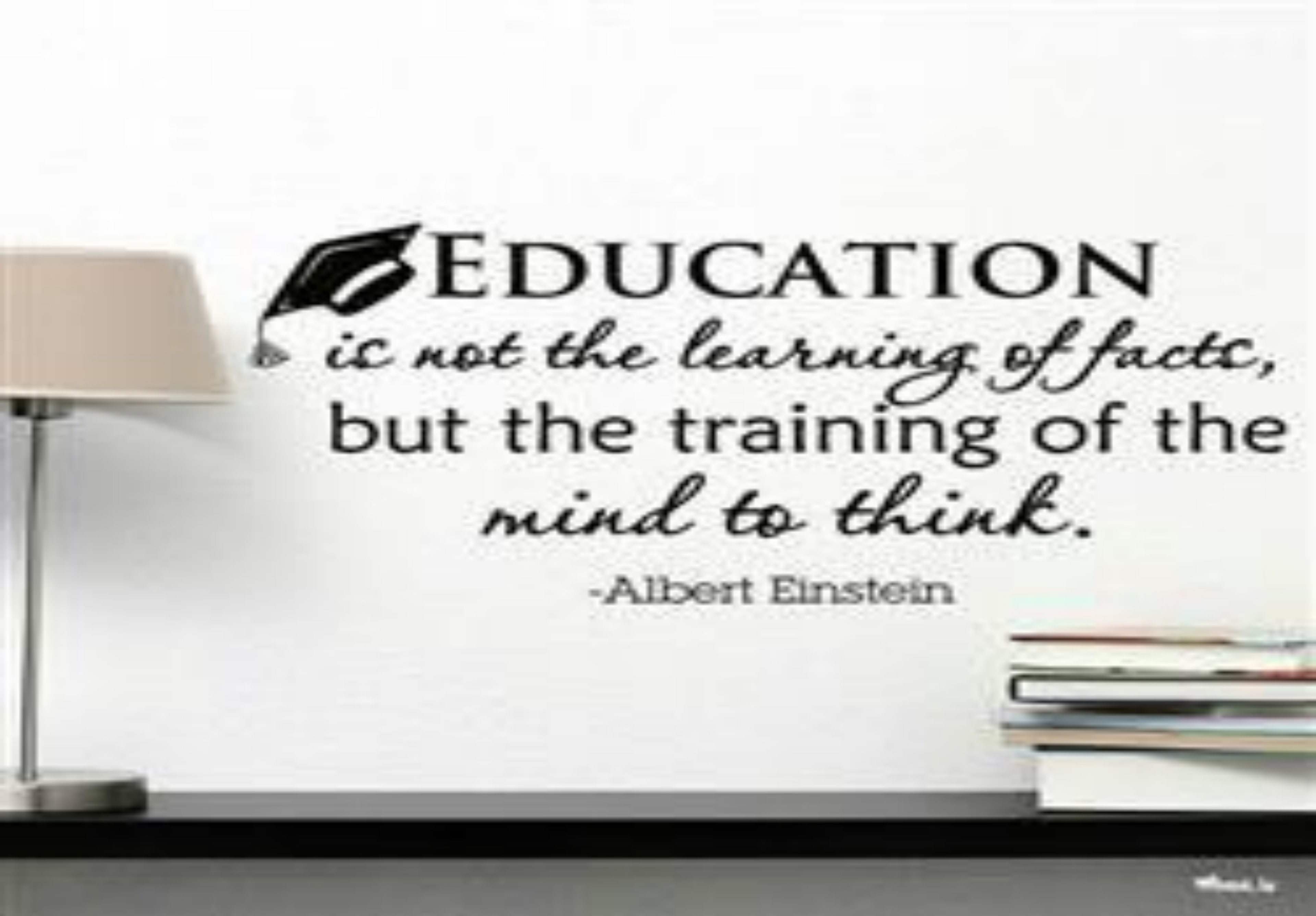
Pakistan School
Kingdom of Bahrain

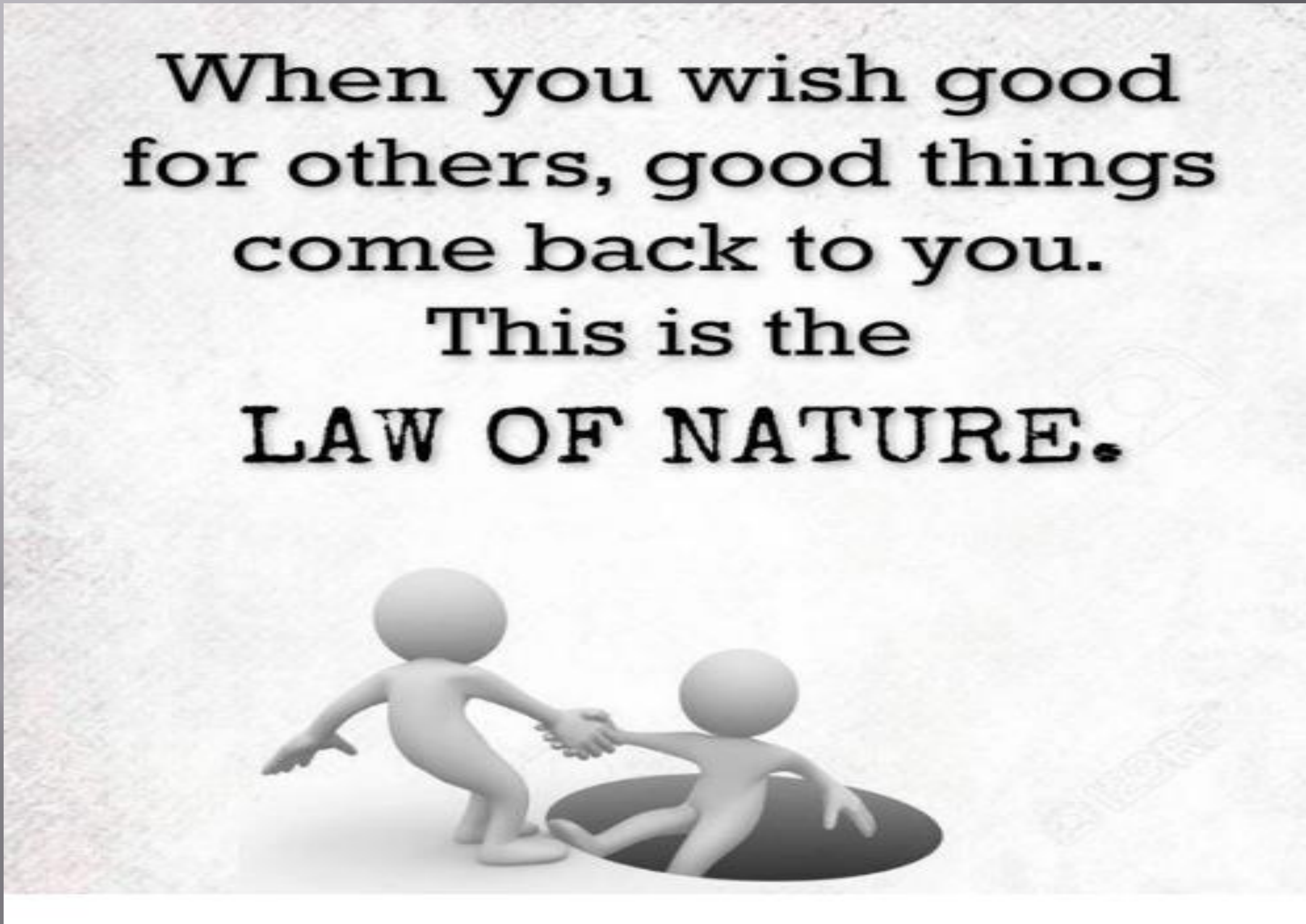
gradeup

Important Notes on
Chemical Equilibrium


EDUCATION
is not the learning of facts,
but the training of the
mind to think.
-Albert Einstein


