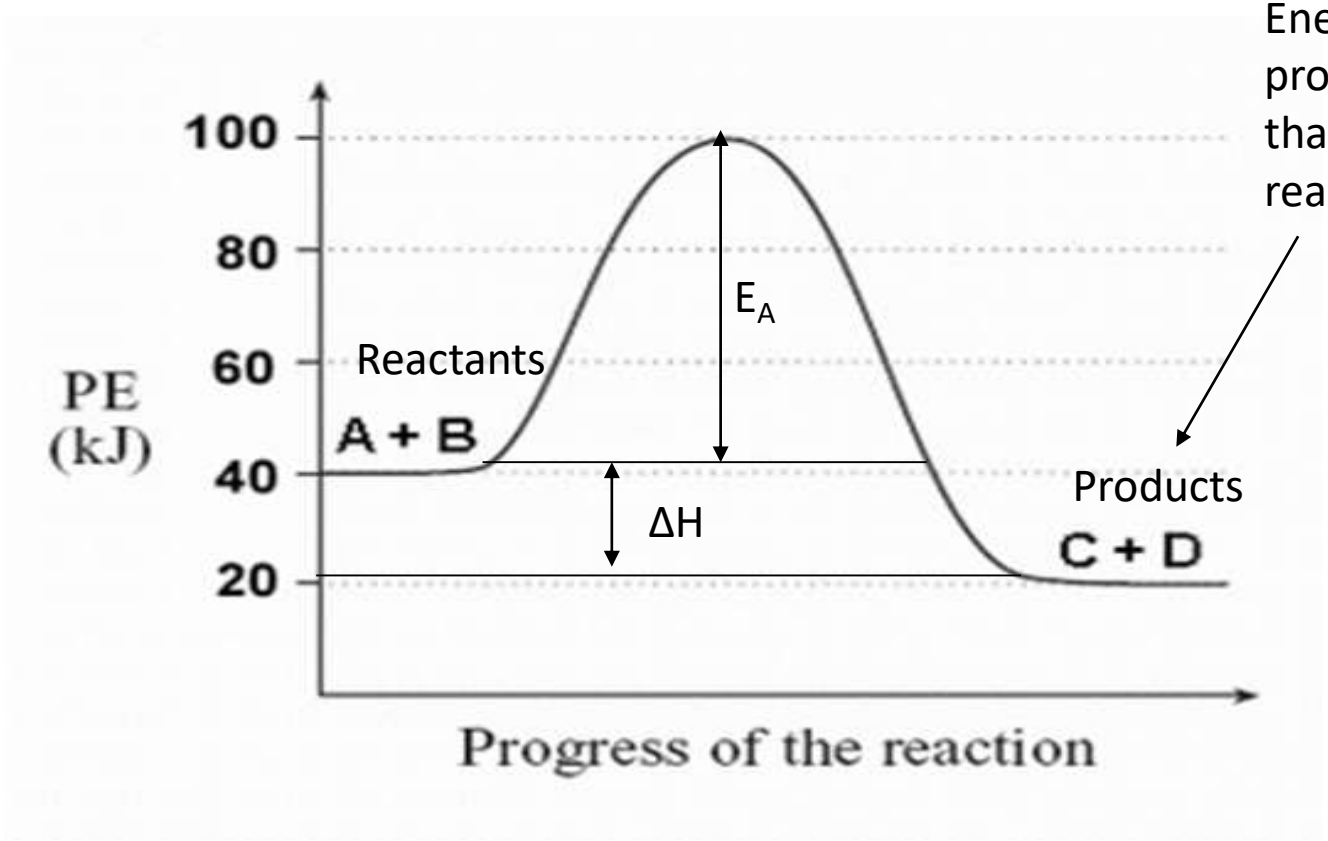
SAIP - VHEMBE TEACHER DEVELOPMENT WORKSHOP
07 – 09 FEB 2022

By
Mmaphefo Mothapo

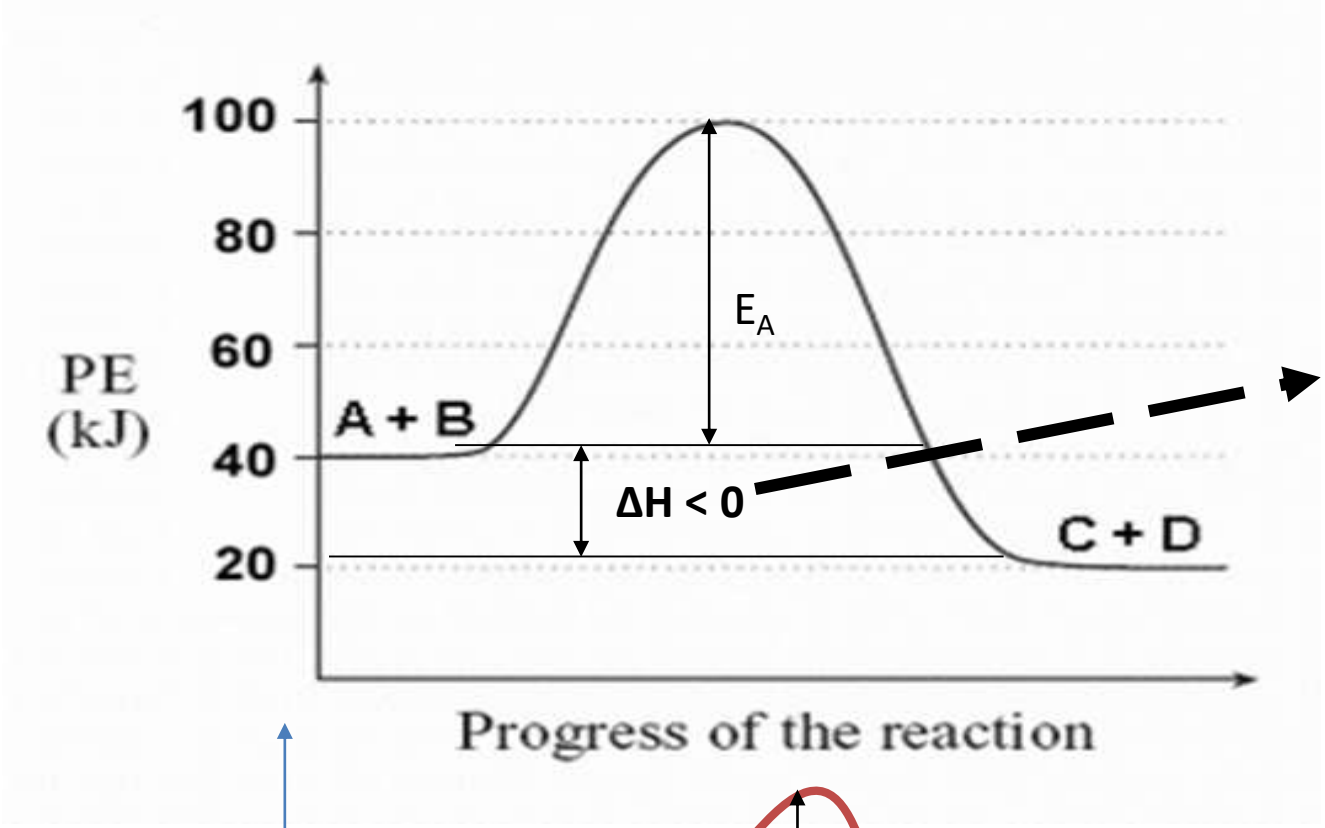
Chemical Equilibrium

- *Explain the difference between reversible and irreversible reactions*
- *Explain the difference between an open and closed system*
- *Define chemical equilibrium*
- *State Le Chatelier's principle*
- *List factors that influence chemical equilibrium*

