STUDY PACK : 3.C

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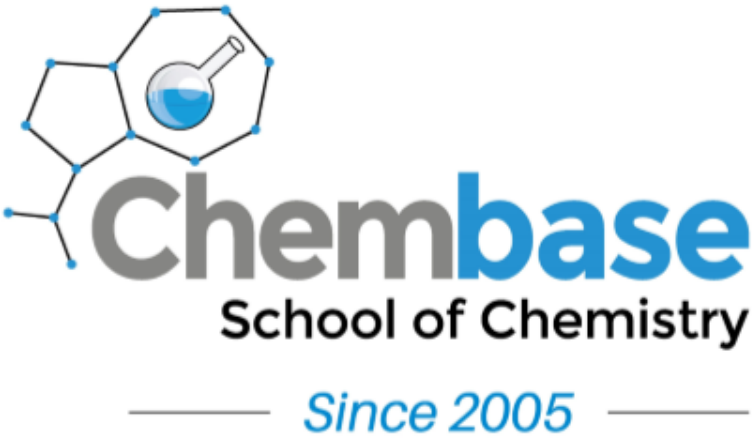
PHYSICAL CHEMISTRY

REVERSIBLE REACTIONS & EQUILIBRIA



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Reversible Reactions & Equilibria

(01)

i. Explain what a Reversible Reaction is?

Reactions where reactants give products and the products give reactants under the same conditions of temperature, pressure and concentration.

ii. How a reversible reaction is shown in a chemical equation?

iii. Give some examples of reversible reactions

iv. What are the reversible reactions which we can observe a colour change, Hence prove it's reversibility

v. Explain an experiment to show the reversible reaction of the Hydration of heated anhydrous Copper (II) sulphate

When blue hydrous $CuSO_4$ ($CuSO_4.5H_2O$) crystals heated, they lose their water of crystallisation resulting white anhydrous $CuSO_4$. If water is added to this mixture upon cooling, the blue colour immediately returns.

(02) What is a chemical Equilibrium?

Chemical equilibrium is a state of balance in which the rates of the forward and backward reactions are equal at constant temperature, pressure & concentration. (macroscopic properties)

(03) What do we understand when we say that a system is in equilibrium?

When we consider the overall system, there is no apparent change taking place.

(04)

i. Explain the concept of dynamic equilibrium hence define dynamic equilibrium

A reaction occurring in both directions where the rate of the forward and the backward reactions are equal at constant temperature, pressure and concentration (macroscopic properties)

ii. What are the factors which should be constant in order to maintain the Dynamic equilibrium

Temperature, pressure and concentration.

iii. How can we alter the position of the equilibrium?

The position of equilibrium can be shifted to the left or to the right by altering the above conditions of temperature, pressure & concentration.

iv. What are the ways that a system can come out of equilibrium?

If the products of a reversible reaction are removed or allowed to escape or prevented from recombining.

(05) State the characteristic properties of a Dynamic equilibrium

- At equilibrium, the macroscopic properties are constant
- The rates of both forward and backward reaction are equal.
- The concentration of reactants & products are constant. (not necessary equal)
- The equilibrium can be achieved in a closed system, as there is no loss or gain of material. An open system may allow the matter to escape or to enter.

(06) Account for dynamic equilibrium in terms of the kinetic theory (collision theory)

Particles of the reactants will be bombarding each other and if they possess energy higher than the activation energy, then the effective collisions will result in the formation of products. At the beginning the rate of the forward reaction will be higher as there are more molecules resulting effective collisions. The rate of the backward reaction will be zero. As the products are formed the rate of the backward reaction will gradually increase. A dynamic equilibrium will be achieved when both of these rates become equal in a sealed container.

(07) Explain how changes in macroscopic properties effect the position of the equilibrium.

When macroscopic properties such as temperature, pressure or concentration change the system adjusts itself to minimize or to nullify that external change. As a result of this the equilibrium will shift to reactants (backward) or products.

