

# Characteristic Properties of Rate Laws

$[A]_t$  = concentration of A after time t,  $[A]_0$  = concentration of A at beginning of reaction.

| Order | Relative Rate vs. Conc. (mol dm <sup>-3</sup> )                                                                                                                     | Rate Law | Integrated Rate Law | Straight Line Plot | Relationship of Rate constant to Slope | Units of Rate Constant | Half - Life: $t_{1/2}$ |   |   |           |                                          |                        |     |                                                   |                    |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------------------|--------------------|----------------------------------------|------------------------|------------------------|---|---|-----------|------------------------------------------|------------------------|-----|---------------------------------------------------|--------------------|
| 0     | <table style="border: none;"> <tr><td>[A]</td><td>Rate</td></tr> <tr><td>1</td><td>1</td></tr> <tr><td>2</td><td>1</td></tr> <tr><td>3</td><td>1</td></tr> </table> | [A]      | Rate                | 1                  | 1                                      | 2                      | 1                      | 3 | 1 | $k [A]^0$ | $[A]_t = -kt + [A]_0$                    | $[A]_t$ vs t           | - k | mol dm <sup>-3</sup> s <sup>-1</sup>              | $\frac{[A]_0}{2k}$ |
| [A]   | Rate                                                                                                                                                                |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 1     | 1                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 2     | 1                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 3     | 1                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 1     | <table style="border: none;"> <tr><td>[A]</td><td>Rate</td></tr> <tr><td>1</td><td>1</td></tr> <tr><td>2</td><td>2</td></tr> <tr><td>3</td><td>3</td></tr> </table> | [A]      | Rate                | 1                  | 1                                      | 2                      | 2                      | 3 | 3 | $k [A]^1$ | $\ln[A]_t = -kt + \ln[A]_0$              | $\ln [A]_t$ vs t       | - k | s <sup>-1</sup>                                   | $\frac{0.693}{k}$  |
| [A]   | Rate                                                                                                                                                                |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 1     | 1                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 2     | 2                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 3     | 3                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 2     | <table style="border: none;"> <tr><td>[A]</td><td>Rate</td></tr> <tr><td>1</td><td>1</td></tr> <tr><td>2</td><td>4</td></tr> <tr><td>3</td><td>9</td></tr> </table> | [A]      | Rate                | 1                  | 1                                      | 2                      | 4                      | 3 | 9 | $k [A]^2$ | $\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$ | $\frac{1}{[A]_t}$ vs t | k   | dm <sup>3</sup> mol <sup>-1</sup> s <sup>-1</sup> | $\frac{1}{k[A]_0}$ |
| [A]   | Rate                                                                                                                                                                |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 1     | 1                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 2     | 4                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |
| 3     | 9                                                                                                                                                                   |          |                     |                    |                                        |                        |                        |   |   |           |                                          |                        |     |                                                   |                    |

## Rate Law Summary

1. Rate law is determined experimentally.
2. Rate law is defined in terms of reactant concentration (not product concentration).
3. The order is not related to the stoichiometric coefficients of the reactants in the overall balanced equation, however it is related to the coefficients in the rate determining step.

## Rate Equations for Elementary Steps

Molecularity is defined as the number of species that must collide to produce the reaction indicated in that step. The molecularity of an elementary step and its order are the same.

### Elementary Step

A ----> product  
 A + B ----> product  
 A + A ----> product  
 2 A + B ----> product

### Molecularity

unimolecular  
 bimolecular  
 bimolecular  
 termolecular

### Rate Equation

Rate =  $k [A]$   
 Rate =  $k [A][B]$   
 Rate =  $k [A]^2$  or  $k [B]^2$   
 Rate =  $k [A]^2 [B]$  or  $k [A][B]^2$  or  $k [B]^3$  or  $k [A][B][C]$