Province of the

EASTERN CAPE

EDUCATION

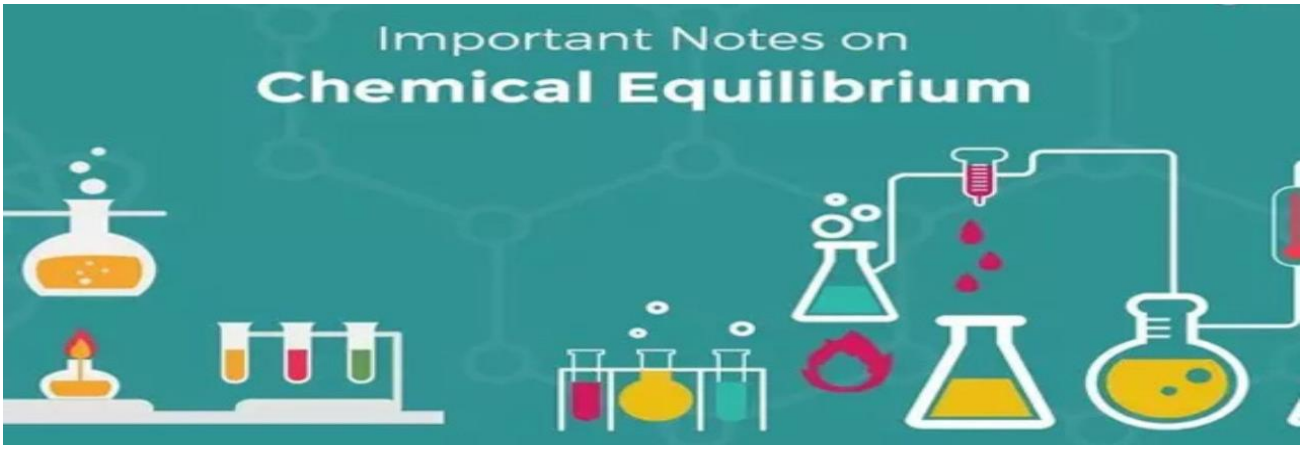
PHYSICAL SCIENCES LESSON MATERIAL

TERM 2 -2020

CHEMICAL EQUILBRIUM

SUBTOPIC- Chemical equilibrium and factors affecting chemical equilibrium.

DURATION: 8hrs



CHEMICAL EQUILBRIUM

1. **Chemical equilibrium and factors affecting chemical equilibrium**

Key Concepts

-Open system
-Closed system
-Reversible reaction
-Dynamic equilibrium

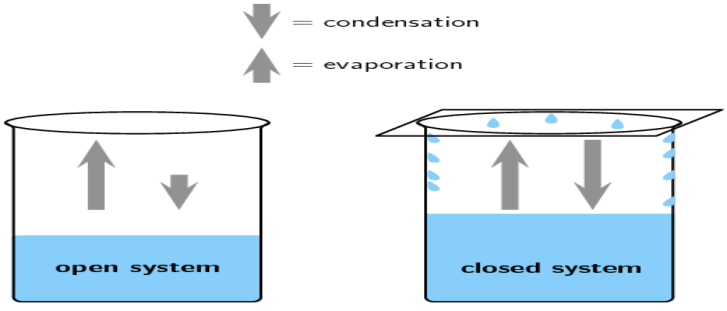
Outcomes

Explain what is meant by:

- Open system
- Closed system
- A reversible reaction
- Chemical equilibrium
- List the factors that influence the position of an equilibrium

Open and Closed system

- The reactants and products together with the container in which the reaction occurs, are known as the system
- Open and closed systems: An open system environment, while a closed system is isolated from its surroundings.



A reversible reaction
It is a reaction is reversible when products can be converted back to reactants

Chemical equilibrium

It is a dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.

The factors that influence the position of an equilibrium:

A change in pressure (gases only).
A change in concentration of a reactant or a product.
A change in temperature.

***NB:* These factors apply to all reversible chemical reactions**

- **Temperature**- increasing or decreasing the temperature of the equilibrium mixture.
- **Concentration**- adding substance to or removing a substance from the system at constant volume (this only applies to solutions (aq) and to gases (g)
  The reaction that counteracting the change will be favoured.
- **Pressure** –increasing or decreasing the pressure on an equilibrium mixture (this ONLY applies to gases

If pressure if pressure is increased, the reaction that proceeda towards the least number of moles of gas will be favoured.
If pressure is decreased, the reaction that proceeds towards the most number of
moles of gas is favoured.