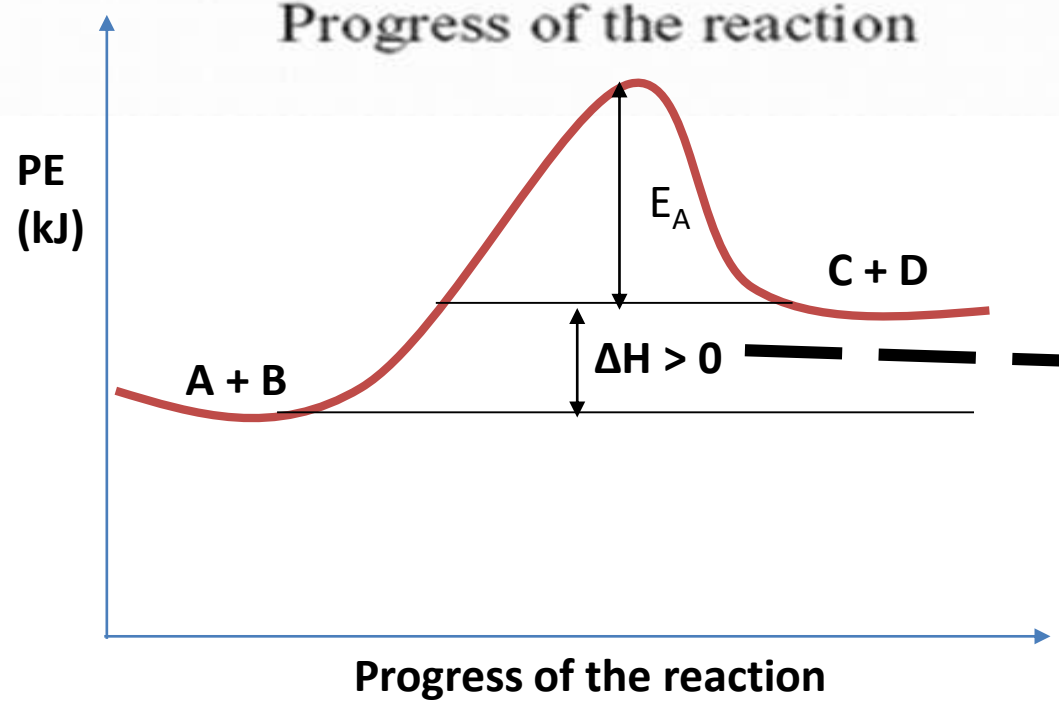
Chemical Equilibrium



Energy of the products is lower than that of the reactants

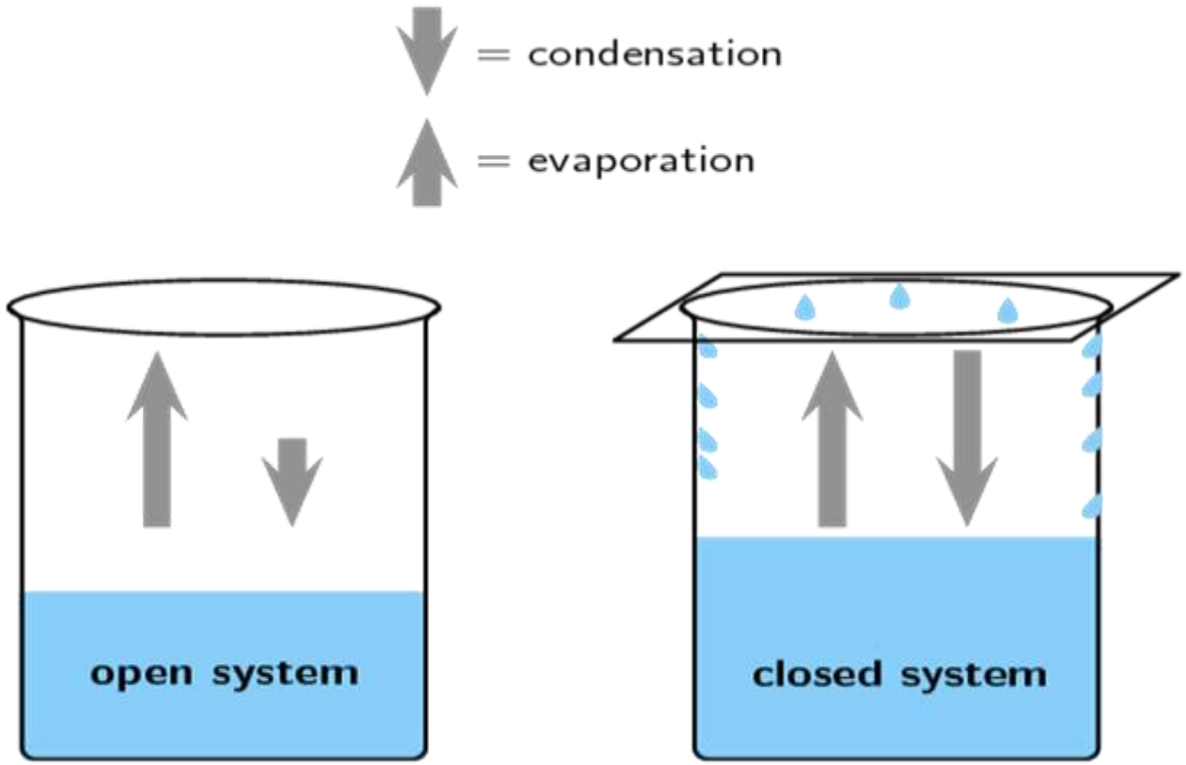


Exothermic reaction



Endothermic reaction

Example of Dynamic Equilibrium



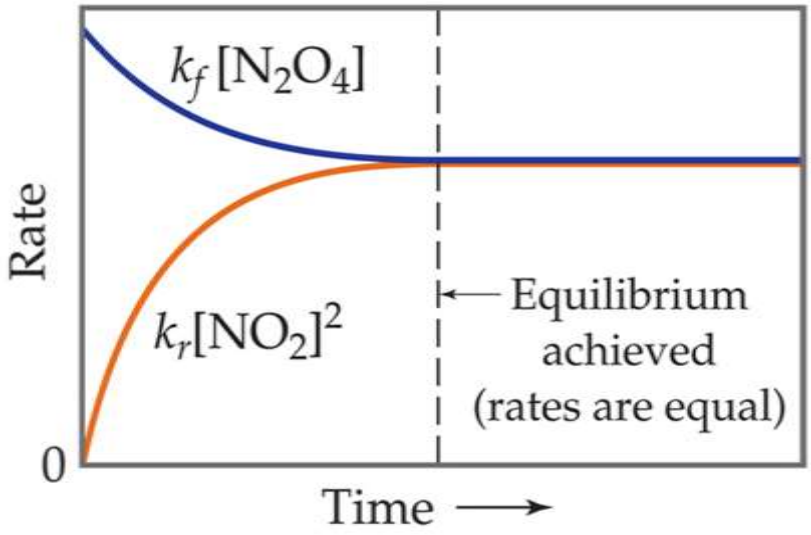
→ *represents a one direction reaction (the reaction is none reversible).*

⇌*represents a forward and reverse reaction. (the rate of the forward reaction = the rate of the reverse reaction)*

The rate of the forward reaction = the rate of the reverse reaction

The Concept of Equilibrium

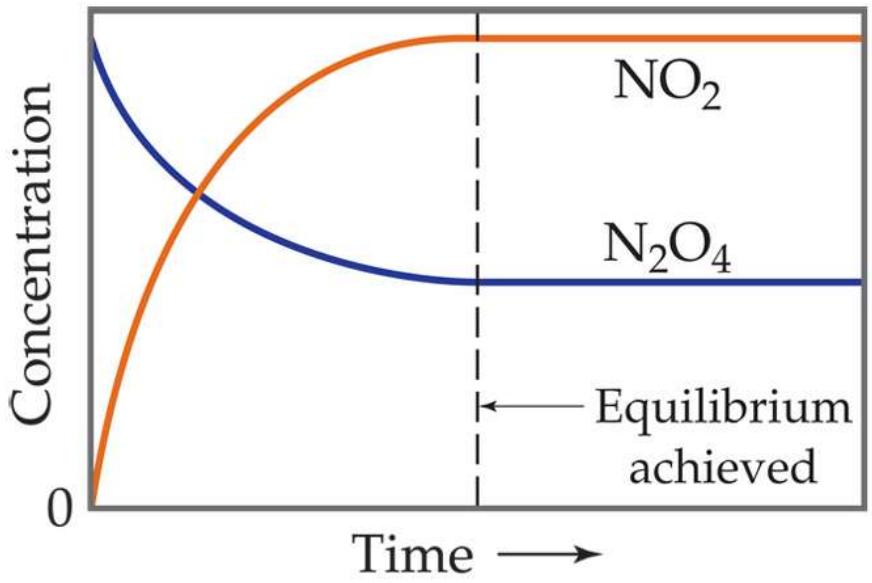
$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$



- As a system approaches equilibrium, both the forward and reverse reactions are occurring.
- At equilibrium, the forward and reverse reactions are proceeding at the same rate.

A system at equilibrium

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



- Once equilibrium is achieved, the *amount* of each reactant and product remains constant.

Factors affecting equilibrium position

- Le Châtelier's Principle : If a chemical system at equilibrium is disturbed by a change in the concentration of one of the components, pressure, or temperature, the system will shift its equilibrium position so as to counteract the effect of the disturbance."