WELCOME
BACK

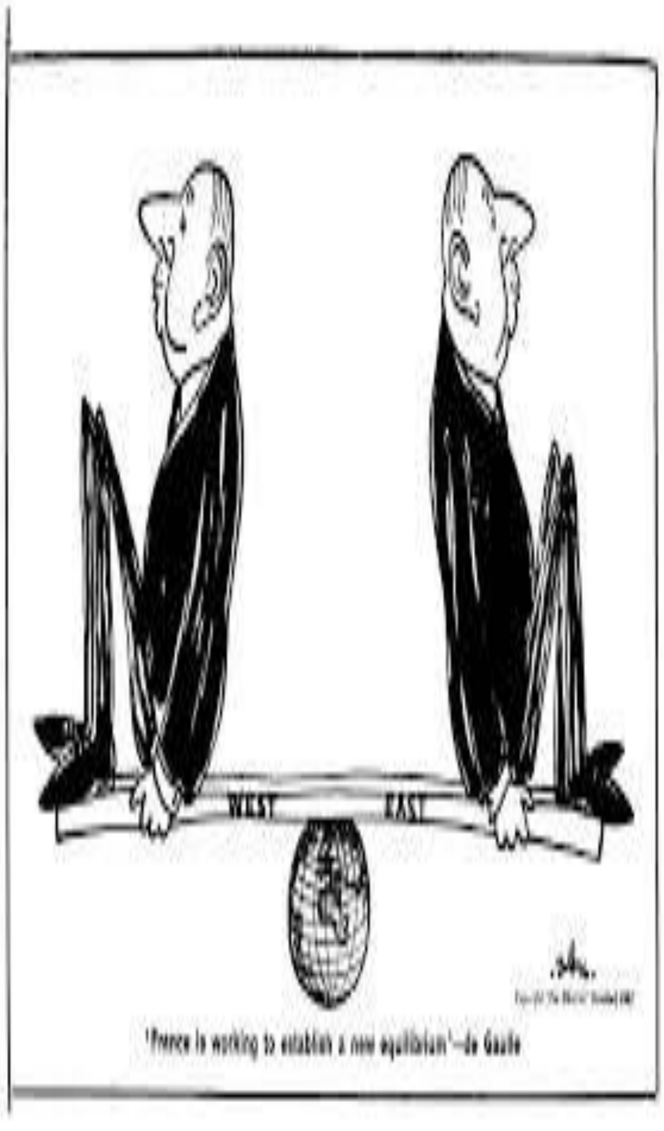

>> Ready for Anything
WELCOME BACK TO
VIRTUAL CLASSES!
#WEAREALWAYSTOGETHER
AMERICAN
AS

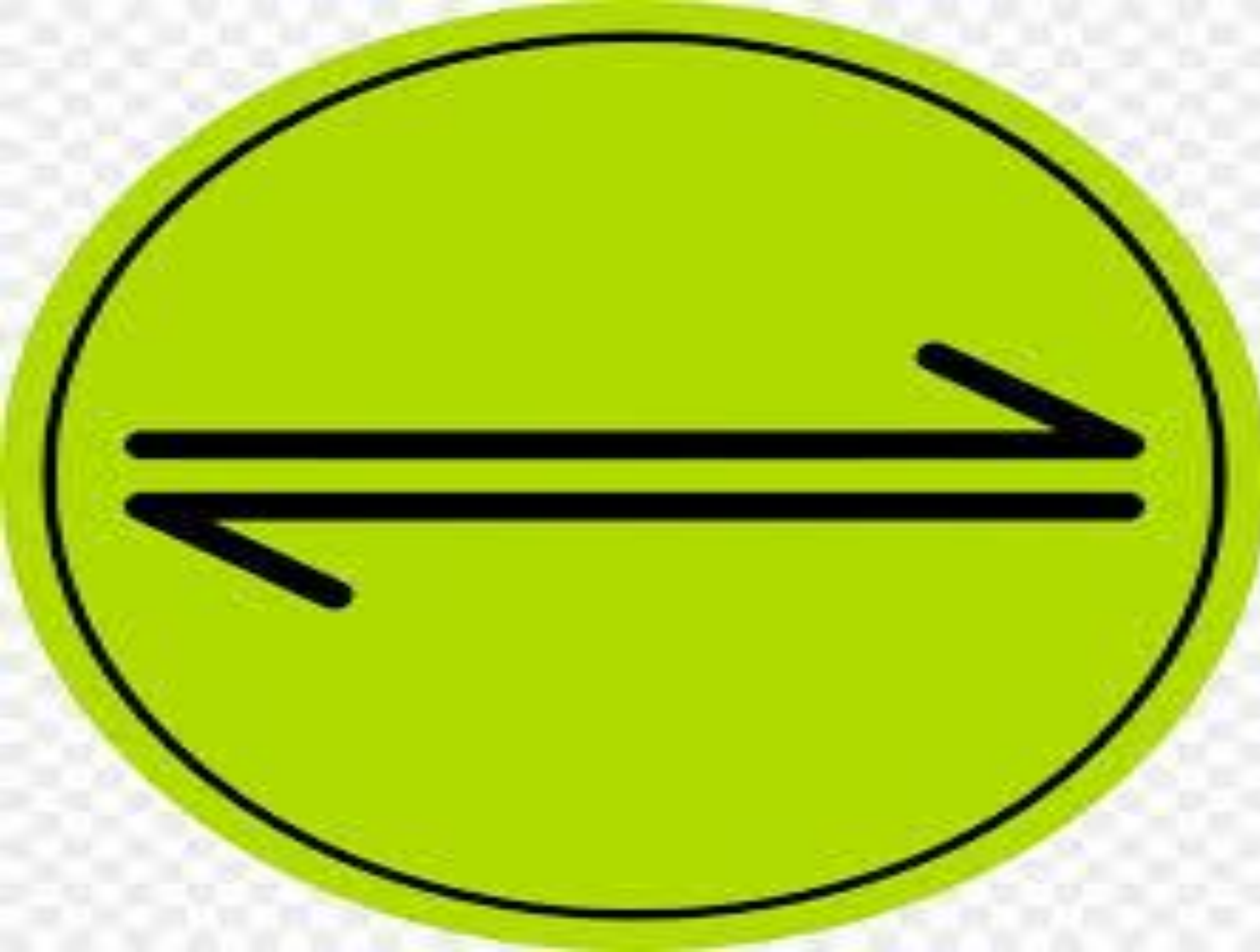

When you wish good
for others, good things
come back to you.
This is the
LAW OF NATURE.

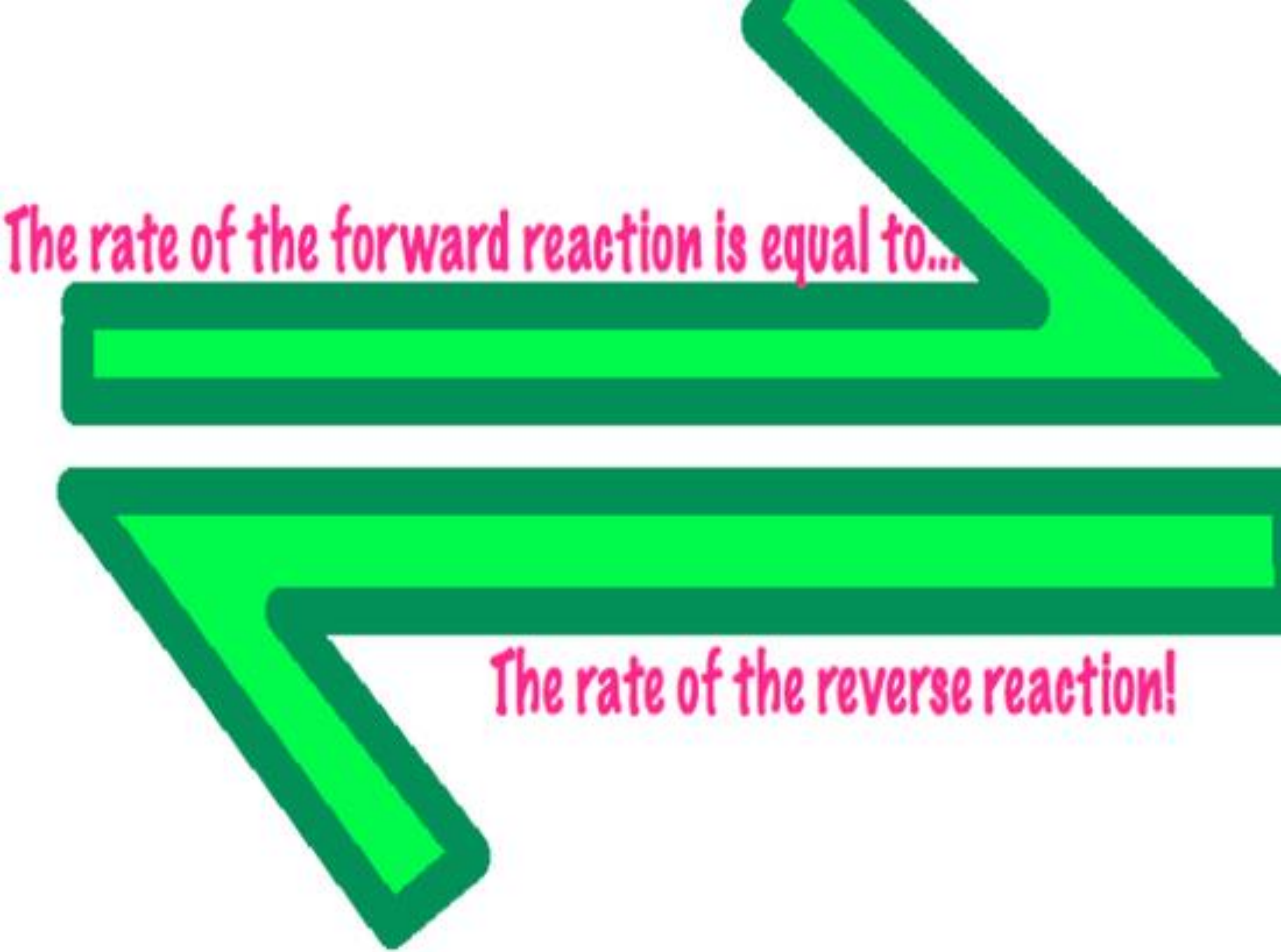
WARM WELCOME

- A WARM WELCOME TO ALL THE STUDENTS IN ONLINE CLASSES. THIS IS D.CHARLES TEACHER SENIOR SECTION (BOYS).WE ARE GOING TO START OUR ONLINE CHEMISTRY CLASS TODAY.
- I HOPE YOU WILL LEARN AND ENJOY.
- RULES OF THE CLASS ROOM:1)BE ON TIME FOR ALL YOUR CLASSES.2)RESPECT ALL PARTICIPANTS OF THE CLASS.3)DO NOT CREATE ANY DISTURBANCES .4) RAISE YOUR HAND IF YOU HAVE ANY QUESTION.5)GIVE RESPECT TO YOUR TEACHER.

POINTS TO PONDER:






The rate of the forward reaction is equal to...
The rate of the reverse reaction!

LESSON OBJECTIVES:

- BY THE END OF THIS PART OF THE LESSON, STUDENTS WILL BE ABLE TO:
- DEFINE REVERSIBLE REACTION ?
- DEFINE CHEMICAL EQUILIBRIUM?
- DIFFERENTIATE BETWEEN FORWARD AND REVERSE REACTION?
- HOW FIZZY DRINKS ARE PREPARED?
- STATE LAW OF MASS ACTION?

Reversible Reactions

When a reaction occurs both forward and reverse direction it is called reversible reaction

(In many reactions the products interact and revert back into the reactants)

$$2SO_{2(g)} + O_2(g) \rightleftharpoons 2SO_{3(g)}$$

$$COCl_2 \rightleftharpoons CO_{(g)} + Cl_2$$

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$$

Chemical Equilibrium

At Chemical Equilibrium Rate of Forward Reaction

Becomes Equal to Rate of Backward Reaction

What is equilibrium?

