4. THE RATE LAW

CH40S UNIT 2 KINETICS WIEBE

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DON'T FORGET…

$$\text{rate}_{NO_2(g)} = -\frac{\Delta[NO_2(g)]}{\Delta t}$$

$$\text{rate}_{O_2(g)} = +\frac{\Delta[O_2(g)]}{\Delta t}$$

Table 1 Concentrations of Reactant and Products over Time

	Concentration (mol/L)		
Time (±1 s)	**$NO_2(g)$**	**NO(g)**	**$O_2(g)$**
0	0.0100	0	0
50	0.0079	0.0021	0.0011
100	0.0065	0.0035	0.0018
150	0.0055	0.0045	0.0023
200	0.0048	0.0052	0.0026
250	0.0043	0.0057	0.0029
300	0.0038	0.0062	0.0031

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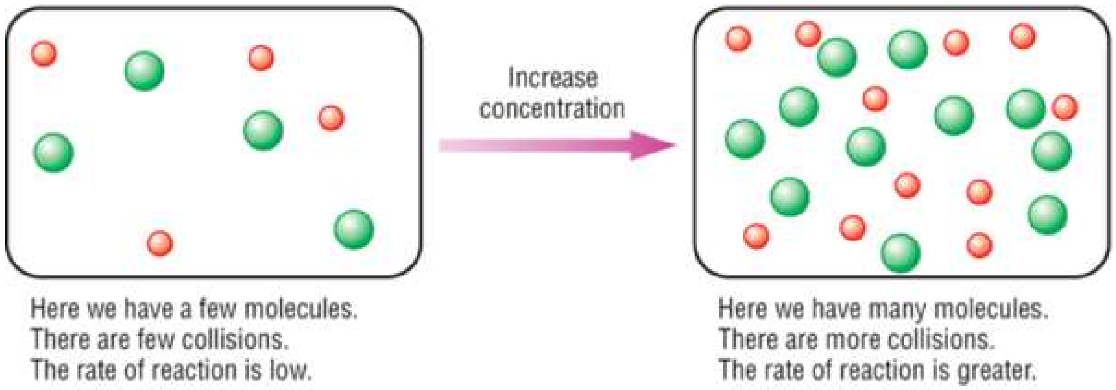
ALSO, DON'T FORGET…

Increasing the surface area and the concentration of a reactant(s) increases the total number of collisions and so the number of effective collisions.



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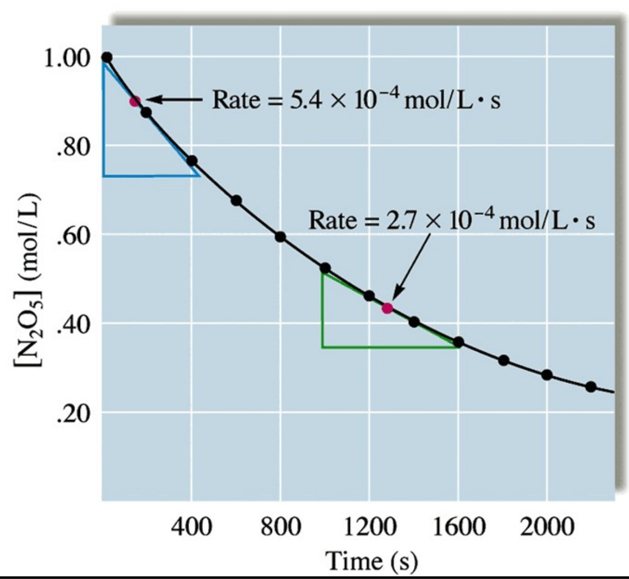
HOW MUCH OF AN EFFECT DOES IT HAVE?



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FORMAT OF A RATE LAW

Rate = k[Reactant A]^x[Reactant B]^y

Rate = speed of reactants turning into products

[Reactant A/B] = the concentration of Reactant A/B in mol/L.

k = specific rate constant for the reaction (if the rate is fast, k will be large, if the rate is slow, k will be small)

<u>x/y (exponent)</u> the <u>order</u> of the reactant. The order reflects the effect concentration has on rate.

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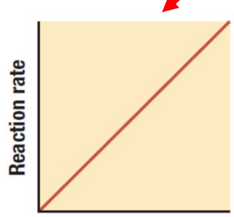
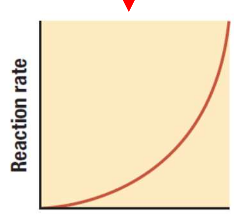
HOW ORDER OF REACTION AFFECTS RATE

$$\text{rate} = k[\text{A}]^1[\text{B}]^2[\text{C}]^0$$

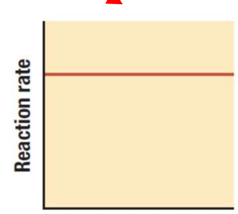
$\text{rate} \propto [\text{A}]^1$ $\text{rate} \propto [\text{B}]^2$ $\text{rate} \propto [\text{C}]^0$



When [A]↑ by x,
Rate ↑ by x.
$[2]^1 = 2$



When [B]↑ by x,
Rate ↑ the <u>square</u> of x
$[2]^2 = 4$



When [C]↑ by x,
Rate stays the <u>same</u>
$[2]^0 = 1$

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SUMMARY

ORDER OF REACTANT	EFFECT ON RATE IF MOLARITY x2	EFFECT ON RATE IF MOLARITY x3	EFFECT ON RATE IF MOLARITY x4
0	NO EFFECT ($2^0 = 1$)	NO EFFECT ($3^0 = 1$)	NO EFFECT ($4^0 = 1$)
1	Rate ↑ x 2 ($2^1 = 2$)	Rate ↑ x 3 ($3^1 = 3$)	Rate ↑ x 4 ($4^1 = 4$)
2	Rate ↑ x 4 ($2^2 = 4$)	Rate ↑ x 9 ($3^2 = 9$)	Rate ↑ x 16 ($4^2 = 16$)
3	Rate ↑ x 8 ($2^3 = 8$)	Rate ↑ x 27 ($3^3 = 27$)	Rate ↑ x 64 ($4^3 = 64$)

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EXAMPLE

The rate law of the reaction between reactants A & B is found to be as follows:

$$Rate = k[A][B]^2$$

Determine how the rate would be affected if each of the following changes in concentration occurred:

Change in Molarity (M)	Rate Increases…
[A] doubled, [B] unchanged	
[A] unchanged, [B] doubled	
[A] doubled, B tripled	

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EXAMPLE

The reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ was studied and the following results were obtained.

Trial	[NO] (mol/L)	[Cl_2] (mol/L)	Initial Rate (mol/L·min)
1	0.10	0.10	0.18
2	0.10	0.20	0.36
3	0.20	0.20	1.45
4	0.30	0.30	

Determine the complete rate law for this reaction. Use your complete rate law to calculate the initial rate of trial 4.

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