- Use two terms to explain the system response the change

Factors affecting equilibrium position

- When a substance that is part of the equilibrium is added to the mixture, the equilibrium shifts to use it (in a direction that makes the substance a reactant thus there is a decrease in the reactants and increase in products).
- When a substance that is part of the equilibrium is removed from the mixture, the equilibrium shifts to produce it (in a direction that makes the substance a product thus there is a increase in the reactants and decrease in products)

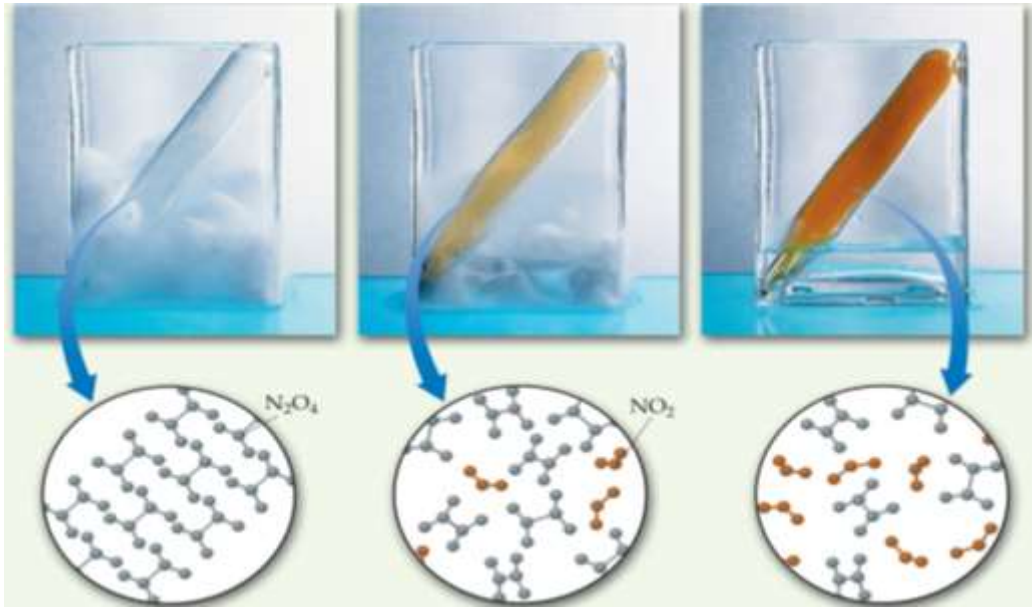
Factors affecting equilibrium position

- A change in the total pressure occurs because of a change in the *volume* of the reaction container.
- When the size of the container decreases, the overall pressure increases. The reaction will shift to reduce the pressure—that is, it will shift toward the side of the reaction with fewer gas molecules.
- When the size of the container increases, the overall pressure decreases. The reaction will shift to increase the pressure—that is, it will shift toward the side with more gas molecules.
- In the event that both sides of the equilibrium reaction have the same number of moles of gas, pressure has no effect on the equilibrium.