Definition (dictionary.com): a state of rest or balance due to the equal action of opposing forces

Chemical Equilibrium: A process where a forward and reverse reaction occur at equal rates

Not all chemical reactions are reversible!!!

Definition of Chemical Equilibrium

In a chemical process, ***chemical equilibrium*** is the state in which the *concentrations* of the reactants and products have *NO* net change over time.

A chemical reaction is in a ***dynamical equilibrium*** when it is occurring in *forward* and *reverse* directions with the rate being *the same* in both directions.

For a chemical reaction of the form:

$$a\text{A} + b\text{B} + \ldots \rightleftharpoons \ldots + y\text{Y} + z\text{Z}$$

when the equilibrium condition is reached and at fixed T, we have:

$$\frac{\ldots[\text{Y}]^y[\text{Z}]^z}{[\text{A}]^a[\text{B}]^b\ldots} = \text{constant} = K_C$$

This ration is known as the ***equilibrium constant*** (***K_C***).

For 1st order reactions, the rate is given by:

$$\upsilon_1 = k_1[\text{A}]^a[\text{B}]^b\ldots \quad \text{and} \quad \upsilon_{-1} = k_{-1}[\text{Y}]^y[\text{Z}]^z\ldots$$

Book: Text Book of Chemistry (Lecture no.1)

FIRST TERM

Unit 9: Chemical Equilibrium

Q: Define complete reaction?

Ans: **Complete reaction:**

A complete reaction is one in which all reactants have been converted to products.

Example: $HCl + NaOH \longrightarrow NaCl + H_2O$

Q: Define reversible reactions. Give examples.

Ans: Reversible reactions:

A reaction in which the products can react together to re-form the original reactants is called reversible reaction

OR

A reaction which may proceeds in the forward direction as well as in the reverse direction under the same conditions is called the reversible reaction.

Properties of reversible reactions:

Reversible reactions never go to completion .All reversible changes (physical and chemical)

Occure simultaneously in both the directions.

Notation of reversible reaction:

The double arrow in the chemical equation shows that the reaction is reversible.

Examples:

i) $2SO_2 + O_2 \quad 2SO_3$

ii) $N_2 + 3H_2 \quad 2NH_3$

iii) $2N_2 + O_2 \quad 2NO_2$

Q: Define equilibrium mixture:

Ans : <u>Equilibrium Mixture:</u>

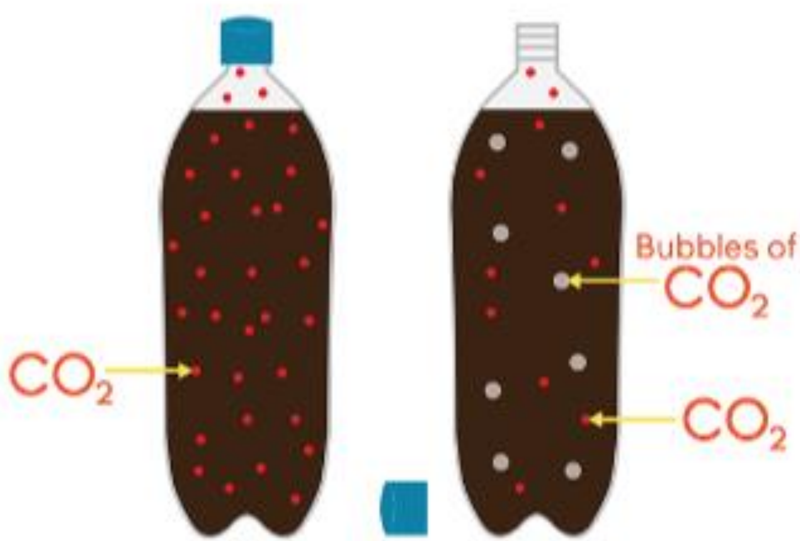
The concentrations of reactants and products are called equilibrium concentrations and the mixture is called equilibrium mixture.

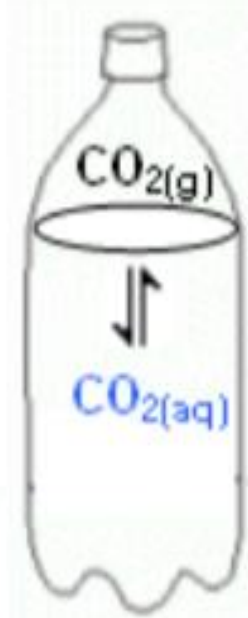
Q: How are fizzy drinks made?

Ans: When fizzy drinks are made, CO_2 is dissolved in the liquid drink under pressure and sealed. When you remove lid of the bottle, bubbles of CO_2 suddenly appear .When you put the lid back on the bottle, the bubbles stop. This is due to the following equilibrium.

CO_2 CO_2

The forward reaction happens during manufacturing and the reverse reaction happens on opening.





Dynamic Equilibrium

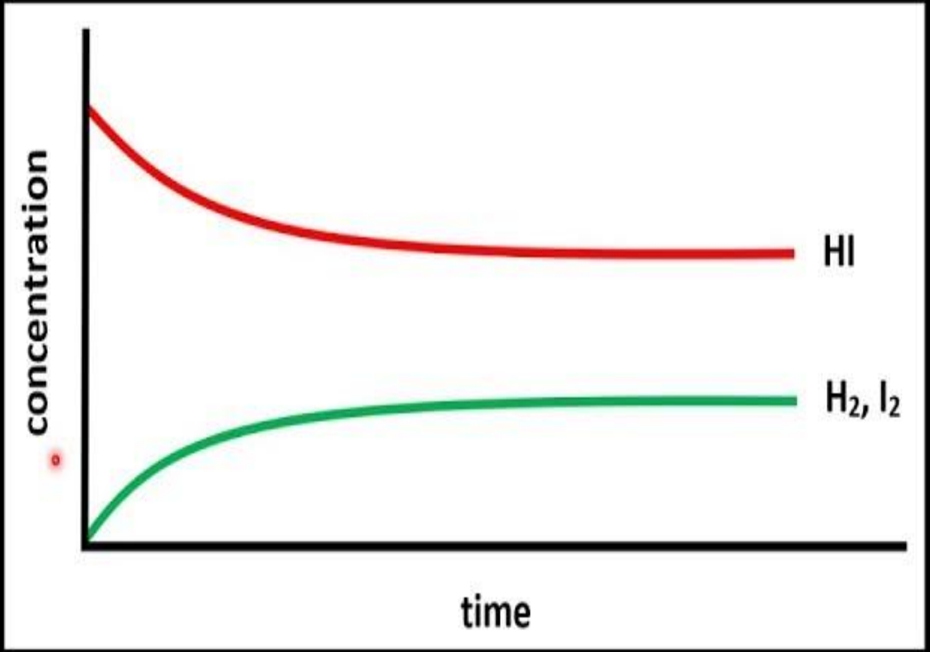
- Example: Closed bottle of pop
- CO_2 gas leaving dissolved state and entering gas state
- CO_2 gas ALSO, leaving gas state and entering liquid state
- No visible change
- $CO_{2(g)} \rightleftharpoons CO_{2(aq)}$

