

RATE EQUATIONS

The relationship between the rate of a chemical reaction and the concentration of the reactants is shown by the **rate equation** of the reaction.

Consider the reaction $A + 3B \rightarrow 2C + 4D$

The rate of this chemical reaction is given by the equation

$$\text{Rate} = k[A]^x[B]^y$$

where $[A]$ is the concentration of A, and $[B]$ is the concentration of B.

x and y are the **orders of reaction** with respect to A and B respectively.

The ***order of reaction*** with respect to a given reactant is the **exponential power** of that reactant's concentration in the **rate equation**.

The sum of these powers, in this case $x + y$, is known as the overall order of reaction:

k is the **rate constant** of the reaction.

The **rate constant** is the ***constant of proportionality*** in the rate equation.

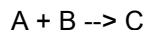
To obtain the values for the exponents, we hold the concentration of one of the reactants constant while we double the concentration of the other. This allows us to evaluate the change in rate, determining the numerical value for the exponent.

Conc. Change	Rate change	value of exponent
Double	none	Zero
Double	Double	1
Double	quadruple	2
Double	8 times	3

To obtain the value of the rate constant, we substitute the values of the concentrations and the value of the rate in a particular experiment to isolate for k.

Practice for Rate Law Expressions

The following data were collected for the following reaction at a particular temperature. What is the rate law expression for this reaction?



Experiment	Initial [A]	Initial [B]	Initial Rate of Formation of C
1	0.10M	0.10M	4.0×10^{-4} M/min
2	0.20M	0.20M	3.2×10^{-3} M/min
3	0.10M	0.20M	1.6×10^{-3} M/min

- a) Rate = $k[A]$ b) Rate = $k[A]^2$ c) Rate = $k[A][B]$ d) Rate = $k[B]$ e) Rate = $k[A][B]^2$

Rate data have been determined at a particular temperature for the overall reaction $2NO + 2H_2 \rightarrow N_2 + 2H_2O$ in which all reactants and products are gases.

Trial Run	Initial [NO]	Initial [H ₂]	Initial Rate (M/s)
1	0.10 M	0.20 M	0.0150
2	0.10 M	0.30 M	0.0225
3	0.20 M	0.20 M	0.0600

Write up the Rate Law expression for this reaction:

What is the order of the reaction relative to the concentration of NO?

What is the order of the reaction relative to the concentration of H₂?

What is the overall rate order for the experiment?

What is the value of the constant, k?

Consider the reaction $AX + OH^- \rightarrow AOH + X^-$

The following rate data were obtained at constant temperature:

Initial concentration of AX/ mol dm ⁻³	Initial concentration of OH/ mol dm ⁻³	Initial rate/ mol dm ⁻³ s ⁻¹
0.01	0.04	8×10^{-3}
0.01	0.02	4×10^{-3}
0.005	0.04	4×10^{-3}

Write up the Rate Law expression for this reaction:

What is the order of the reaction relative to the concentration of AX?

What is the order of the reaction relative to the concentration of OH⁻?

What is the overall rate order for the experiment?

What is the value of the constant, k?

Given the following data for the $\text{NH}_4^+ + \text{NO}_2^- \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$ reaction

Trial	$[\text{NH}_4^+]$	$[\text{NO}_2^-]$	Rate
1	0.010 M	0.020 M	0.020 M/s
2	0.015	0.020	0.030
3	0.010	0.010	0.005

Write up the Rate Law expression for this reaction:

What is the order of the reaction relative to the concentration of ?

What is the order of the reaction relative to the concentration of H_2 ?

What is the overall rate order for the experiment?

What is the value of the constant, k?

Consider the reaction $\text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5$

The following rate data were obtained at constant temperature:

Initial concentration of PCl_3 / mol dm^{-3}	Initial concentration of Cl_2 / mol dm^{-3}	Initial rate/ $\text{mol dm}^{-3} \text{ s}^{-1}$
0.2	0.1	0.0004
0.4	0.1	0.0008
0.8	0.2	0.0064

Write up the Rate Law expression for this reaction:

What is the order of the reaction relative to the concentration of PCl_3 ?

What is the order of the reaction relative to the concentration of Cl_2 ?

What is the overall rate order for the experiment?

What is the value of the constant, k?