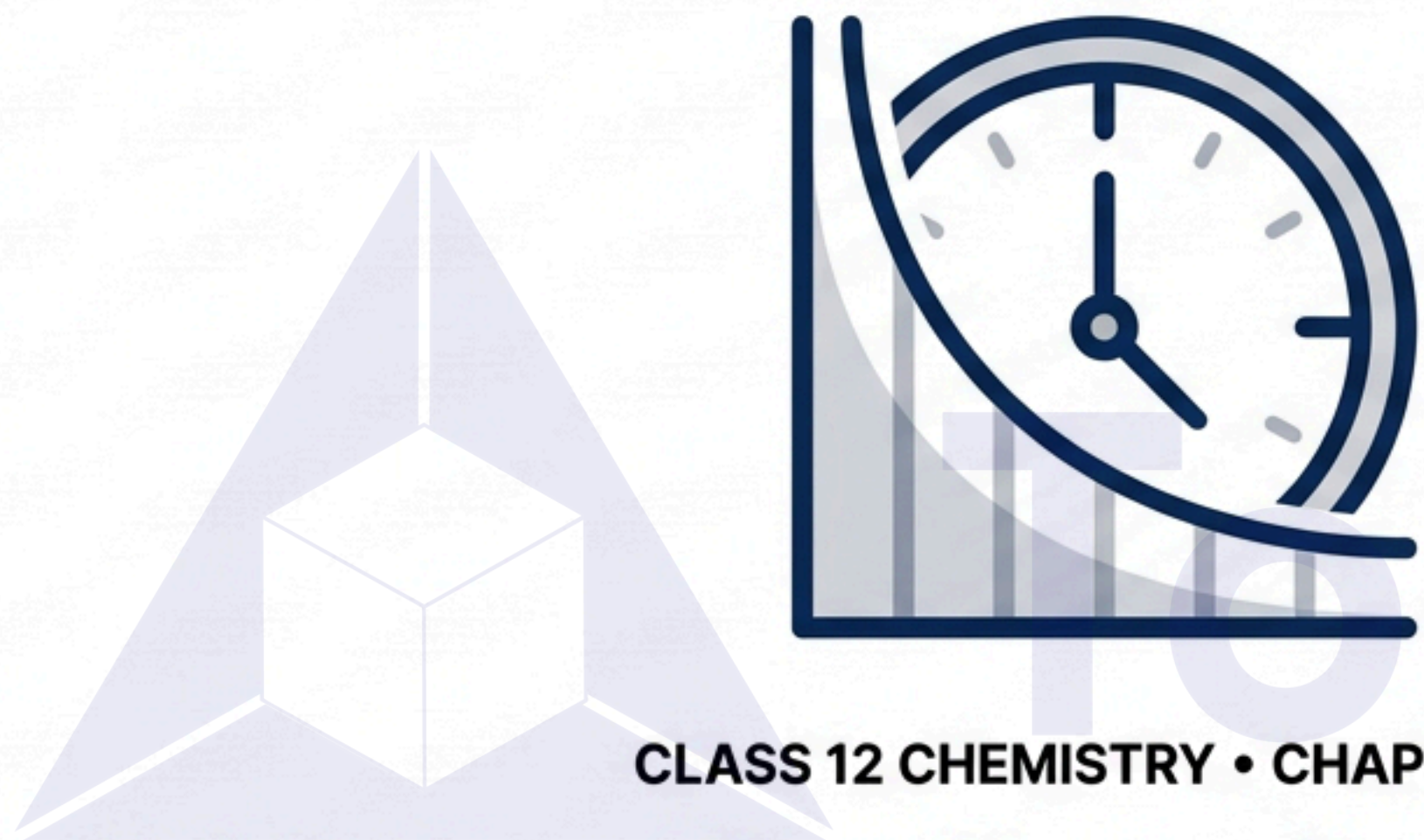




CLASS 12 CHEMISTRY • CHAPTER 3

3.1 Rate of a Chemical Reaction

Understanding the speed of chemical processes, from average intervals to instantaneous moments.

Exam-Smart Series

What Chemical Kinetics Studies

To fully understand a chemical reaction, chemists must answer three fundamental questions:



Thermodynamics

Feasibility

Will the reaction happen?
(Predicts if a reaction is possible
based on $\Delta G < 0$).



Equilibrium

Extent

How far will it go? (Determines
the point where the reaction
balances).



Chemical Kinetics

Speed

How fast will it happen?
(Studies the rate of reaction and
the mechanism behind it).

Kinetics is derived from the Greek word "kinesis" (movement). It explains why diamond converting to graphite is thermodynamically feasible, but kinetically imperceptible.

Average Rate of Reaction (r_{av})

The speed of a chemical reaction is defined as the change in concentration of a reactant or product over a specific interval of time.