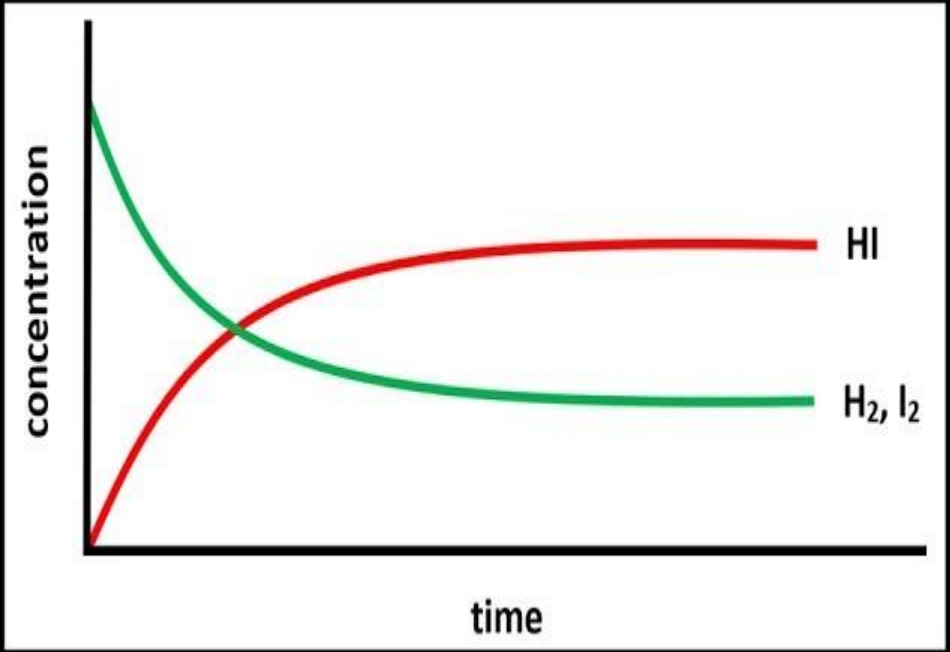
MSJChem
Tutorials for IB Chemistry

Dynamic equilibrium

$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$

$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$





Equilibrium can be reached from either direction.
Concentrations of reactants and products are constant (not equal).

Q: Differentiate between forward and reverse reactions:

Ans:

Forward Reaction	Reverse Reaction
i) It is written from left to right. ii) Reactants produce products. iii) Rate is fastest in the beginning and gradually slows down. Example Forward Reaction: $2NO_2 \longrightarrow N_2O_4$	i) It is written from right to left. ii) Products produce reactants. iii) Its rate is zero in the beginning and gradually speeds up. Example Reverse Reaction: $N_2O_4 \longrightarrow 2NO_2$

Steam + CO, closed container, high temp

$$H_2O + CO \rightleftharpoons H_2 + CO_2$$

↑

add more

causes more collisions

causes more reactions

shift reaction to the right →

as it makes more H_2 + CO_2

causes more collisions

causesmore reactions

shifts back to the left

←

Until equilibrium forward and reverse are constant

Law of Mass Action:

It states that " the rate at which a substance react is proportional to its active mass and the rate of chemical reaction is proportional to the product of the active masses of the reacting substances."

$$A + B \rightleftharpoons C + D$$

Reactants Product

Law of Mass Action (K values, Kc, or Keq)

Law of Mass Action:

For a general reaction of the form

aA +Bb → cC + dD.,

the law of mass actions states that the equilibrium condition is expressed by the equation:

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

The Equilibrium Constant
The Law of Mass Action

Two Norwegian chemist, Cato Maximilian Guildberg (1836-1902) and Peter Waage (1833-1900) proposed in 1864 a general description of the equilibrium condition (called the Law of Mass Action). They proposed for the rxn of the type

a A + b B ←→ c C + d D

The equilibrium concentrations of rxn and products can be represented by the equilibrium constant expression

Equilibrium Constant = **K** = $\frac{[C]^c[D]^d}{[A]^a[B]^b}$ $\frac{\textbf{PRODUCTS}}{\textbf{REACTANTS}}$

[ ] represent concentration at equilibrium

A, B, C, and **D** represent chemical species and **a,b, c,** and **d** are their coefficients in the balanced equation.

Equilibrium Constant K_c

$$aA_{(aq)} + bB_{(aq)} \rightleftharpoons cC_{(aq)} + dD_{(aq)}$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Conc of product and reactant at equilibrium

Equilibrium expression HOMOGENEOUS gaseous rxn

$4NH_{3(g)} + 5O_{2(g)} \leftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

$$K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$$

$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$

$$K_c = \frac{[NH_3]^2}{[N_2]^1[H_2]^3}$$

$2SO_{2(g)} + O_{2(g)} \leftrightarrow 2SO_{3(g)}$

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]^1}$$

Equilibrium expression HOMOGENEOUS liquid rxn → Reactant/product same phase

$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \leftrightarrow CH_3COOC_2H_{5(l)} + H_2O_{(l)}$

