1) At a certain temperature the following data were collected for the decomposition of HI.

$2HI \rightarrow H_2 + I_2$

Determine the rate law for the reaction.

Rate = $k[HI]^2$

Experiment	Initial [HI] (mol L^{-1})	Initial rate of reaction (mol L^{-1} s^{-1})
1	1.0×10^{-2}	4.0×10^{-6}
2	2.0×10^{-2}	1.6×10^{-5}
3	3.0×10^{-2}	3.6×10^{-5}

×2 ×4

What is the value of the rate constant for the decomposition of HI? *Include units in your answer.*

$$k = \frac{\text{Rate}}{[HI]^2} = \frac{4.0 \times 10^{-6}\ M/s}{[1.0 \times 10^{-2} M]^2} = \boxed{0.040\ M^{-1} s^{-1}}$$

2) Nitrogen monoxide, a noxious pollutant, reacts with oxygen to produce nitrogen dioxide, another toxic gas: $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ The rate data in the table was collected at 225°C.

Determine the rate law for the reaction

Rate = $k[NO]^2[O_2]$

Exp	$[NO]_0$ (M)	$[O_2]_0$ (M)	Initial Rate, $-\Delta[O_2]/\Delta t$ (M s^{-1})
1	1.3 x 10^{-2}	1.1 x 10^{-2}	1.6 x 10^{-3}
2	1.3 x 10^{-2}	2.2 x 10^{-2}	3.2 x 10^{-3}
3	2.6 x 10^{-2}	1.1 x 10^{-2}	6.4 x 10^{-3}

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Calculate the value of the rate constant at 225°C.

$$k = \frac{\text{Rate}}{[NO]^2[O_2]} = \frac{1.6 \times 10^{-3}\ M\ s^{-1}}{[1.3 \times 10^{-2} M]^2 [1.1 \times 10^{-2} M]} = \boxed{860\ M^{-2} s^{-1}}$$

Calculate the rate of *appearance of* NO_2 when [NO] = $[O_2]$ = 6.5 x 10^{-3}M.

$$\text{Rate} = (860\ M^{-2} s^{-1})[6.5 \times 10^{-3} M]^2[6.5 \times 10^{-3} M] = 2.4 \times 10^{-4}\ M\ s^{-1}$$ (for $-O_2$)

O_2 and NO_2
1 : 2

$= 2.4 \times 10^{-4} \times 2 = \boxed{4.8 \times 10^{-4}\ M\ s^{-1}}$

Evaluate the following mechanism for the reaction. Which is the slow step? Does it match the rate law?

$NO + NO \rightleftharpoons N_2O_2$ fast

$N_2O_2 + O_2 \rightarrow 2NO_2$ slow

NO is involved in rate law + 2nd order
O_2 is involved in rate law + 1st order
N_2O_2 is an intermediate - not in rate law

3) Nitric oxide, a noxious pollutant, and hydrogen react to give nitrous oxide and water according to the reaction: $2NO_{(g)} + H_{2(g)} \rightarrow N_2O_{(g)} + H_2O_{(g)}$

The following rate data was collected at 225°C.

Determine the rate law for the reaction.

Exp	$[NO]_0$ (M)	$[H_2]_0$ (M)	Initial Rate, $-\Delta[NO]/\Delta t$ ($M\ s^{-1}$)
1	6.4×10^{-3}	2.2×10^{-3}	2.6×10^{-5}
2	1.3×10^{-2}	2.2×10^{-3}	1.0×10^{-4}
3	6.4×10^{-3}	4.4×10^{-3}	5.1×10^{-5}

Rate $= k[NO]^2[H_2]$

Calculate the value of the rate constant at 225 °C.

$k = \frac{Rate}{[NO]^2[H_2]} = \frac{2.6 \times 10^{-5}\ M s^{-1}}{[6.4 \times 10^{-3} M]^2[2.2 \times 10^{-3} M]} = \boxed{290\ M^{-2} s^{-1}}$

Calculate the rate of appearance of N_2O when $[NO] = [H_2] = 6.6 \times 10^{-3}M$.

Rate $= (290\ M^{-2}s^{-1})[6.6 \times 10^{-3} M]^2[6.6 \times 10^{-3} M] = 8.3 \times 10^{-5}\ M s^{-1}$

2 : 1 ratio $\rightarrow 8.3 \times 10^{-5} \div 2 = \boxed{4.2 \times 10^{-5}\ M s^{-1}}$

Evaluate the following mechanism does it match the rate law. Which step is fast?

$2NO \rightleftharpoons N_2O_2$ fast

$N_2O_2 + H_2 \rightarrow N_2O + H_2O$ slow

N_2O_2 is an intermediate, 2nd Order w/respect to NO and 1st Order w/respect to H_2

4) The major pollutants NO (g), CO (g), NO_2 (g) and CO_2 (g) are emitted by cars and can react according to the following equation: $NO_{2(g)} + CO_{(g)} \rightarrow NO_{(g)} + CO_{2(g)}$ The rate data was collected at 225°C.

Determine the rate law for the reaction.

Exp	$[NO_2]_0$ (M)	$[CO]_0$ (M)	Initial Rate, $-\Delta[CO_2]/\Delta t$ ($M\ s^{-1}$)
1	0.263	0.826	1.44×10^{-5}
2	0.263	0.413	1.44×10^{-5}
3	0.526	0.413	5.76×10^{-5}

Rate $= k[NO_2]^2$

Calculate the value of the rate constant at 225 °C.

$k = \frac{Rate}{[NO_2]^2} = \frac{1.44 \times 10^{-5}\ M s^{-1}}{[0.263\ M]^2} = \boxed{2.08 \times 10^{-4}\ M^{-1} s^{-1}}$

Calculate the rate of appearance of CO_2 when $[NO_2] = [CO] = 0.500$ M.

Rate $= (2.08 \times 10^{-4}\ M^{-1}s^{-1})[0.500 M]^2 = \boxed{5.20 \times 10^{-5}\ M s^{-1}}$

1 : 1 ratio

Evaluate the following mechanism for the reaction based on the form of the rate law. Explain you answer.

$NO_2 + NO_2 \rightarrow NO + NO_3$ slow

$NO_3 + CO \rightarrow NO_2 + CO_2$ fast

2nd Order w/ respect to NO_2

CO is zero order (not in rate law)