1. QUANTIFYING RATES OF REACTION

UNIT 2 – CHEMICAL KINETICS

CH40S *MR. WIEBE*

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CALCULATING REACTION RATES

reaction rate the change in concentration of a reactant or a product of a chemical reaction per unit time

average reaction rate the change in reactant or product concentration over a given time interval

$$\text{rate}_A = \frac{\text{concentration of A at time } t_2 - \text{concentration of A at time } t_1}{t_2 - t_1}$$

$$\text{rate}_A = \frac{\Delta[A]}{\Delta t}$$

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CALCULATING AVERAGE RATE OF REACTION

Based on the data in this table, what chemical reaction is occurring? Write its balanced equation:

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

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

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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CALCULATING AVERAGE RATE OF REACTION

1. Calculate the average rate of appearance of nitrogen monoxide gas over the first 50 s of the reaction.

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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CALCULATING AVERAGE RATE OF REACTION

2. Calculate the average rate of disappearance of nitrogen dioxide gas between 50 s and 100 s of the reaction.

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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REACTION RATES

Time (±1 s)	$NO_2(g)$
0	0.0100
50	0.0079
100	0.0065
150	0.0055
200	0.0048
250	0.0043
300	0.0038

Time period (±1 s)	Average reaction rate (mol/L·s)
0 to 50	4.2×10^{-5}
50 to 100	2.8×10^{-5}
100 to 150	2.0×10^{-5}
150 to 200	1.4×10^{-5}
200 to 250	1.0×10^{-5}
250 to 300	1.0×10^{-5}

AS REACTIONS PROGRESS & REACTANT PARTICLES GET USED UP, THE AVERAGE RATE OF REACTION DECREASES OVER TIME.

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CALCULATING RATES USING STOICHIOMETRY

The following chemical equation represents the decomposition of dinitrogen pentoxide.

$$2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$$

1. If the rate of disappearance of $N_2O_5(g)$ 60 seconds into the reaction is 5.6×10^{-2} mol/L·s at 60 seconds, determine the rate of appearance of oxygen at the same point in time.

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CALCULATING RATES USING STOICHIOMETRY

The following chemical equation represents the decomposition of dinitrogen pentoxide.

$$2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$$

2. Calculate the rate of appearance of $NO_2(g)$ at 90 seconds if the rate of appearance of oxygen is 2.0×10^{-2} mol/L·s at the same point in time.

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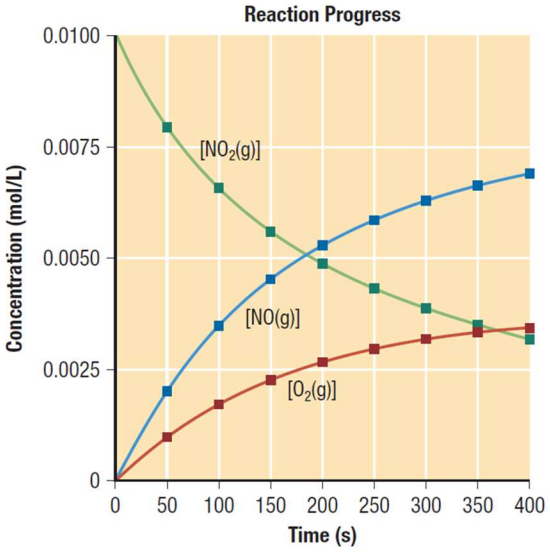
REPRESENTING CHEMICAL REACTIONS GRAPHICALLY

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

As reaction progresses, the rate at which reactants deplete and products form decreases, as shown by the continuous decrease in slope.



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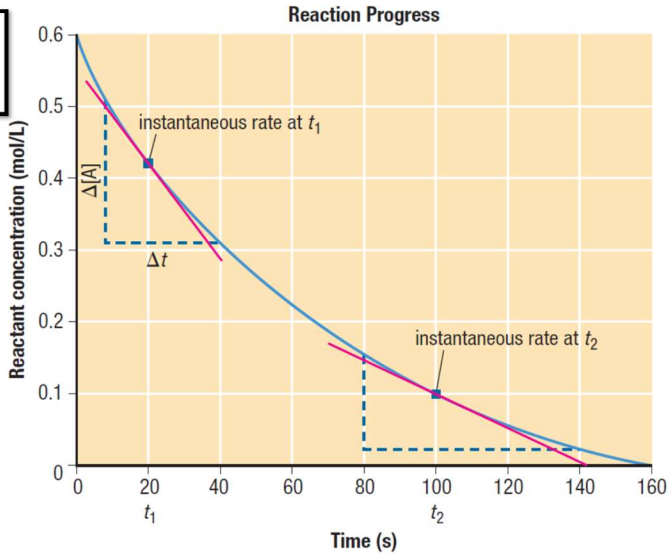
CALCULATING INSTANTANEOUS RATE FROM A GRAPH

instantaneous reaction rate the rate of a chemical reaction at a single point in time

Draw a TANGENT LINE to the point on graph you are analyzing.

Calculate the SLOPE of that line.

SLOPE = RATE



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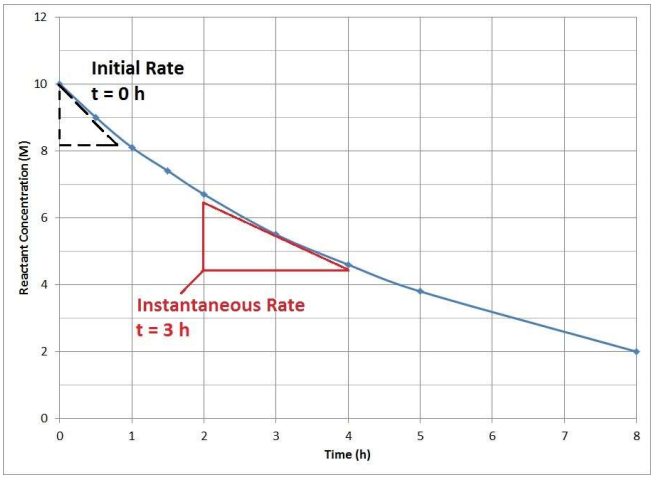
INSTANTANEOUS RATE

Calculate the instantaneous rate of disappearance of this reactant at the 3-hour mark of this reaction.



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INSTANTANEOUS RATE

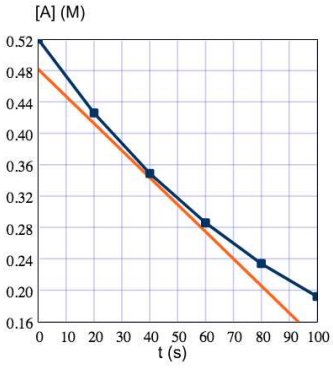
For the reaction

$$\mathbf{A} \longrightarrow \textbf{products}$$

time and concentration data were collected.

t (s)	[A] (M)
0	0.52
20	0.43
40	0.35
60	0.29
80	0.24
100	0.20

The blue curve is the plot of the data. The orange line is tangent to the blue curve at t = 40 s.



Approximate the instantaneous rate of this reaction at time t = 40 s.

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