$$K_c = \frac{[CH_3COOC_2H_5]^1[H_2O]^1}{[CH_3COOH]^1[C_2H_5OH]^1}$$

Equilibrium expression HETEROGENOUS rxn → Reactant/product diff phase

$NH_4Cl_{(s)} \leftrightarrow NH_{3(g)} + HCl_{(g)}$

$$K_c = \frac{[NH_3]^1[HCl]^1}{[\cancel{NH_4Cl}]^0}$$

$$K_c = [NH_3]^1[HCl]^1$$

$CaCO_{3(s)} \leftrightarrow CaO_{(g)} + CO_{2(g)}$

$$K_c = \frac{[CaO]^1[CO_2]^1}{[\cancel{CaCO_3}]^0}$$

$$K_c = [CaO]^1[CO_2]^1$$

$Cu^{2+}_{(aq)} + 4NH_{3(aq)} \leftrightarrow [Cu(NH_3)_4]^{2+}$

$$K_c = \frac{\left[[Cu(NH_3)_4]^{2+}\right]}{[Cu^{2+}]^1[NH_3]^4}$$

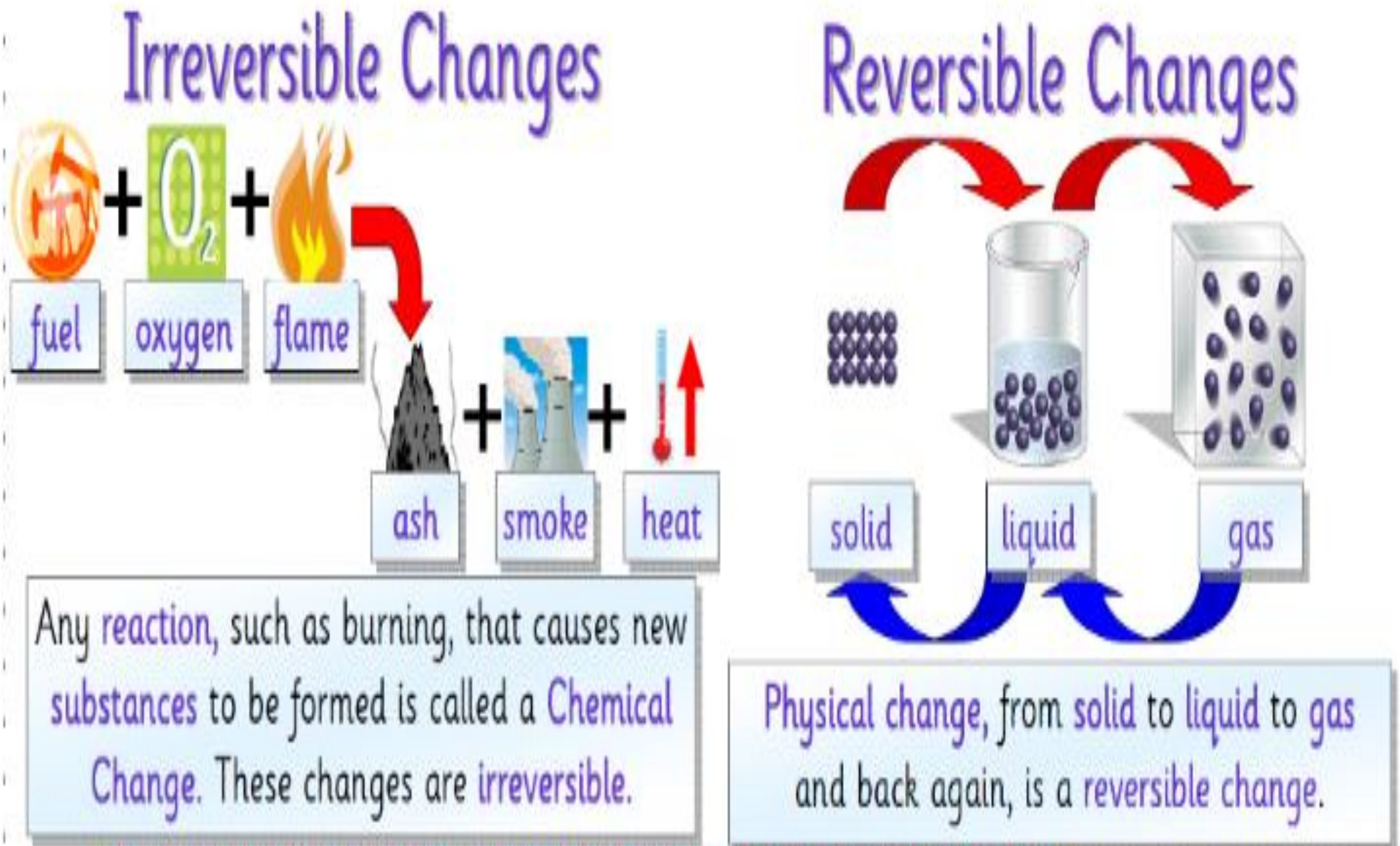
Writing Equilibrium Constant Expressions

- for the reaction
  $aA_{(aq)} + bB_{(aq)} \Leftrightarrow cC_{(aq)} + dD_{(aq)}$
  the equilibrium constant expression is

$$K = \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b}$$

- so for the reaction
  $2\ N_2O_5 \Leftrightarrow 4\ NO_2 + O_2$ the equilibrium constant expression is:

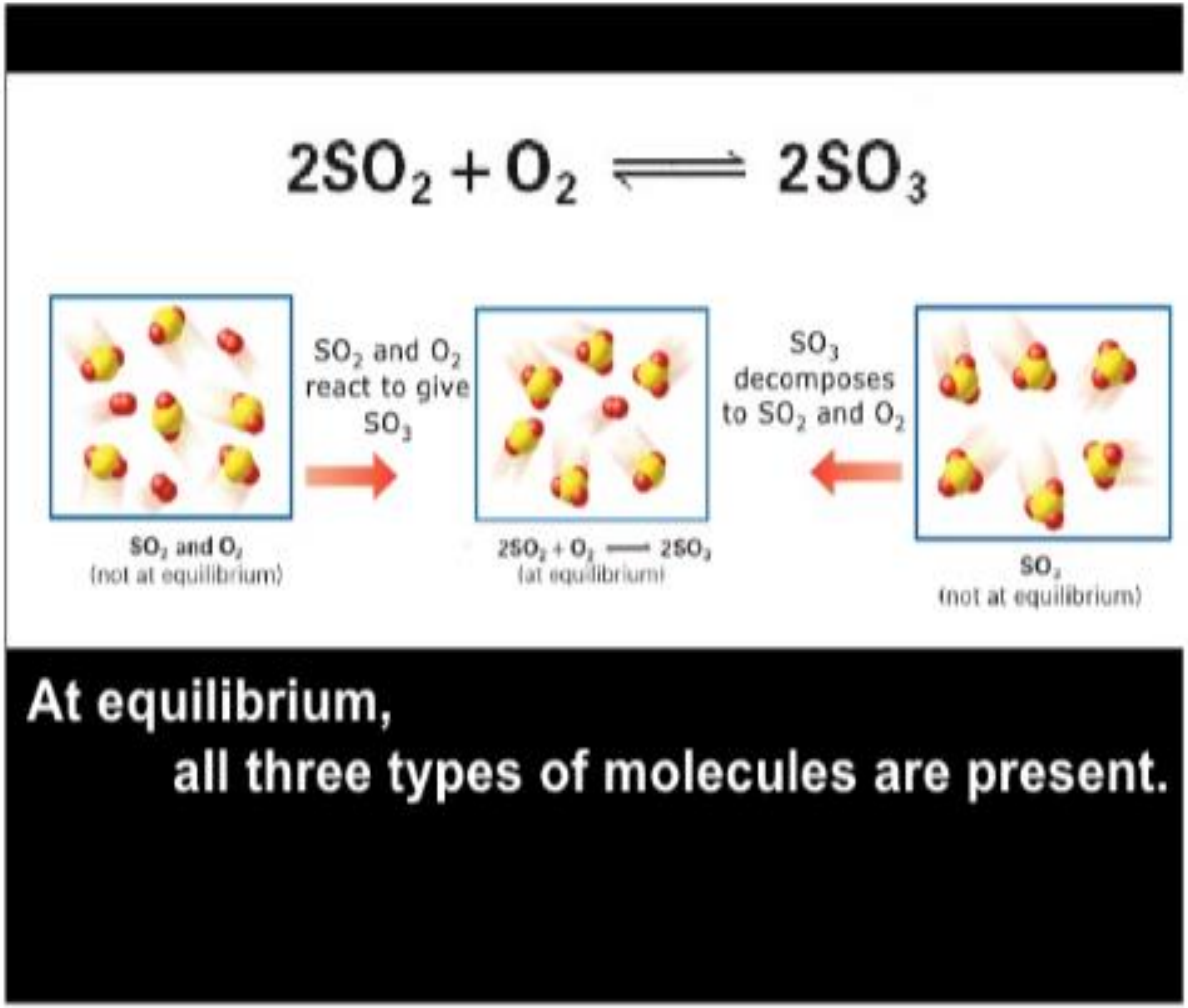
$$K = \frac{[NO_2]^4 \times [O_2]}{[N_2O_5]^2}$$