Factors affecting equilibrium position

- Changing the temperature changes the value of the equilibrium constant.
- Changing the temperature can also cause a shift in the equilibrium.
- The direction of each of these changes depends on the sign of ΔH^o.(+ ΔH^o means forward reaction is endothermic and – ΔH^o means forward reaction is exothermic)
- For an endothermic reaction, increasing the temperature increases the value of K_c.
- For an exothermic reaction, increasing the temperature decreases the value of K_c

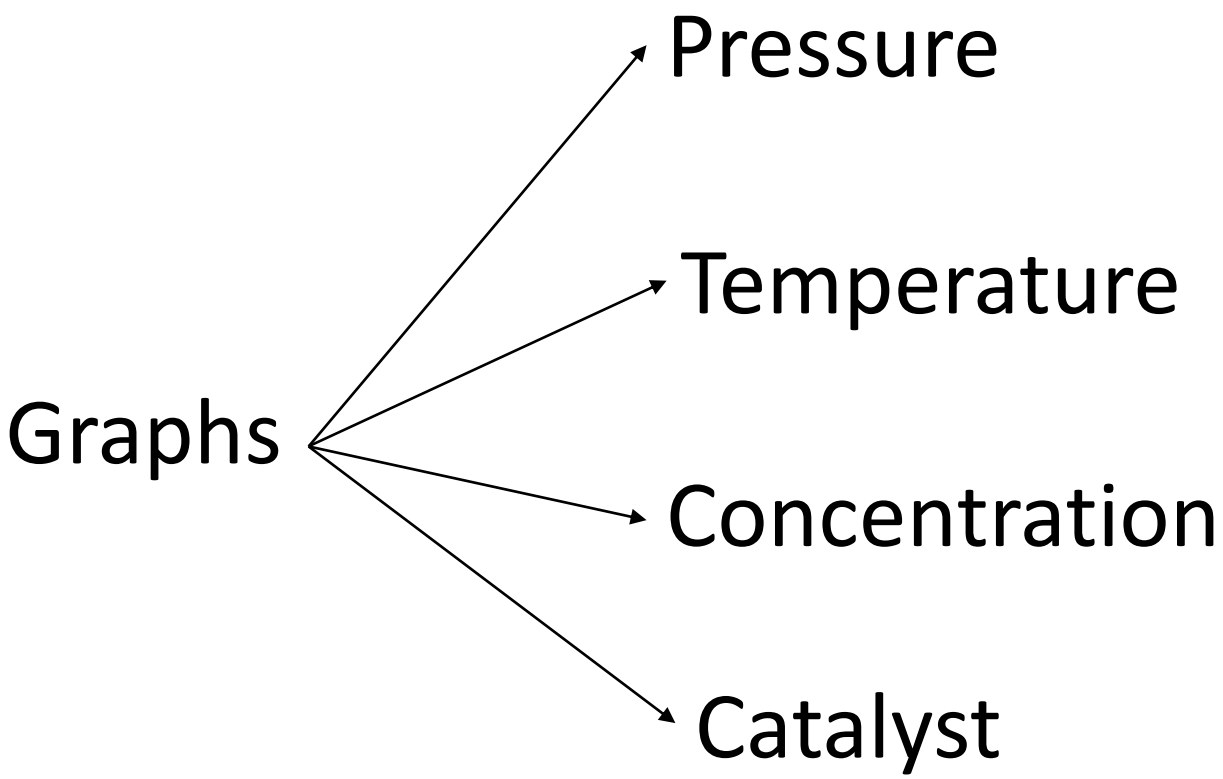
Chemical Equilibrium



Effect of Temperature and Pressure

- Chemical equilibrium occurs when a reaction and its reverse reaction proceed at the same rate

