Practical Session n°6: KINETIC FACTORS

Introduction

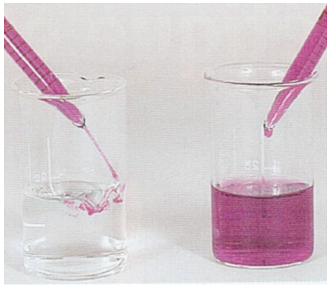
Kinetics in physics is the study of motions and their causes.
Kinetics in chemistry is the study of chemical reactions rates.
In chemistry, a **kinetic factor** is a parameter of the chemical reaction that has an effect on its rate.

Objective

Some reactions proceed very fast (e.g. inflation of airbags used in cars), whereas others can proceed so slowly that it can take billions of years before any appreciable amounts of products are formed (e.g. the transformation of diamond into graphite in the air at room temperature).

The objective of this lab session is to study the effect of different kinetic factors such as temperature, the initial concentrations of the reactants or the use of a catalyst.

1- FAST REACTIONS, SLOW REACTIONS…



⌦ In beaker A, pour 10 mL of an iron (II) sulphate solution ($Fe^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$) of concentration 1.0×10^{-2} mol.L^{-1}.
⌦ In beaker B, pour 10 mL of an oxalic acid solution ($H_2C_2O_{4(aq)}$) of concentration 5.0×10^{-1} mol.L^{-1}.
⌦ Add **simultaneously** 5 mL of an acidified potassium permanganate solution ($K^+_{(aq)} + MnO_4^-{}_{(aq)}$) of concentration 1.0×10^{-3} mol.L^{-1} in each beaker.
Stir and compare how the two mixtures evolve.

1. *Give the equation of the redox reaction that occurs in beaker A. Same question for beaker B.*
   Involved redox couples: $Fe^{3+}_{(aq)}$ / $Fe^{2+}_{(aq)}$; $MnO_4^-{}_{(aq)}$ / $Mn^{2+}_{(aq)}$; $CO_{2\,(g)}$ / $H_2C_2O_{4\,(aq)}$
2. *Which of the two reactions is the fastest? Which feature enables to find out the answer?*
3. *Why is it said that the two reactions have different kinetics?*

2- KINETIC FACTORS

1rst parameter- The initial concentrations of the reactants

Studied reaction

In acidic medium, thiosulphate ions ($S_2O_3^{2-}$) slowly react with hydrogen ions (H^+) to give sulphur $S_{(s)}$ and sulphur dioxide $SO_{2\,(aq)}$ according to this following equation:

$$S_2O_3^{2-}{}_{(aq)} + 2\,H^+_{(aq)} \rightarrow H_2O_{\,(l)} + S_{(s)} + SO_{2\,(aq)}$$

The sulphur remains in suspension in the solution and the reaction mixture becomes gradually opaque. Therefore, to compare the rate of this reaction in different conditions, we can measure the time (denoted t_d) taken by a letter, placed underneath the beaker containing the reaction mixture, to completely disappear.

Available equipment

- identical beakers (100 mL)
- two graduated cylinders (15 mL and 25 mL)
- a chronometer
- 3 sodium thiosulphate solutions ($0,5\times10^{-1}$ mol.L^{-1}, 1.0×10^{-1} mol.L^{-1} and 5.0×10^{-1} mol.L^{-1})
- 3 hydrochloric acid solutions ($0,5\times10^{-1}$ mol.L^{-1}, 1.0×10^{-1} mol.L^{-1} and 5.0×10^{-1} mol.L^{-1})

1. *Suggest a procedure enabling to show the effect of the* ***initial concentration*** *of* ***one of the reactants*** *on the rate of the studied chemical reaction.*
2. *Carry out your procedure after agreement of your teacher.*
3. *Synthesize the observations in a table and conclude.*

2nd parameter- Temperature

Studied reaction

The permanganate ions MnO_4^- can react with oxalic acid $H_2C_2O_4$ according to this following equation:

$$2\ MnO_4^-{}_{(aq)} + 5\ H_2C_2O_4{}_{(aq)} + 6\ H^+{}_{(aq)} \rightarrow 2\ Mn^{2+}{}_{(aq)} + 10\ CO_2{}_{(g)} + 8\ H_2O_{(l)}$$

When MnO_4^- is the limiting reactant, the disappearance of its purple colour indicates the end of the chemical reaction.

Available equipment

- identical beakers (100 mL)
- two graduated cylinders (15 mL and 25 mL)
- a chronometer
- some crushed ice in a crystallizing dish
- a warm water bath (bain-marie) at 50°C
- an acidified potassium permanganate solution ($K^+{}_{(aq)} + MnO_4^-{}_{(aq)}$) at 5.0×10^{-3} mol.L^{-1}
- an oxalic acid solution ($H_2C_2O_4{}_{(aq)}$) at 1.0×10^{-1} mol.L^{-1}

1. *Suggest a procedure enabling to show the effect of temperature on the rate of the studied chemical reaction.*
2. *Carry out your procedure after agreement of your teacher.*
3. *Write down your observations and conclude.*

3rd parameter- The use of a catalyst

Studied reaction

Hydrogen peroxide can decompose into dioxygen and water according to this following equation:

$$2\ H_2O_2{}_{(aq)} \rightarrow O_2{}_{(g)} + 2\ H_2O_{(l)}$$

⌧ Pour 20 mL of an aqueous solution of hydrogen peroxide in four different beakers (You can mark them A, B, C and D.)
⌧ Beaker A will be the reference.
⌧ Place a small cylinder covered with platinum (used to sterilize contact lenses) in beaker B.
⌧ Add a few drops of a concentrated solution of iron (III) chloride or iron (III) sulphate in beaker C.
⌧ Add a small piece of potato (it contains an enzyme called catalase) in beaker D.
⌧ Observe.

1. *Why is there no (or a very small amount of) dioxygen released in beaker A?*
2. *What is the function of platinum, iron (III) ions and catalase in the progress of the decomposition of hydrogen peroxide? (See beakers B, C and D.)*
3. *Suggest a definition for each following term*: **catalyst**, **catalysed reaction**, **heterogeneous catalysis**, **homogeneous catalysis** and **enzymatic catalysis**.
4. *Find out examples of everyday life applications of catalysis.*
5. *Find out examples of enzymatic catalysis seen in your biology class.*