CHAPTER 10: REACTION KINETICS

- What is Reaction Kinetics?

  The branch of chemistry that deals with the rate of chemical reaction, the factors that affect these rates, and the reaction mechanisms by which reactions occur.

- **Chemical Reactions**:
  - **some are very fast** (explosion of a firecracker)

    very slow (rusting)
  - **Eg: Neutralisation, precipitation reaction, rusting nail or food going bad**

Reaction Kinetics

↓ Important

Industrial process

- Time
- Optimum **yield**
- Optimum conditions

  Control over reaction,

  obtain products economically

Chapter 10 Reaction Kinetics

10.1 Reaction Rate

10.2 Collision Theory &
Transition State Theory

10.3 Factors Affecting
Reaction Rate

10.1 :
REACTION RATE

Objectives:

- Define ‘reaction rate’.
- Write the expression for the average rate, the instantaneous rate and the differential rate equation
- Calculate the rate of formation of a product (or the rate of disappearance of a reactant)

Definition

- For a chemical reaction, *reactant* ⟶ *product*, the rate of reaction can be defined in two ways:-

  a) The decrease in reactant concentration, [A], per unit time

  b) The increase in product concentration, [B], per unit time

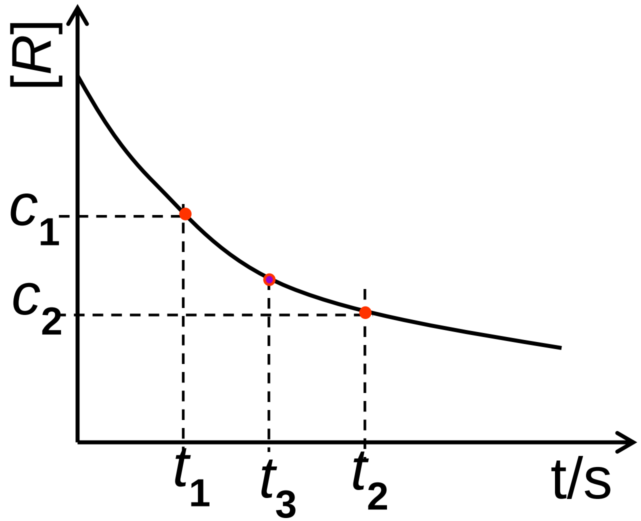
Reaction rate – the change in concentration of a reactant or a product with time (Ms^{-1})

Reaction rate, r = $\frac{\text{Change in concentration of substance}}{\text{Time taken}}$

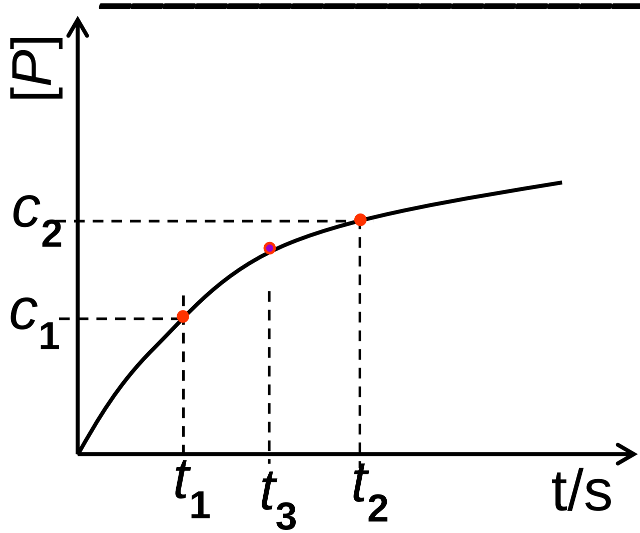
The shorter time,
the faster the reaction

Definition

- The ______________________________ per unit time.



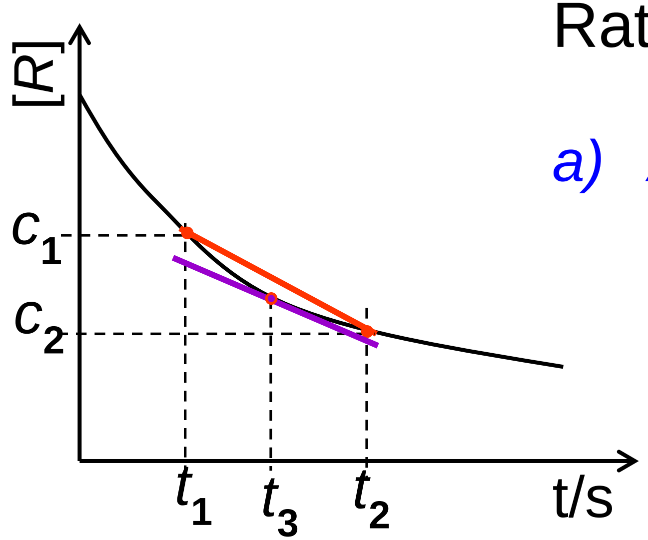
- The ______________________________ per unit time.