The Macro View

Average rate relies on macroscopic, measurable changes. It depends on the total change in concentration (ΔC) divided by the total time taken (Δt).

$$r_{av} = \frac{\Delta[R]}{\Delta t} \text{ or } \frac{\Delta[P]}{\Delta t}$$

Notation Key:

Δ = Large, measurable change

[] = Molar concentration ($\text{mol}\cdot\text{L}^{-1}$)

$t_2 - t_1$ = Time interval

Think of r_{av} like calculating the average speed of a road trip—it gives the overall pace, but ignores variations in speed along the way.



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Instantaneous Rate of Reaction (r_{inst})

Because reaction rates continuously decrease as reactants are consumed, the average rate isn't always precise enough. We need the rate at a specific moment.



The Micro View

When the time interval (Δt) becomes infinitesimally small (approaching zero), the average rate becomes the instantaneous rate.

$$r_{\text{inst}} = \lim_{\Delta t \rightarrow 0} \frac{\Delta[C]}{\Delta t} = \frac{d[C]}{dt}$$

d = Infinitesimally small change

Mathematical Shift: We move from algebra (Δ) to calculus (d) to capture the exact speed at a freeze-frame moment in time.

Reactant Disappearance vs. Product Appearance

For a hypothetical reaction $R \rightarrow P$ (assuming constant volume), the rate can be expressed in two mirrored ways.

Reactants

Disappearance

Reactant concentration decreases over time.

$$r = - \frac{\Delta[R]}{\Delta t}$$

We must multiply by -1 because $\Delta[R]$ is a negative quantity. This ensures the final reaction rate is always a positive value.

Products

Appearance

Product concentration increases over time.

$$r = + \frac{\Delta[P]}{\Delta t}$$

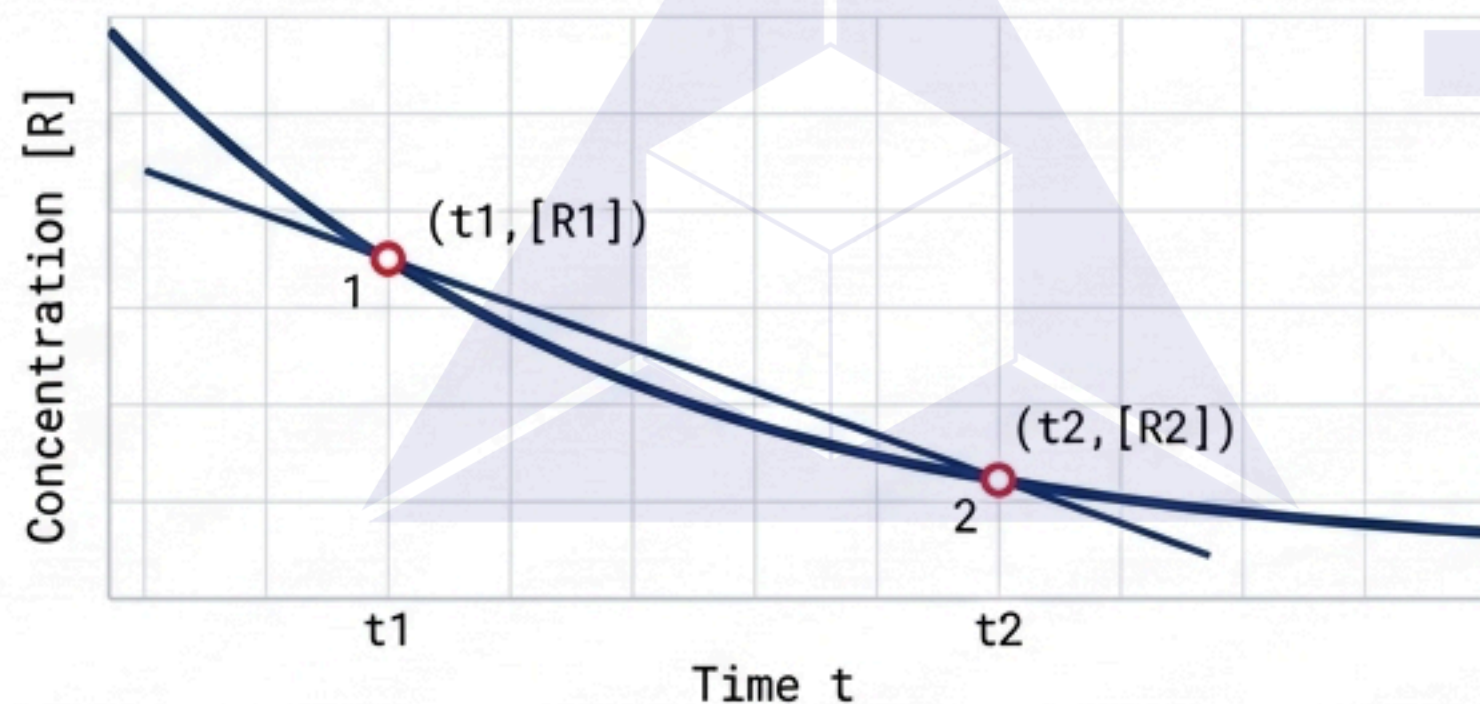
No negative sign is needed, as $\Delta[P]$ is inherently a positive quantity.