(08)

i. Explain the effect of temperature on **endothermic** reaction which is in equilibrium

As the forward reaction is endothermic it absorbs heat from the surroundings. When the temperature is increased the system will adjusts itself to decrease the temperature by favouring the forward reaction (products) as forward reaction decreases the heat.

Likewise when the temperature is decreased the system will adjust itself to increase the temperature by favouring the backward reaction, as the backward reaction increases the heat (exothermic)

ii. Explain the effect of temperature for an equilibrium reaction which is **exothermic**

As the forward reaction is exothermic it releases heat to the surroundings. When the temperature is increased the system will adjusts itself to decrease the temperature by favouring the backward reaction (reactants) as forward reaction increases the heat.

Likewise when the temperature is decreased the system will adjust itself to increase the temperature by favouring the forward reaction (products) as the forward reaction increases the heat (exothermic)

iii. Fill the below table by indicating the effects in the reaction

Reaction	△H	Temperature Change	Reactants	Products
Exothermic	(-)ve	Decrease		
		Increase		
Endothermic	(+)ve	Increase		
		Decrease		

(09) State the effect of temperature on below equilibrium reactions

i. $N_{2(g)} + O_{2(g)} \text{ ==== } 2NO_{(g)}$ $\quad \triangle H$ +185 $kJmol^{-1}$

High Temperature:

Low Temperature:

ii. $2SO_{2(g)} + O_{2(g)} \text{ ==== } 2SO_{3(g)}$ $\quad \triangle H$ -192 $kJmol^{-1}$

High Temperature:

Low Temperature:

iii. $N_{2(g)} + 3H_{2(g)} \text{ ==== } 2NH_{3(g)}$ $\quad \triangle H$ -92 $kJmol^{-1}$

High Temperature:

Low Temperature:

(10) Explain the effect of pressure on an equilibrium reaction

The effect of pressure applies only to the gaseous equilibrium reactants. When the no. of gaseous molecules in a system is lowered the pressure is less. Likewise when the no. of gaseous molecules in a system is higher the pressure is high. If the pressure is high, the system will adjust itself to decrease the pressure. This will happen by equilibrium shifting to the side where there is lower no. of gaseous molecules. Similarly when the pressure is decreased, the system will adjust by increasing pressure by equilibrium shifting to the side where there is more no. of gaseous molecules.

(11) Describe what will happen if an equilibrium mixture in each of the following reaction subjected to (i) Increase in Pressure

(ii) Decrease in Pressure

i. $N_{2(g)} + 3H_{2(g)} \text{ ==== } 2NH_{3(g)}$

ii. $C_{(s)} + H_2O_{(g)} \text{ ==== } CO_{(g)} + H_{2(g)}$

iii. $C_{(s)} + O_{2(g)} \text{ ==== } CO_{2(g)}$

iv. $4NH_{3(g)} + 5O_{2(g)} \text{ ===== } 4NO_{(g)} + 6H_2O_{(g)}$

v. $N_{2(g)} + O_{2(g)} \text{ ==== } 2NO_{(g)}$

vi. $Cl_{2(g)} + PCl_{3(g)} \text{ ==== } PCl_{5(s)}$

(12) State the effect of a catalyst on the equilibrium state

The addition of catalyst to a system at equilibrium does not alter the equilibrium state. It simply increases the rate of both the forward and the backward reaction so that equilibrium condition is achieved faster.

(13) In the Haber process ammonia is manufactured from nitrogen & hydrogen

$N_{2(g)} + 3H_{2(g)} ==== 2NH_{3(g)}$ $\triangle H$ -92 $kJmol^{-1}$

Suggest why a high yield of ammonia at equilibrium is favoured by:

a) Low Temperatures: (450C)

b) High Pressures: (200atm)

c) Justify the use of the above temperature.

e) Explain how the use of iron catalyst affect the above process