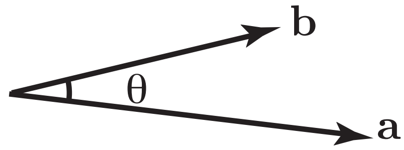
Vectors

If $\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ then $|\mathbf{r}| = \sqrt{x^2 + y^2 + z^2}$.

Scalar product:

$$\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}|\,|\mathbf{b}| \cos\theta$$

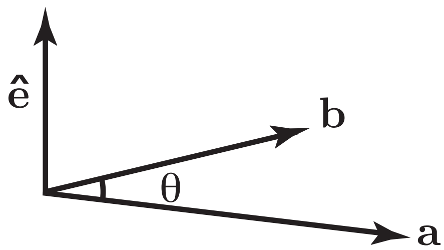


If $\mathbf{a} = a_1\mathbf{i} + a_2\mathbf{j} + a_3\mathbf{k}$ and $\mathbf{b} = b_1\mathbf{i} + b_2\mathbf{j} + b_3\mathbf{k}$ then

$$\mathbf{a} \cdot \mathbf{b} = a_1 b_1 + a_2 b_2 + a_3 b_3$$

Vector product:

$$\mathbf{a} \times \mathbf{b} = |\mathbf{a}|\,|\mathbf{b}| \sin\theta\,\hat{\mathbf{e}}$$



$\hat{\mathbf{e}}$ is a unit vector perpendicular to the plane containing $\mathbf{a}$ and $\mathbf{b}$ in a sense defined by the right hand screw rule.

If $\mathbf{a} = a_1\mathbf{i} + a_2\mathbf{j} + a_3\mathbf{k}$ and $\mathbf{b} = b_1\mathbf{i} + b_2\mathbf{j} + b_3\mathbf{k}$ then

$$\begin{aligned} \mathbf{a} \times \mathbf{b} &= (a_2 b_3 - a_3 b_2)\mathbf{i} + (a_3 b_1 - a_1 b_3)\mathbf{j} + (a_1 b_2 - a_2 b_1)\mathbf{k} \\ &= \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix} \end{aligned}$$

Kinetics

Arrhenius equation: The **rate** at which most chemical reactions proceed depends upon the **temperature**. The amount of energy necessary for the reaction to take place at all is called the **activation energy**. These quantities are related by the Arrhenius equation:

$$k = A\mathrm{e}^{-E_a/(RT)}$$

where k = rate constant, E_a = the activation energy for the reaction, R = ideal gas constant, T = absolute temperature, and A is a constant.

By taking logarithms this can be expressed as

$$\ln \frac{k}{k^{\ominus}} = \ln \frac{A}{k^{\ominus}} - \frac{E_a}{RT}$$

where $k^{\ominus}$ is a chosen standard rate constant. Together, A and E_a are called the **Arrhenius parameters**.

Rate Laws

In the table, $[A]$ = molar concentration of reactant A at time t. $[A]_0$ = concentration of reactant A at time $t = 0$.

Order	Rate Law Differential form	Rate Law Integrated form	Half-life	Common unit of k
0	$\frac{\mathrm{d}[A]}{\mathrm{d}t} = -k$	$[A]_0 - [A] = kt$	$\frac{[A]_0}{2k}$	$\mathrm{mol\,dm^{-3}\,s^{-1}}$
1	$\frac{\mathrm{d}[A]}{\mathrm{d}t} = -k[A]$	$[A] = [A]_0\mathrm{e}^{-kt}$	$\frac{\ln 2}{k}$	$\mathrm{s^{-1}}$
2	$\frac{\mathrm{d}[A]}{\mathrm{d}t} = -k[A]^2$	$\frac{1}{[A]} - \frac{1}{[A]_0} = kt$	$\frac{1}{k[A]_0}$	$\mathrm{mol^{-1}\,dm^3\,s^{-1}}$
2*	$\frac{\mathrm{d}[A]}{\mathrm{d}t} = -k[A][B]$	$\frac{1}{[B]_0-[A]_0} \ln \frac{[B][A]_0}{[A][B]_0} = kt$	-	$\mathrm{mol^{-1}\,dm^3\,s^{-1}}$

(* $A + B \rightarrow P$ reaction.)