Exam-Smart Insight: Reaction rate is a scalar quantity and must ALWAYS be positive. Always attach a negative sign to reactant rate expressions!

Graph-Based Rate Interpretation

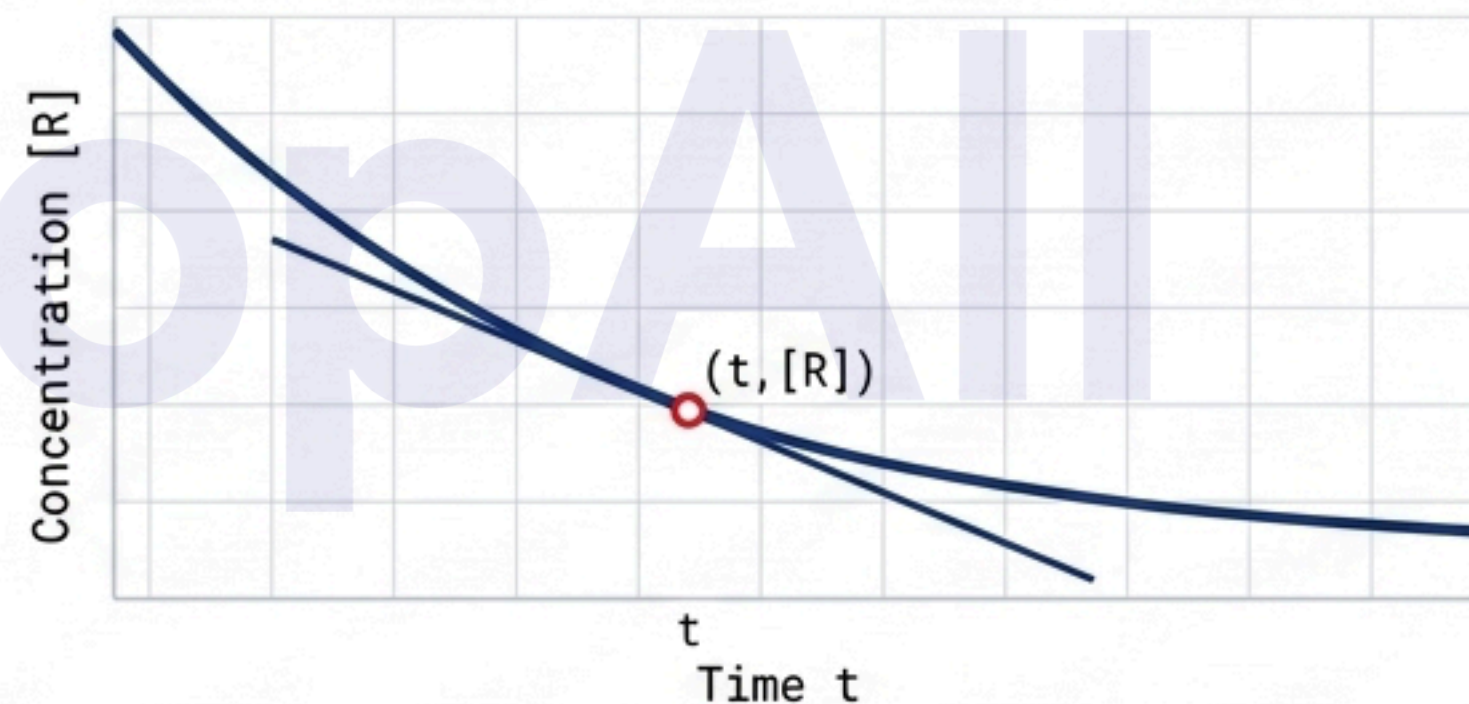
Reaction rates are determined experimentally by plotting concentration-time curves.

Average Rate



$$r_{av} = -(\text{Slope of Secant Line}) = -([R_2] - [R_1]) / (t_2 - t_1)$$

Instantaneous Rate



$$r_{inst} = -(\text{Slope of Tangent Line}) = -d[R] / dt$$

Steeper slopes equal faster rates. As the reaction progresses, the slope flattens, showing the rate decreasing over time.

Final Recap: 3.1 Reaction Rates

The Sign Rules

Reactants (R):
Use **Negative (-)**

Products (P): Use
Positive (+)

Why? To guarantee the overall rate value is strictly positive.

The Units

$$\text{Rate} = \frac{\text{Concentration}}{\text{Time}}$$

Liquid/Aqueous:
 $\text{mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$ (or min^{-1})

Gases (Partial Pressure):
 $\text{atm}\cdot\text{s}^{-1}$ or $\text{bar}\cdot\text{s}^{-1}$

Slope = Rate

Average Rate (r_{av}) =
Slope of Secant

Instant. Rate (r_{inst})
= Slope of Tangent

Reactant Slope is
negative → Multiply by
-1 to get rate.

Next up in 3.2: How concentration, temperature, and catalysts influence this rate.



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