CONCEPT: RATE LAW

● An expression that relates the rate of a reaction to its Δ [______________], *rate constant* and *reaction order(s)*.

□ **Rate Constant:** a proportionality constant that links the ________ to [______________].

□ **Reaction Orders:** the _____________ component for the given concentrations.

- Determined mathematically with a ________ or from a series of steps called a *reaction mechanism*.

□ Rate Law ignores ___________.

Rate Law

Rate Law Expression

Rate = ___ [   ]$^{\square}$[   ]$^{\square}$

□ _______ = Rate Constant

□ _______ = Reactant Concentrations

□ _______ = Reaction Orders

EXAMPLE: The chemical reaction: 2 A + 3 B + C $\longrightarrow$ D has a Rate Law of $k[A]^3[B][C]^0$. By what factor would the rate increase if the concentration of A were tripled, the concentration of B was cut by half, the concentration of C increased by half, and the rate constant k was kept constant?

a) 2.5   b) 9.0   c) 13.5   d) 3.0

Rate Constant Units

● The units of the rate constant k can be determined by first calculating the *overall order*.

□ **Overall order (__):** The numerical value calculated from the __________ of all reaction orders.

Rate Constant

$k = M^{\square} \cdot time^{\square}$

□ _______ = Rate Constant

□ _______ = Molarity

□ _______ = Overall order

EXAMPLE: What is the overall order and the units for the rate constant k for the following chemical reaction shown below that has Rate = k $[NO_2]^2[Cl_2]$?

$$NO_2\,(g) + Cl_2\,(g) \longrightarrow NOCl\,(g) + ClO\,(g)$$

CONCEPT: RATE LAW

Rate Law Determination

● Rate constant and reaction orders of the Rate Law are determined mathematically when given [_____] and initial rates.

□ **Sequence for Solving:** **A** ____________ ⟶ **B** ____________ ⟶ **C** ____________

EXAMPLE: The initial rates of reaction for 2 NO (g) + Cl_2 (g) ⟶ 2 NOCl (g) are:

Experiment	[NO], M	[Cl_2], M	Initial Rate, M/s
1	0.0250	0.0510	18.2
2	0.0250	0.0255	9.08
3	0.0500	0.0255	18.2

Determine the new rate if given new initial concentrations of [NO] = 0.0730 M and [Cl_2] = 0.0510 M.

STEP 1: Choose a reactant and look at ____ experiments where its concentration changes, but the other(s) stay the same.

□ ___________ the reactant(s) whose concentrations remain the same.

STEP 2: Create a pair of _________ for the reactant that sets rate/rate = [reactant]/[reactant].

□ Place the ________ rate value on top of the ________ rate value to get whole numbers when solving.

□ Raise the [reactant]/[reactant] to an unknown _________ for the reaction order and solve.

$$\frac{\text{Rate}\ \_\_\_}{\text{Rate}\ \_\_\_} = \left(\frac{[\quad]}{[\quad]}\right)^{\square} \Rightarrow \frac{}{} = \left(\frac{[\quad]}{[\quad]}\right)^{\square} \Rightarrow \frac{}{} = [\qquad]^{\square}$$

STEP 3: Repeat the process for any remaining reactant(s) until all reaction orders are determined.

$$\frac{\text{Rate}\ \_\_\_}{\text{Rate}\ \_\_\_} = \left(\frac{[\quad]}{[\quad]}\right)^{\square} \Rightarrow \frac{}{} = \left(\frac{[\quad]}{[\quad]}\right)^{\square} \Rightarrow \frac{}{} = [\qquad]^{\square}$$

STEP 4: If necessary, to solve for the rate constant k plug in the [reactant] and reaction orders into the Rate Law.

$$\text{Rate}\ \_\_\_ = \_\_\_[\qquad]^{\square}[\qquad]^{\square} \Rightarrow \_\_\_\_\_ = \_\_\_[\qquad]^{\square}[\qquad]^{\square} \Rightarrow \_\_\_\_\_ = \_\_\_\ \_\_\_\_\_$$

STEP 5: If necessary, to solve for the _______ initial rate plug in the k, reaction orders, and additional [reactants] given.

$$\_\_\_\_\ \text{Rate} = \_\_\_[\qquad]^{\square}[\qquad]^{\square} = \_\_\_\_\_[\qquad]^{\square}[\qquad]^{\square} = \_\_\_\_\_\_$$

CONCEPT: RATE LAW

PRACTICE: Given the following chemical reaction, $A \longrightarrow B$. If the concentration of A is doubled the rate increases by a factor of 2.83, what is the order of the reaction with respect to A.

a) 1 b) 0.5 c) 1.5 d) 0 e) 2

PRACTICE: In the experiments on the reaction $2\ ICl\ (g) + H_2\ (g) \longrightarrow I_2\ (g) + 2\ HCl\ (g)$, the following initial rate data were obtained. What is the overall order of the reaction?

Experiment	[ICl], M	$[H_2]$, M	Initial Rate, M/s
1	1.5	1.5	3.7×10^{-7}
2	3.0	1.5	1.5×10^{-6}
3	3.0	4.5	1.34×10^{-5}

a) Third b) Second c) Zeroth d) Fourth e) First

PRACTICE: The data below were collected for the following reaction: $CH_3Cl\ (g) + 3\ Cl_2\ (g) \longrightarrow CCl_4\ (g) + 3\ HCl\ (g)$

Experiment	$[CH_3Cl]$, M	$[Cl_2]$, M	Initial Rate, M/s
1	0.050	0.050	0.014
2	0.100	0.050	0.029
3	0.100	0.100	0.041
4	0.200	0.200	0.115

Calculate the value and units for the rate constant k.