Q: What happens when SO_2 and O_2 gases are mixed in a sealed container ?

Explain concentration time graph with example.

Ans:



Molecules of SO_2 and O_2 react to give SO_3. Molecules of SO_3 decompose to give SO_2 and O_2

Forward Reaction:

In the first reaction (from left to right) SO_2 and O_2 produce SO_3.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

Reverse Reaction:

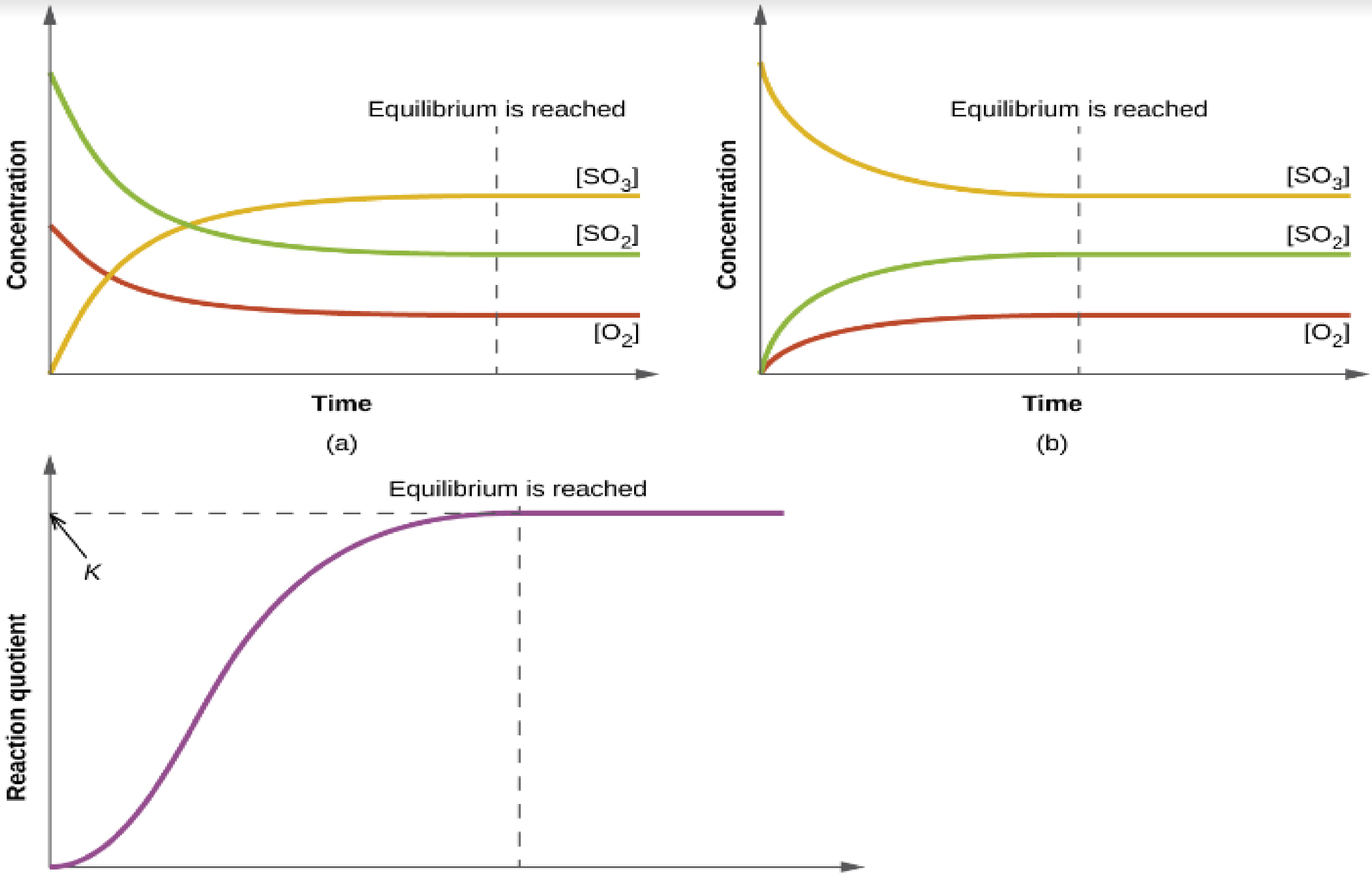
In the second reaction (from right to left) SO_3 decompose into SO_2 and O_2.

$$2SO_3 \longrightarrow 2SO_2 + O_2$$

Equilibrium State:

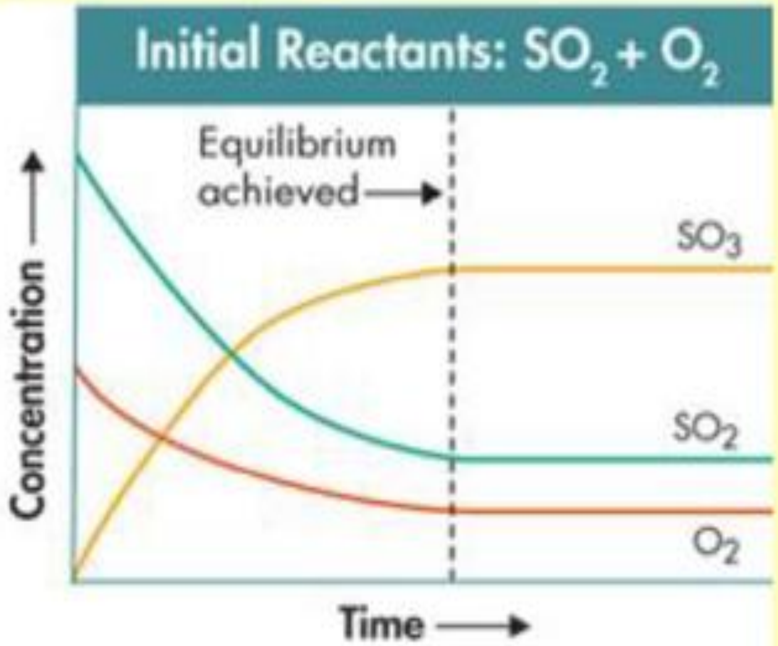
As the concentration of SO_3 becomes higher, the reverse reaction speeds up. Eventually the two rates become equal. At this stage SO_3 decomposes to SO_2 and O_2 as fast as SO_2 and O_2 produce SO_3 .At this stage reaction is said to have reached equilibrium state.

POINTS TO PONDER:

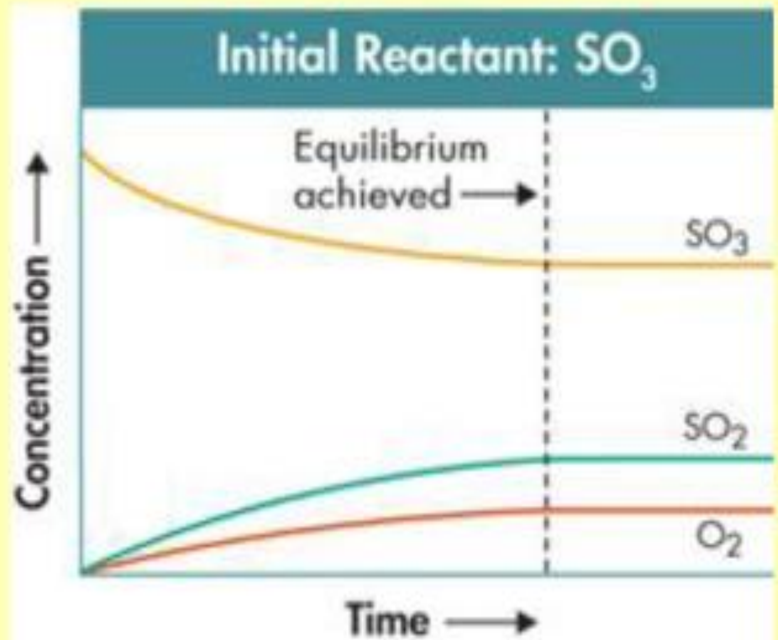


When the rates of the forward and reverse reactions are equal, the reaction has reached a state of balance called chemical equilibrium.

Reaction starting SO_2 & O_2, but no SO_3.



Reaction starting with SO_3, but no SO_2 and O_2.



Eventually, the concentrations remain constant.

Today's Learning

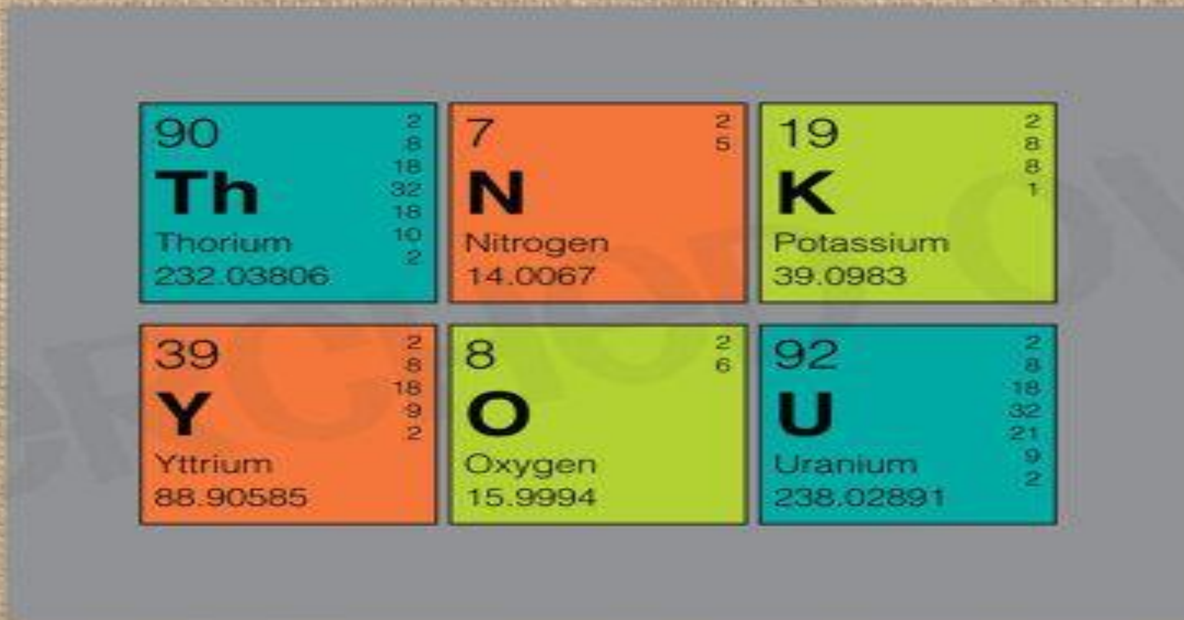
Don't forget to put your name on!

Something I can do now that I couldn't do before the lesson is…	A question I would like to know the answer to is…	I need to improve on…

HOME-WORK:

- **Homework:**
- **DO ANY ONE QUESTION:**
- DIFFERENTIATE BETWEEN FORWARD AND REVERSE REACTION?
- STATE LAW OF MASS ?GIVE EXAMPLE?
- DEFINE REVERSIBLE REACTION,EQUILIBRIUM CONSTANT?GIVE EXAMPLE?
- EXPLAIN CONCENTRATION TIME GRAPH WITH THE HELP OF AN EXAMPLE?

CLOSURE OF THE LESSON: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7 N Nitrogen 14.0067 2 5
19 K Potassium 39.0983 2 8 8 1
39 Y Yttrium 88.90585 2 8 18 9 2
8 O Oxygen 15.9994 2 6
92 U Uranium 238.02891 2 8 18 32 21 9 2


THANK YOU


good bye
good bye
SCHOOL BUS