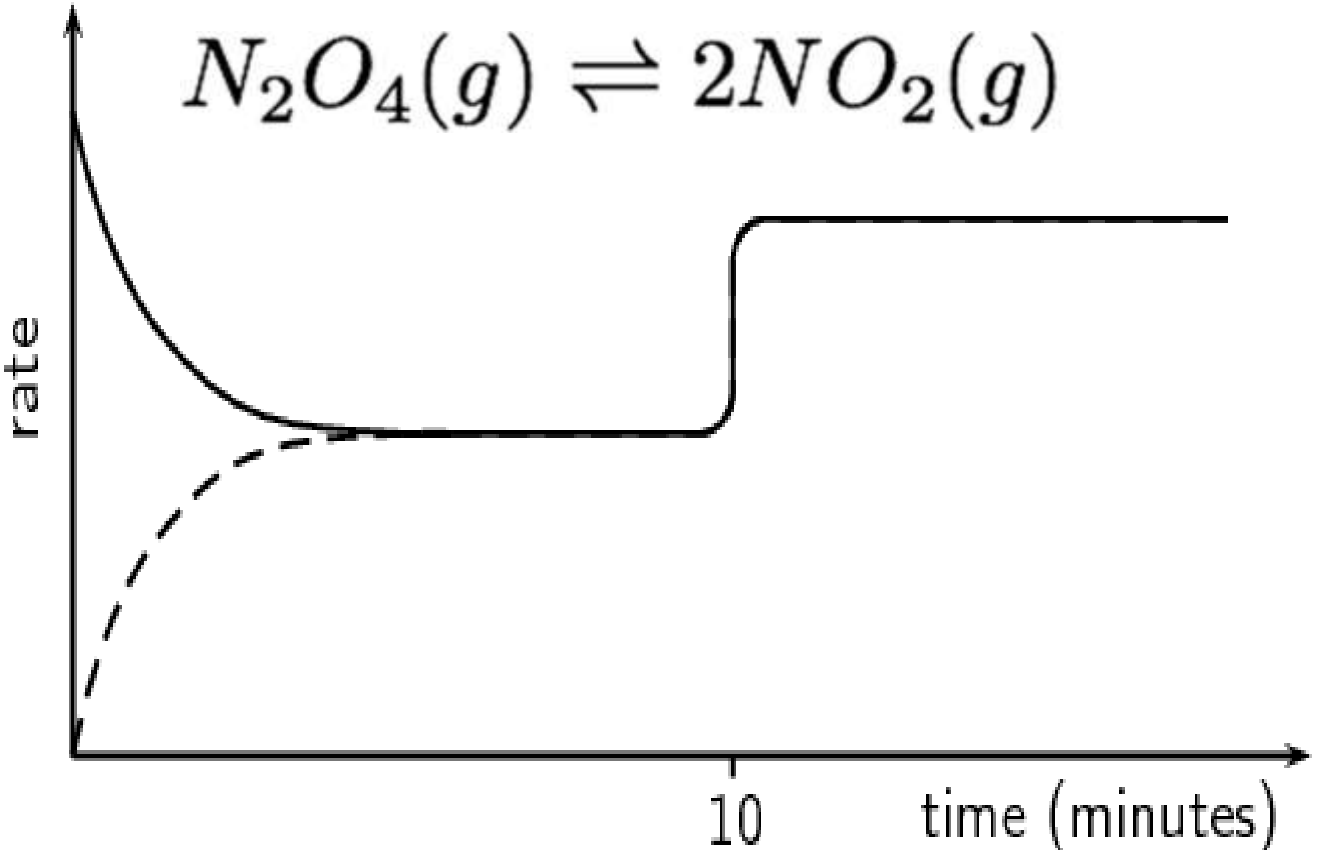
Chemical Equilibrium



Chemical Equilibrium

Catalyst effect

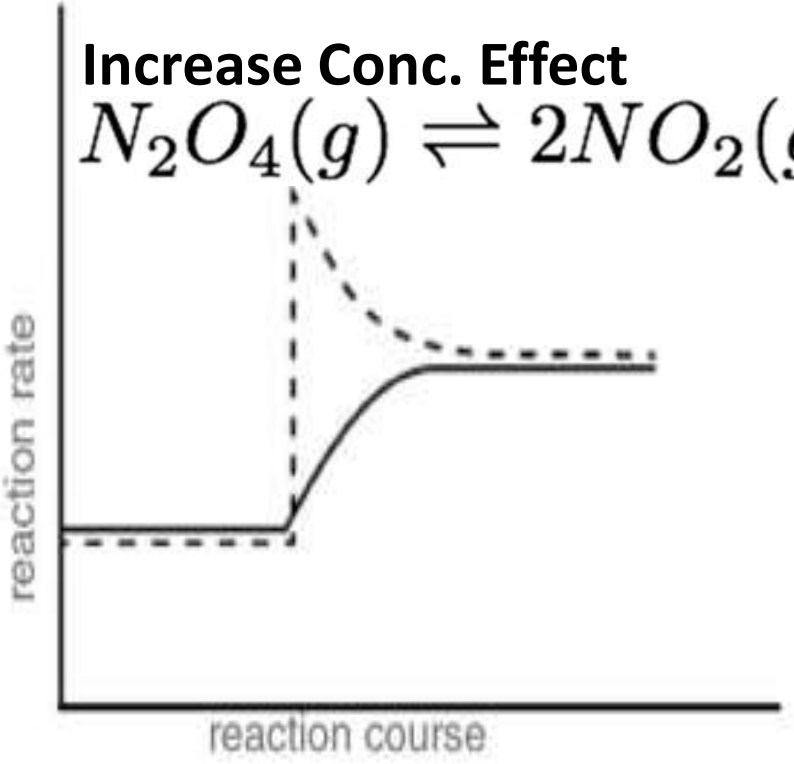
$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$