NB: Catalyst do not affect the equilibrium position.

The change in equilibrium condition	**The effect on equilibrium**
Increases in concentration of reactants	The rate of the reaction towards the formation of products is increased.
Decrease in concentration of reactants	The rate of the reaction towards products is increased.
Increase in temperature	Both forward and reverse reaction rate increase, however, the equilibrium shifts towards the endothermic side of the reaction
Decrease in temperature	Reaction rate slows down

	The shift in equilibrium is towards the exothermic side
Change in pressure(for gases)	An increase in pressure will shift the equilibrium towards the reaction where there are fewer moles of gas and vice versa

2. EQUILIBRIUMS CONSTANT

Key Concepts

Equilibrium constant

Outcomes

- List the factors that influence the value of the equilibrium constant, K_c.
- Write down an expression for the equilibrium constant having been given the equation for the reaction.
- Perform calculations based on K_c values.
- Explain the significance of high and low values of the equilibrium constant.

Equilibrium constant expression

Equilbrium constant can be described as an expression of the concentration of the products over the concentration of the reactants for a reaction that is in equilbrium.

$$k_c = \frac{[product]}{[reactant]}$$

Where :

- Kc is an equilibrium constant (no unit)
- [Substance] is concentration of (aq) or (g) reactant or product in $mol.dm^{-3}$
- mol is number of moles of each compound in the balanced reaction equation.

Low Kc value (Kc <1) indicates that a higher concentration of reactants than

products are present (the equilibrium lies to the left).

In a closed system in equilibrium:
The value of Kc does **NOT** change:

- If pressure in the system changes
- If the concentration of a reactant or product in the system changes
- If a catalyst is added to the system

The value of Kc changes if the temperature changes.

The effect of a change in temperature on Kc

Forward reaction favoured	Reverse reaction favoured
More products form	More reactants form
[Products] increases	[products] decreases
[Products] decreases and	[Reactants] increases and
Kc increases	Kc decreases

Worksheet 1

1. Explain the difference between open and closed system. (2)

2. Explain what is meant by the term reversible reaction (2)

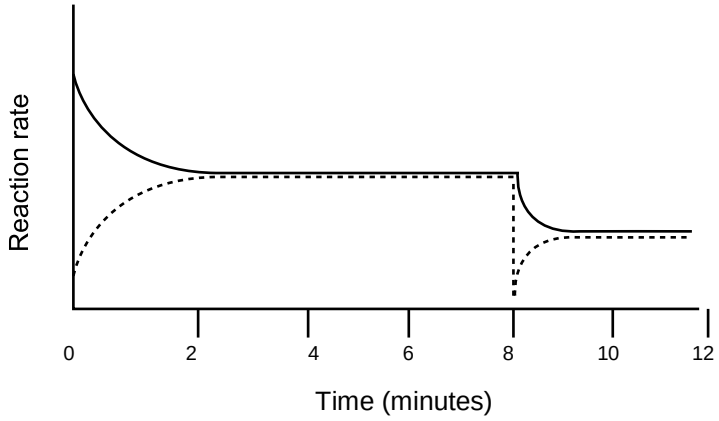
3. Explain is what is meant when a system is in dynamic equilibrium. (2)

4. How do we present a system that is in dynamic equilibrium. (2)

5. Name three factors that are able to change the equilibrium of a system in dynamic equilibrium. (3)

[11]

Worksheet 2



2.1 Write down the balanced equation which is represented by the **broken line**. (2)

2.2 After 8 minutes the pressure is decreased.

2.2.1 State *Le Chatelier's Principle*. (2)

2.2.2 Apply *Le Chatelier's principle* to the reaction in order to EXPLAIN the changes shown on the graph between 8 and 10 minutes. (3)

2.3 Write down an expression for the equilibrium constant (K_c) for this reaction. (2)

2.4 Initially 5mol of XA_3 ( )g was sealed in a $2dm^3$ flask. At equilibrium the reaction mixture contained exactly 1,5mol of A g_2 ( ) at 300ºC. Calculate the value of the equilibrium constant (K_c) at this temperature. (6)

2.3 7 moles of nitrogen gas (N_2) and 2 moles of oxygen gas (O_2) are placed in an empty container of volume $2dm^3$. The container is sealed and the following equilibrium is established:

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

The K_c value for this reaction at 25^0C is 4 ,8 x 10^{-31}.