Unit:

Definition

$$aR \rightarrow bP$$



Rate of decomposition of ***R***

a) *Average rate* (from t_1 to t_2) = $-\dfrac{\Delta[R]}{\Delta t}$

(**red line**)

$$= -\frac{c_2 - c_1}{t_2 - t_1}$$

b) *Instantaneous rate* (at t_3) = $-\dfrac{d[R]}{dt}$

= − Gradient of the tangent line (**purple line**)

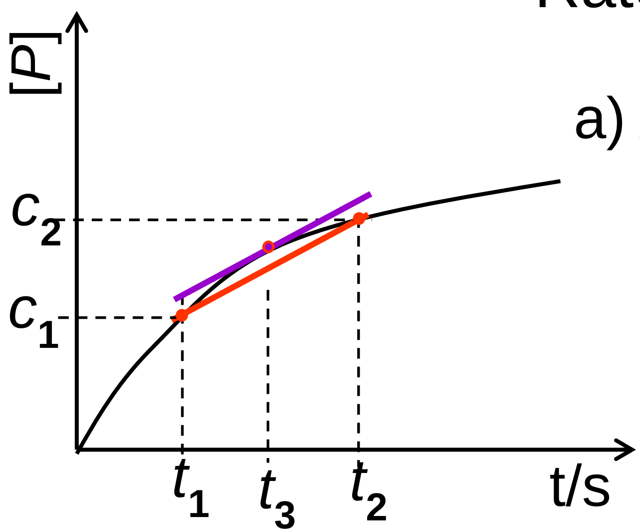
Instantaneous rate

=

Definition

$$a\mathbf{R} \rightarrow b\mathbf{P}$$

Rate of formation of ***P***



a) *Average rate* (from t_1 to t_2) = $\dfrac{\Delta[P]}{\Delta t}$

(**red line**)

$= \dfrac{c_2 - c_1}{t_2 - t_1}$

b) *Instantaneous rate* (at t_3) = $\dfrac{d[P]}{dt}$

= Gradient of the tangent line (**purple line**)

Instantaneous rate

=

Differential Rate Equation

$$pA + qB \rightarrow xC + yD$$

- the **differential rate equation** for the above reaction is:

$$\text{Rate of reaction} = -\frac{1}{p}\frac{d[A]}{dt} = -\frac{1}{q}\frac{d[B]}{dt} = +\frac{1}{x}\frac{d[C]}{dt} = +\frac{1}{y}\frac{d[D]}{dt}$$

Indicates the concentration of the reactant A, ________________ .

Indicates the concentration of the product B, _________________ .

Differential Rate Equation

$$pA + qB \rightarrow xC + yD$$

- the **differential rate equation** for the above reaction is:

$$\text{Rate of reaction} = \boxed{-\frac{1}{p}\frac{d[A]}{dt} = -\frac{1}{q}\frac{d[B]}{dt} = +\frac{1}{x}\frac{d[C]}{dt} = +\frac{1}{y}\frac{d[D]}{dt}}$$

Note:

p, q, x and ***y*** are the stoichiometric coefficients

$-\frac{d[A]}{dt}$ and $-\frac{d[B]}{dt}$ are the ________________________ of *A* and *B* respectively.

$\frac{d[C]}{dt}$ and $\frac{d[D]}{dt}$ are the ________________________ of *C* and *D* respectively.

Differential Rate Equation

Example 1:

Equation for formation of NH_3,

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The differential rate equation is;

Rate =

The equation means that the rate of disappearance of N_2 is 1/3 the rate of disappearance of H_2 and ½ the rate of formation of NH_3.

Differential Rate Equation

Example 2:

Consider the reaction, $2HI \rightarrow H_2 + I_2$,

determine the rate of disappearance of HI when the rate of I_2 formation is 1.8×10^{-6} M s^{-1}.

Solution 2:

Rate =

Rate of disappearance of HI =

Check Point

1) Because it has a nonpolluting product (water vapour), hydrogen gas is used for fuel aboard the space shuttle and may be used by Earth-bound engines in the near future.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

a) Express the rate in terms of changes in $[H_2]$, $[O_2]$ and $[H_2O]$ with time.

b) When $[O_2]$ is decreasing at 0.23 mol L^{-1} s^{-1}, at what rate is $[H_2O]$ increasing?

<0.46 M s^{-1} >

Check Point

2) Consider the reaction,

$$NO(g) + O_2(g) \rightarrow 2NO_2(g).$$

Suppose that at a particular moment during the reaction nitric oxide (NO) is reacting at the rate of 0.066 M s^{-1}.

a) At what rate is NO_2 being formed?

b) At what rate is molecular oxygen reacting?

3) Butane, C_4H_{10} burns in oxygen to give CO_2 and water. If the butane concentration is decreasing at a rate of 0.20 M s^{-1}, what is the rate at which the oxygen concentration is decreasing? What are the rates at which the CO_2 concentration is increasing?

<1.3 ; 0.8>

SUMMARY

- Average rate: over a period of time
- Instantaneous rate: at a specific time
- Differential rate equation:

$$\text{Rate of reaction} = -\frac{1}{p}\frac{d[A]}{dt} = -\frac{1}{q}\frac{d[B]}{dt} = \frac{1}{x}\frac{d[C]}{dt} = \frac{1}{y}\frac{d[D]}{dt}$$