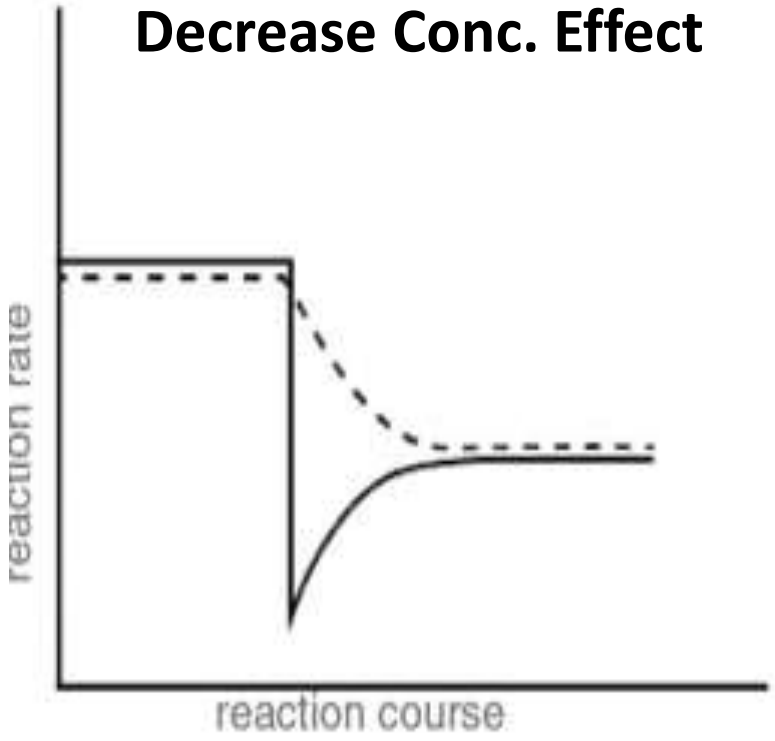
Chemical Equilibrium

Increase Conc. Effect

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

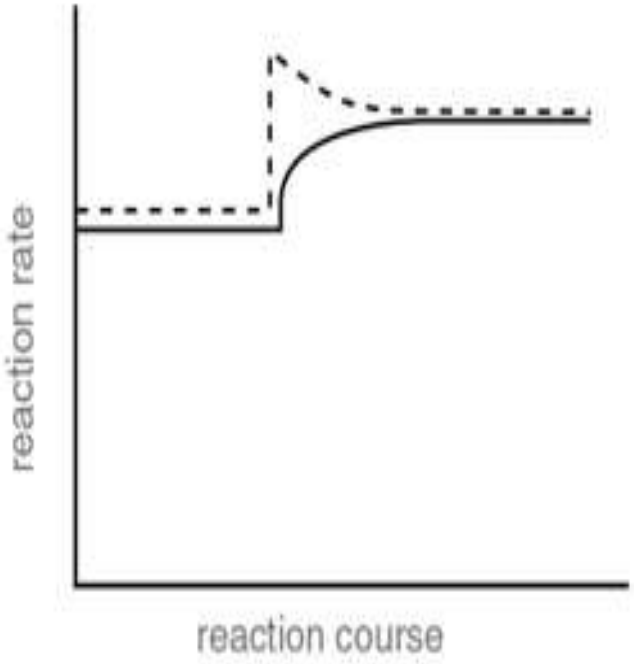


Decrease Conc. Effect

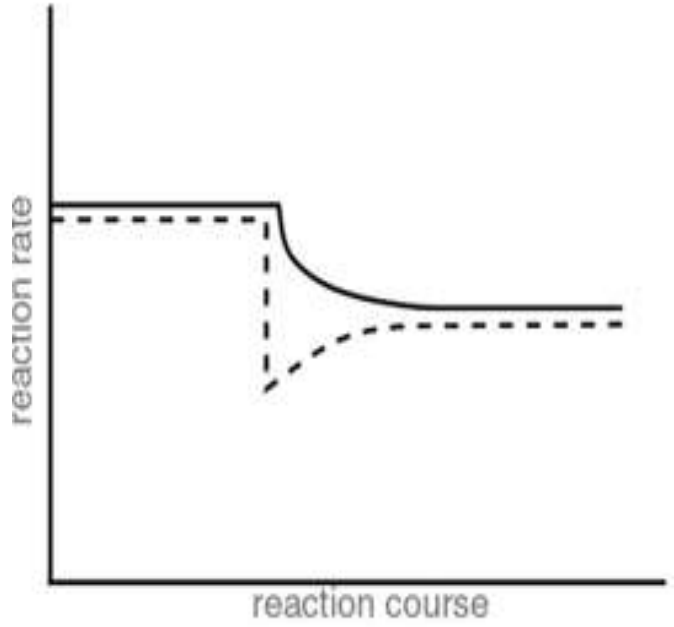


Chemical Equilibrium

Increase Temp. Effect

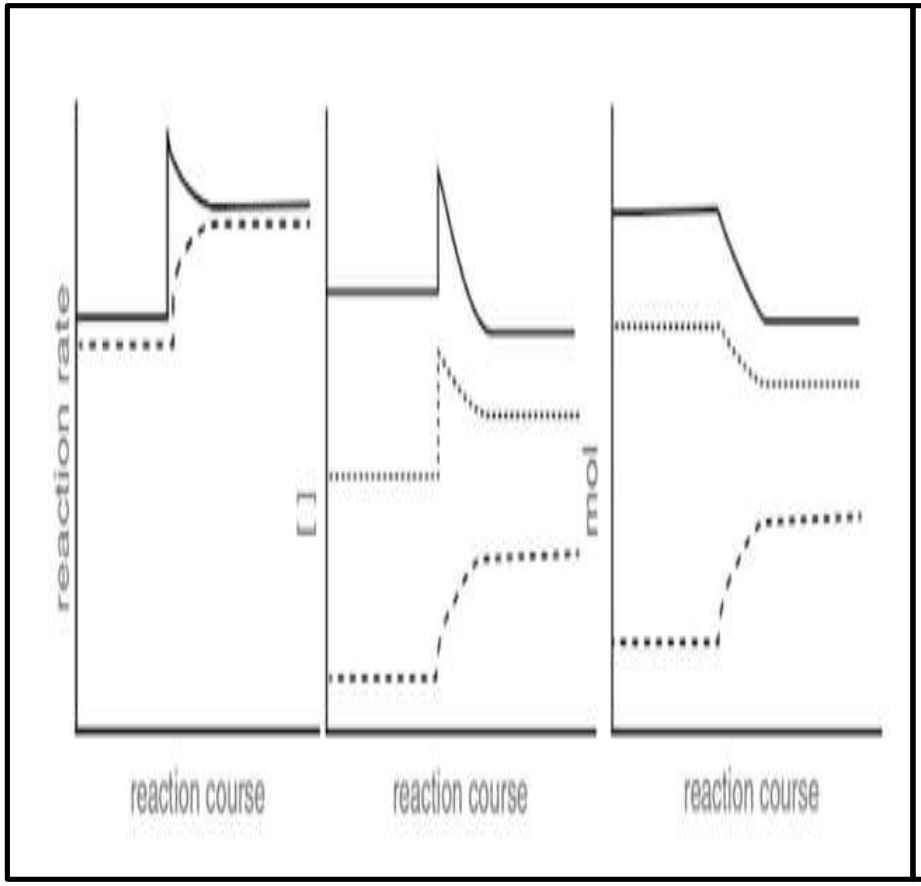


Decrease Temp. Effect

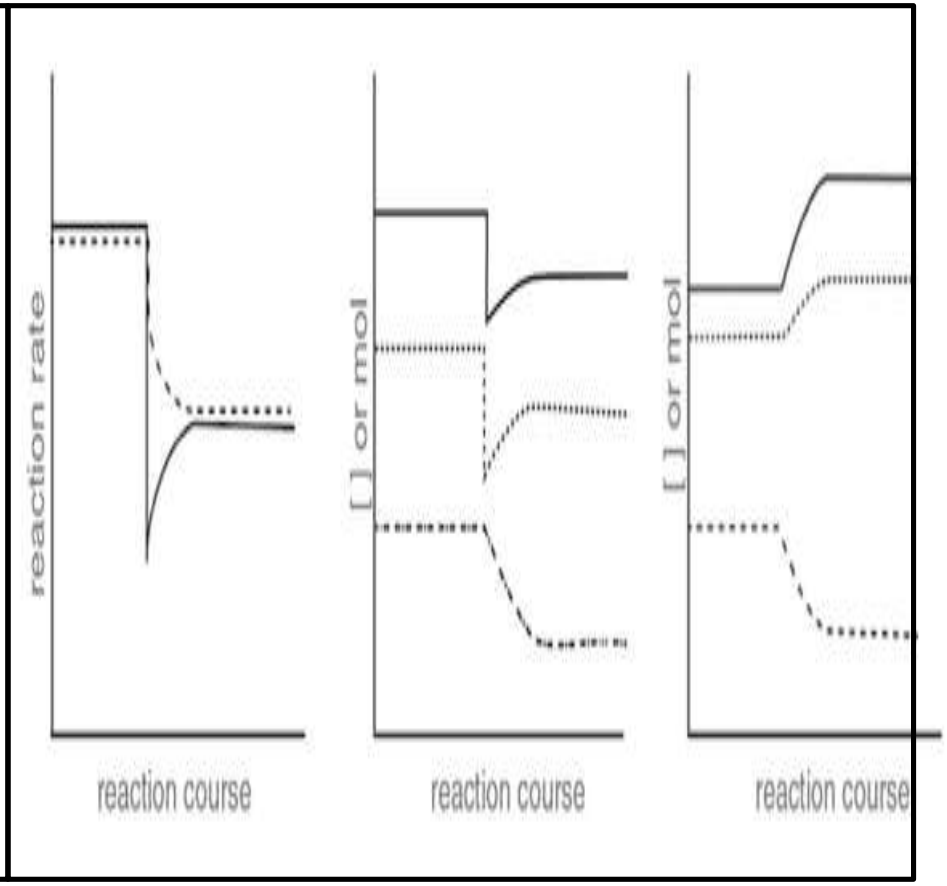


Chemical Equilibrium

Increase Pressure Effect



Decrease Pressure Effect



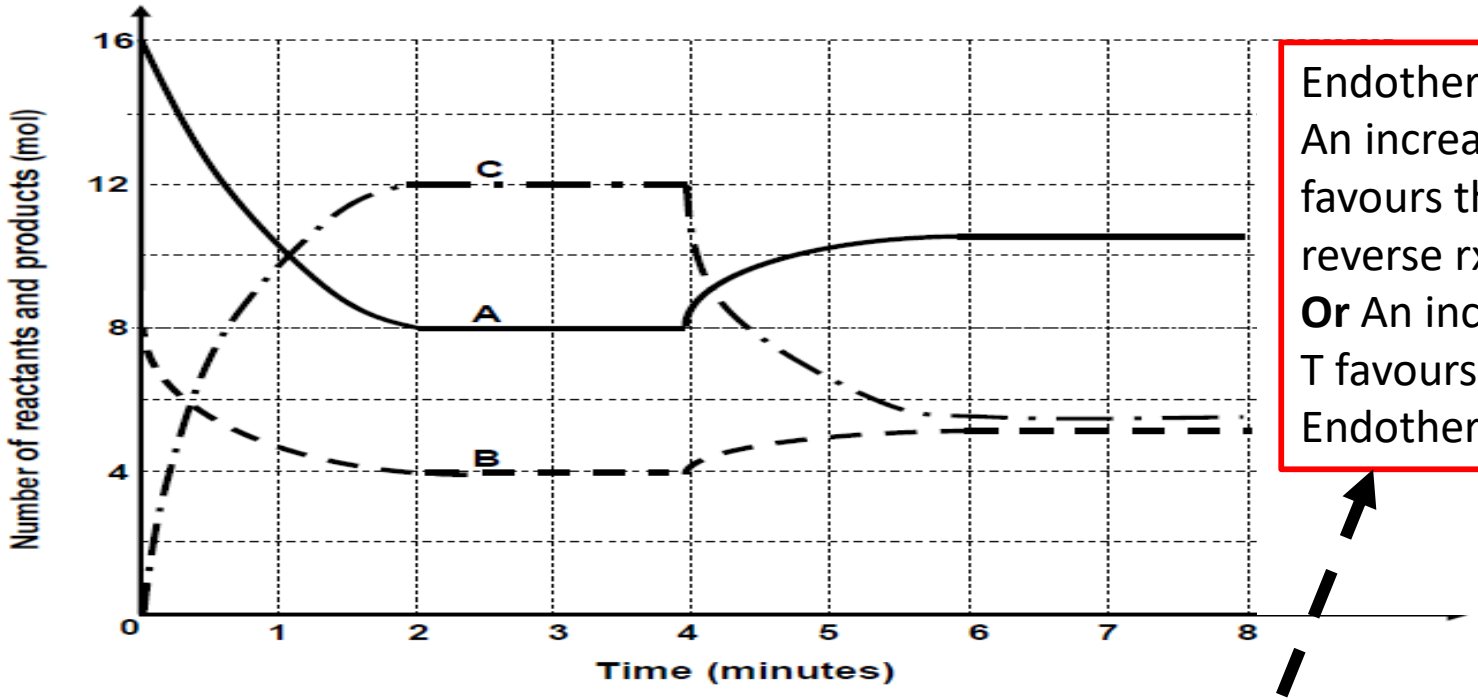
QUESTION 6 (Start on a new page.)

The equation below represents a hypothetical reaction that reaches equilibrium in a closed container after 2 minutes at room temperature. The letters **x**, **y** and **z** represent the number of moles in the balanced equation.

$$xA(aq) + yB(aq) \rightleftharpoons zC(aq)$$

The graph below shows the change in the number of moles of reactants and products versus time during the reaction.

Graph of number of moles of reactants and products versus time