2.3.1 What information does this value of K_c indicate with regards to the amount of NO(g) in the equilibrium mixture at 25^0C? (2)

The container is heated and the system reaches a new

equilibrium at 2500ºC. At this temperature it is found that there are 0,4 moles of NO(g) present.

2.3.2 How much N_2 reacted? (1)

2.3.3 How much O_2 is there at equilibrium? (1)

2.3.4 Determine the concentration of NO at equilibrium. (3)

2.3.5 Determine the K_c value at this temperature. (4)

2.3.6 Making use of *Le Chatelier's principle*, explain why the forward reaction is endothermic. (4)

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Worksheet 3

1. A certain amount of NO_2 gas is sealed in a gas syringe at 25ºC. When equilibrium is reached, the volume occupied by the reaction mixture in the gas syringe is 80cm^3 . The balanced chemical equation for the reaction taking place is:

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

dark brown colourless

1.1 State two conditions necessary for chemical equilibrium to occur. (2)

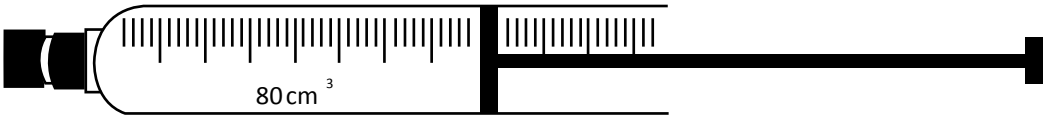
1.2 At equilibrium the concentration of the $NO_{2\,(g)}$ is 0 2, mol dm^{-3} . The equilibrium constant for the reaction is 171 at 25^{0}C.

1.3 Calculate the number of moles of N_2O_4 at equilibrium. (3)

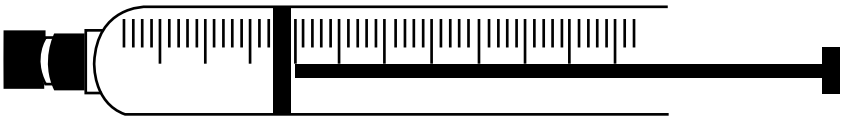
1.4 Calculate the initial number of moles of $NO_2(\ )g$ placed in the gas syringe. (3)

1.5 Write an expression for the equilibrium constant, K_c, of this reaction. (2)

1.6 The diagram below shows the reaction mixture in the gas syringe after equilibrium is established as seen at time t_1.



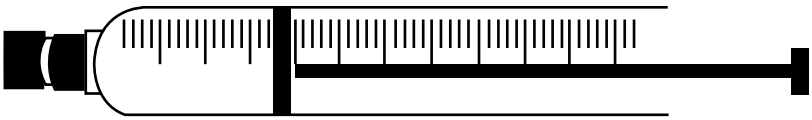
The pressure is now increased by decreasing the volume of the gas syringe at constant temperature as illustrated in the diagram belo.



Immediately after increasing the pressure, before the new equilibrium is established, the colour of the reaction mixture in the gas syringe appears darker than before.

1.7 Give a reason for this observation. (1)

After a while, at time t_2, a new equilibrium is established as illustrated below. The colour of the reaction mixture in the gas syringe now appears lighter than the initial colour.



1.8 Use *Le Chatelier's principle* to explain the colour change observed in the gas syringe.

1.8.1 Colour of the reaction mixture (3)

1.8.2 Value of the equilibrium constant, K_c (3)

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Worksheet 4

1 A chemical engineer studies the reaction of nitrogen and oxygen in a laboratory. The reaction reaches equilibrium in a closed container at a certain temperature, T, according to the following balanced equation:

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

Initially, 2 mol of nitrogen and 2 mol of oxygen are mixed in a 5dm^3 sealed container.

The equilibrium constant (K_c) for the reaction at this temperature is 1,2 x 10^{-4}.

1.1 Is the yield of NO(g) at temperature T HIGH or LOW? Give a reason for the answer. (2)

1.2 4.2 Calculate the equilibrium concentration of NO(g) at this temperature. (8)

1.3 How will each of the following changes affect the YIELD of NO(g)?
Write down only INCREASES, DECREASES or REMAINS THE SAME.

1.3.1 The volume of the reaction vessel is decreased at constant temperature. (1)

1.3.2 An inert gas such as argon is added to the mixture. (1)

1.4 It is found that K_c of the reaction increases with an increase in temperature. (3)
Is this reaction exothermic or endothermic? Explain the answer.

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