Marks 4

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

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

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

Experiment	Initial [CO] (mol L^{-1})	Initial [Cl_2] (mol L^{-1})	Initial rate (mol L^{-1} s^{-1})
1	1.00	0.100	1.29×10^{-3}
2	0.100	0.100	1.33×10^{-4}
3	0.100	1.00	1.30×10^{-3}
4	0.100	0.0100	1.32×10^{-5}

Write the rate law for the formation of phosgene at 150 °C.

Between experiments (1) and (2), [Cl_2] is constant and [CO] is increased by a factor of ten. This leads to a tenfold increase in the rate. The reaction is first order with respect to [CO].

Between experiments (2) and (3), [CO] is constant and [Cl_2] is increased by a factor of ten. This leads to a tenfold increase in the rate. The reaction is also first order with respect to [Cl_2].

Hence, the rate law is,

rate = k[CO(g)][Cl_2(g)]

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

In experiment (1), rate = 1.29×10^{-3} mol L^{-1} s^{-1} when [CO] = 1.00 mol L^{-1} and [Cl_2] = 0.100 mol L^{-1}. Substituting into the rate law gives,

$$(1.29 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}) = k \times (1.00 \text{ mol L}^{-1}) \times (0.100 \text{ mol L}^{-1})$$

$$k = 1.29 \times 10^{-2} \text{ mol}^{-1} \text{ L s}^{-1}$$

The same method gives k = 1.33×10^{-2} mol^{-1} L s^{-1}, 1.30×10^{-2} mol^{-1} L s^{-1} and 1.32×10^{-2} mol^{-1} L s^{-1} for experiments (2), (3) and (4) respectively. The accuracy of the experiments suggests a value of 1.3×10^{-2} mol^{-1} L s^{-1}.

Answer: **1.3×10^{-2} mol^{-1} L s^{-1}**

ANSWER CONTINUES ON THE NEXT PAGE

Calculate the rate of appearance of phosgene when $[CO] = [Cl_2] = 1.3$ M.

Using the rate law derived above.

$$\textbf{rate} = (1.3 \times 10^{-2}\ \text{mol}^{-1}\ \text{L}\ \text{s}^{-1}) \times [CO] \times [Cl_2]$$
$$= (1.3 \times 10^{-2}\ \text{mol}^{-1}\ \text{L}\ \text{s}^{-1}) \times (1.3\ \text{mol L}^{-1}) \times (1.3\ \text{mol L}^{-1})$$
$$= 2.2 \times 10^{-2}\ \text{mol L}^{-1}\ \text{s}^{-1}$$

Answer: **2.2×10^{-2} mol L^{-1} s^{-1}**