
ColdGlow glow sticks get brighter based on how cold their surroundings are. Both Z and Y are colourless gases, whereas X has a distinct fluorescent red colour.

a. State whether the above reaction is endothermic or exothermic. Justify your answer. (2 marks)

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b. The volume of the glow sticks is decreased and the temperature can be assumed to be constant. Describe and explain any observable effects on the system. (2 marks)
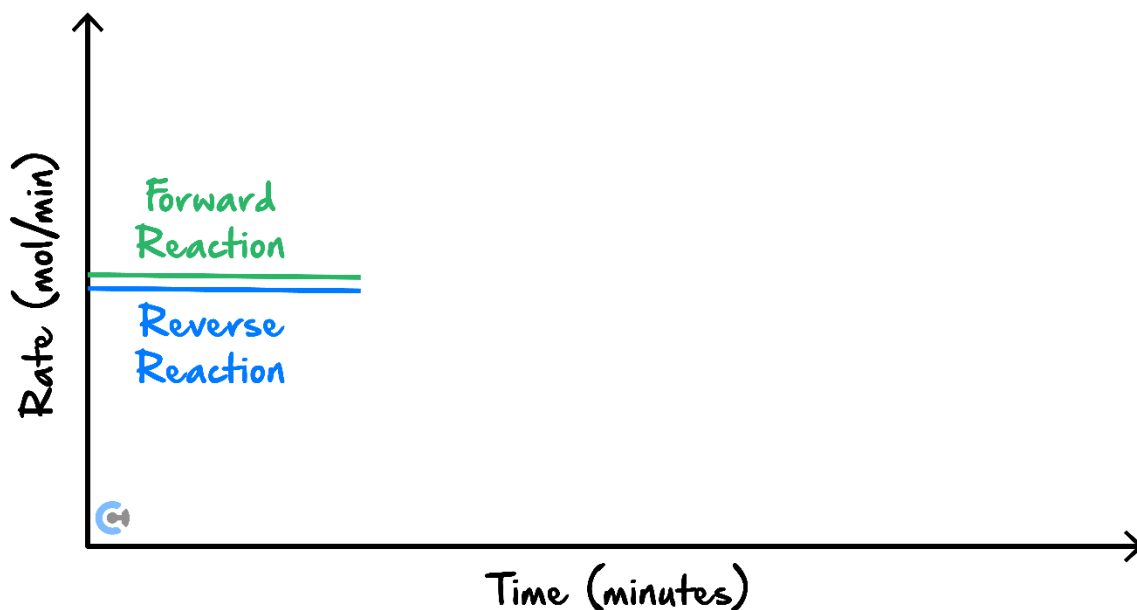
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Sub-Section [2.9.2]: Graph Effects of Temperature, Inert Gas Catalyst on Equilibrium Systems

Question 20 (1 mark)

A noble gas is added to an equilibrium system. Sketch the change to the system.

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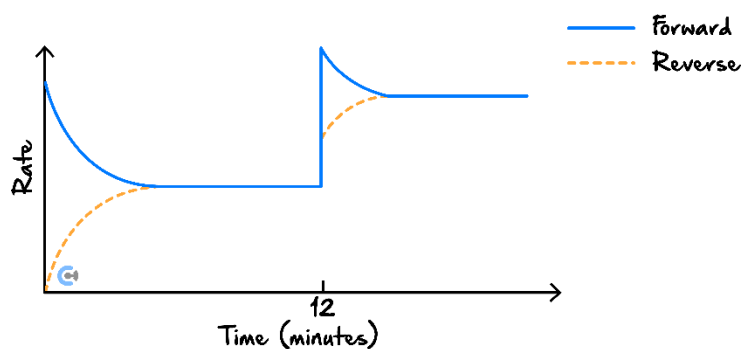VCE Chemistry ¾ Questions? Message +61 440 137 304

Sub-Section [2.9.3]: Find the Change Made to System from Equilibrium Graph

Question 21 (1 mark)

A change is made to a gaseous equilibrium system at 12 minutes after the system is set up. The effect of the change is shown.

The change made to the system could be:

A. Reactants were added to the system.

B. The temperature was decreased.

C. A catalyst was added to the system.

D. The volume of the system was increased.

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Sub-Section [2.9.4]: Find Equilibrium Constant Changes Due to Temperature

Question 22 (1 mark)

Consider an endothermic equilibrium system for which the equation is unknown. The temperature of the system is increased. Which of the following would be observed once the system re-established equilibrium?

A. The rate of the reverse reaction only, has decreased compared to before the temperature change.

B. The concentration of the reactants has increased.

C. The value of the equilibrium constant has increased.

D. The system feels colder.

Question 23 (7 marks)

The following system has been allowed to reach equilibrium.

$$4X(aq) \rightleftharpoons Y(aq) + Z(aq) \qquad \Delta < 0$$
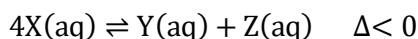
At equilibrium, there are $4.00 \ mol$ of X and $6.00 \ mol$ of Y in 2 litre of solution. The value of the equilibrium constant is $0.1875 \ M^{-2}$.

a. Calculate the concentration of Z. (2 marks)

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The chemist decides to change the temperature of the system and measures the concentration of Z to be 1.10 *M* after the change in temperature.

b. Explain whether the chemist increases or decreases the temperature of the system. (2 marks)

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c.

i. State the expression for the equilibrium constant. (1 mark)

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ii. Calculate the new equilibrium constant. (2 marks)

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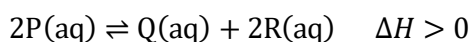VCE Chemistry ¾ Questions? Message +61 440 137 304

Sub-Section [2.9.5]: Find Optimum Operating Conditions in All Circumstances such as the Rate-Yield Conflict

Question 24 (1 mark)

A chemist is trying to maximise the yield of P in an industrial process involving the equilibrium system shown below.

$$2P(aq) \rightleftharpoons Q(aq) + 2R(aq) \qquad \Delta H > 0$$

Which of the following could be applied to the system to maximise the yield of P?

A. Decreasing the volume of the container.

B. Decreasing the temperature of the system.

C. Reacting P with another species in a precipitate reaction.

D. Removing products as they are produced.

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Question 25 (8 marks)

A chemist is trying to increase the yield of Z in the following equilibrium system.

$$X(g) \rightleftharpoons 2Z(g) \qquad \Delta H > 0$$
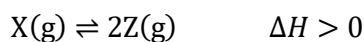
a. Explain the effect of decreasing the temperature of the system on the value of the equilibrium constant. (2 marks)

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b. Compare the effect of decreasing the temperature of the system on the rate of the forward reaction at equilibrium and the rate of the reverse reaction at equilibrium. (2 marks)

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c. Explain why increasing the volume of this system is not optimal for increasing the rate and yield of Z with explicit reference to collision theory and Le Chatelier's principle. (4 marks)

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