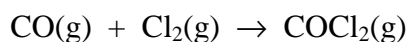


- Phosgene is a toxic gas prepared by the reaction of carbon monoxide with chlorine:



The following data were obtained in a kinetics study of its formation at 150 °C.

Marks
5

Experiment	initial [CO] (M)	initial [Cl ₂] (M)	Initial rate (M s ⁻¹)
1	1.00	0.100	1.29×10^{-29}
2	0.100	0.100	1.33×10^{-30}
3	0.100	1.00	1.30×10^{-29}
4	0.100	0.0100	1.32×10^{-31}

Determine the rate law for the reaction.

Between experiments (1) and (2), [Cl₂]_{initial} is kept constant and [CO]_{initial} is reduced by a factor of 10. The rate decreases by a factor of $\frac{1.29 \times 10^{-29}}{1.33 \times 10^{-30}} \sim 10$.

Hence the reaction is first order with respect to CO.

Between experiments (1) and (3), [Cl₂] is increased by a factor of 10 and [CO]_{initial} is decreased by a factor of 10. The rate does not change. As this change in [CO]_{initial} is known from above to increase the rate by a factor of 10, the change in [Cl₂]_{initial} must be decreasing the rate by a factor of 10. Hence, the reaction is also first order with respect to Cl₂.

Hence, overall,

$$\text{rate} = k[\text{CO}][\text{Cl}_2]$$

Calculate the value of the rate constant at 150 °C.

Using experiment (1), when [CO] = 1.00 M and [Cl₂] = 0.100 M, the rate is $1.29 \times 10^{-29} \text{ M s}^{-1}$. Hence from the rate law:

$$1.29 \times 10^{-29} \text{ M s}^{-1} = k \times (1.00 \text{ M}) \times (0.100 \text{ M})$$

$$k = \frac{1.29 \times 10^{-29} \text{ M s}^{-1}}{(1.00 \text{ M}) \times (0.100 \text{ M})} = 1.29 \times 10^{-28} \text{ M}^{-1} \text{ s}^{-1}$$

Answer: $1.29 \times 10^{-28} \text{ M}^{-1} \text{ s}^{-1}$

Calculate the rate of appearance of phosgene when [CO] = [Cl₂] = 1.3 M.

$$\text{rate} = k[\text{CO}][\text{Cl}_2] = (1.29 \times 10^{-28} \text{ M}^{-1} \text{ s}^{-1}) \times (1.3 \text{ M}) \times (1.3 \text{ M}) = 2.2 \times 10^{-28} \text{ M s}^{-1}$$

Answer: $2.2 \times 10^{-28} \text{ M s}^{-1}$