Endothermic:
An increase in T favours the reverse rxn
Or An increase in T favours the Endothermic rxn

6.1 Define a *dynamic equilibrium*. (2)

6.2 Use the information in the graph and write down the value of:

6.2.1 **x** 2 ✓ (1)

6.2.2 **y** 1 ✓ (1)

6.2.3 **z** 3 ✓ (1)

6.4 At t = 4 minutes, the temperature of the system was increased to 60 °C. Is the REVERSE reaction EXOTHERMIC or ENDOTHERMIC? Explain how you arrived at the answer. (3)

[15]

QUESTION 6 (Start on a new page.)

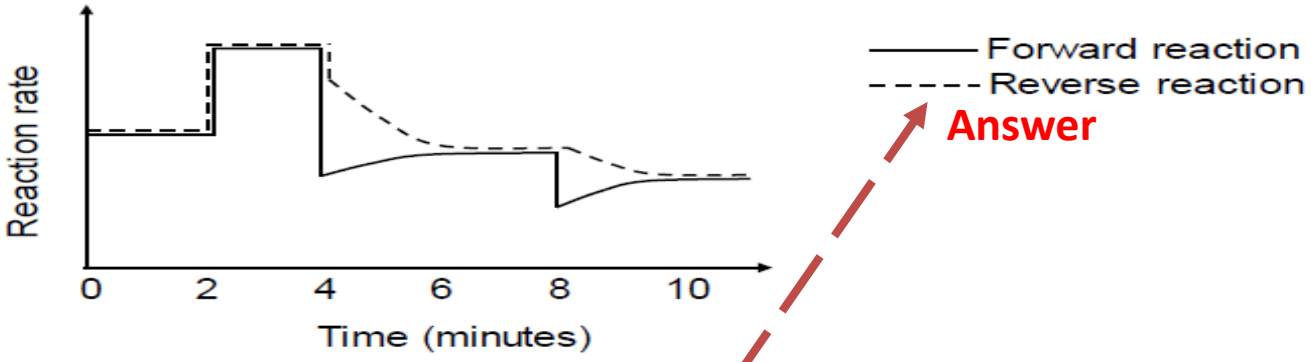
Hydrogen and iodine are sealed in a 2 dm^3 container. The reaction is allowed to reach equilibrium at 700 K according to the following balanced equation:

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

6.1 Give a reason why changes in pressure will have no effect on the equilibrium position. (1)

Both sides have equal amounts of moles.

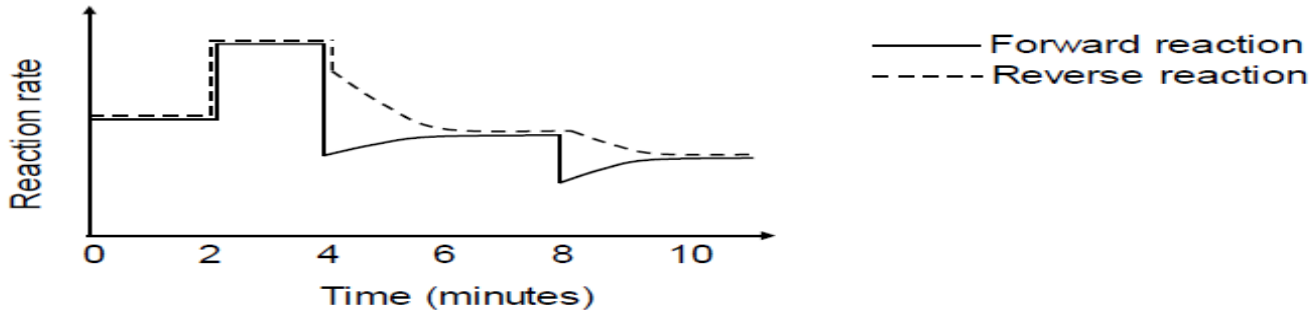
The reaction rate versus time graph below represents different changes made to the equilibrium mixture.



Answer

6.3 What do the parallel lines in the first two minutes indicate? (1)

- **Express Kc in terms of temperature**
- **Kc increase with an increase in temperature**



6.4 State TWO possible changes that could be made to the reaction conditions at t = 2 minutes. (2)

Add a catalyst / Increase Pressure

6.5 The temperature of the equilibrium mixture was changed at t = 4 minutes.

6.5.1 Is the forward reaction EXOTHERMIC or ENDOTHERMIC?

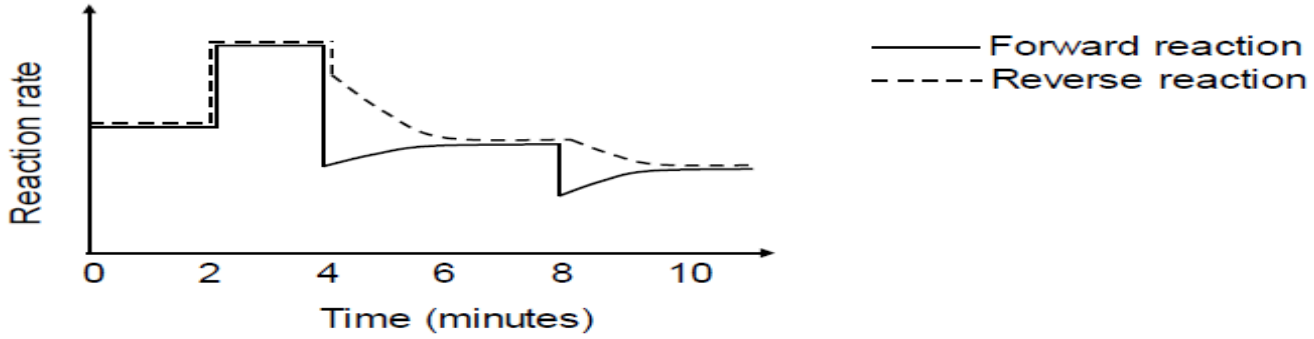
Fully explain the answer. (3)

[18]

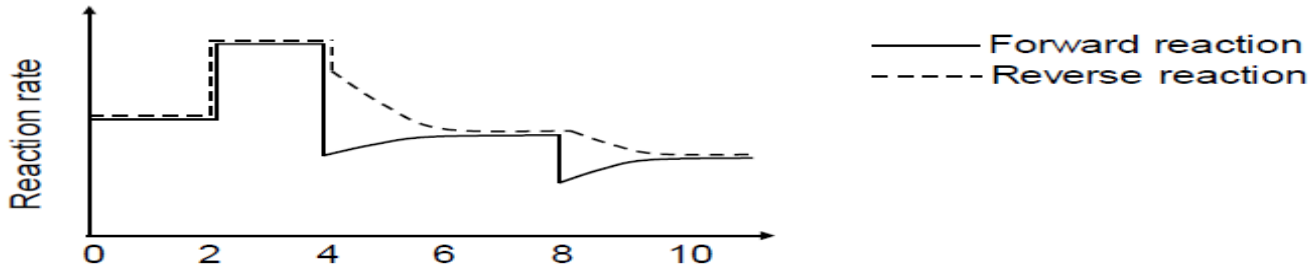
Endothermic:

- **Rate of forward rxn decreases more / rate of reverse reaction decreases less.**
- **Decrease in T favours the exothermic reaction**

- **Express Kc in terms of temperature**
- **Kc increase with an increase in temperature**



6.5.2 How will this change influence the K_c value? Choose from INCREASES, DECREASES or REMAINS THE SAME. **Decreases** (1)



6.6 What change was made to the equilibrium mixture at t = 8 minutes? (1)
[18]

Reactants H_2 and I_2 were removed

The Equilibrium Constant Expression

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

$$Kc = \frac{[NO_2]^2}{[N_2O_4]}$$

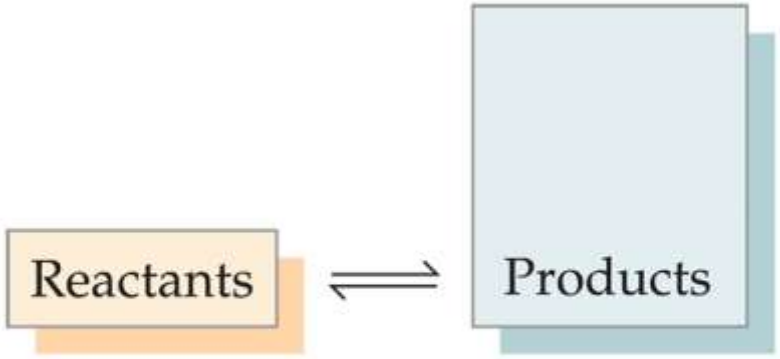
$$CO(g) + NiO(s) \rightleftharpoons CO_2(g) + Ni(s)$$

$$Kc = \frac{[CO_2]}{[CO]}$$

$$H^+(aq) + OH^-(aq) \rightleftharpoons H_2O(l)$$

$$Kc = \frac{1}{[H^+][OH^-]}$$

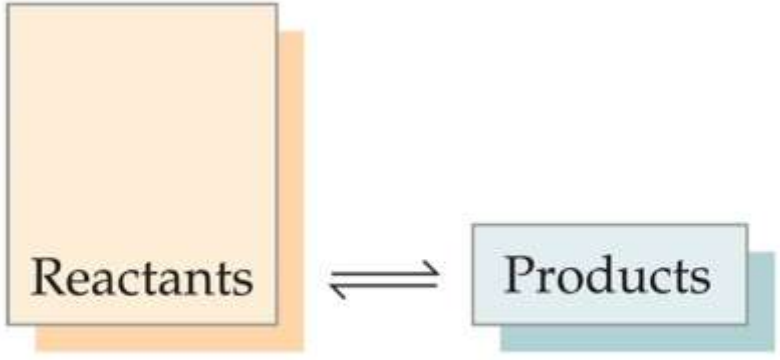
What Does the Value of *K* Mean?



(a) $K \gg 1$

$$K_c = \frac{[P]}{[R]} = \frac{5}{3}$$

There more products than reactants.



(b) $K \ll 1$

$$K_c = \frac{[P]}{[R]} = \frac{3}{5}$$

There are more reactants than products.