Orders of Reactions

① Using the data in the following table, find the order of reaction with respect to A, B and C, and the overall reaction. Write the rate equation and calculate a value for the rate constant including units.

Experiment	Concentrations ($mol\,dm^{-3}$)			Rate of Loss of A ($mol\,dm^{-3}s^{-1}$)
	A	B	C	
1	0·1	0·1	0·1	2.0×10^{-4}
2	0·2	0·1	0·1	4.0×10^{-4}
3.	0·2	0·2	0·1	1.6×10^{-3}
4	0·1	0·1	0·2	2.0×10^{-4}

1st order with respect to A.
2nd order with respect to B
zero order with respect to C.

$\text{Rate} = k[A][B]^2$ $\quad 2\times10^{-4} = k(0.1)\times(0.1)^2$

$\dfrac{2\times10^{-4}}{(0.1)\times(0.1^2)} = k \quad k = 0.2 \quad \dfrac{\cancel{mol\,dm^{-3}}s^{-1}}{\cancel{mol\,dm^{-3}}\times mol\,dm^{-3}\times mol\,dm^{-3}}$

$K = 0.2\,mol^{-2}dm^{6}s^{-1}$

(2) Using the data in the following table, find the order of reaction with respect to A, B and C and the overall order of reaction. Write the rate equation and calculate a value for the rate constant including units.

Experiment	Concentrations (mol dm⁻³) A	B	C	Rate of loss of A (mol dm⁻³ s⁻¹)
1	0.010	0.020	0.0050	1.4×10^{-6}
2	0.010	0.010	0.0050	7.0×10^{-7}
3	0.020	0.020	0.0050	1.4×10^{-6}
4	0.020	0.020	0.015	4.2×10^{-6}

0 ÷2 ×3

A = zero order
B = 1st order
C = 1st order

Rate = $k[B][C]$ $1.4 \times 10^{-6} = k[0.020][0.0050]$

$\frac{1.4 \times 10^{-6}}{(0.020) \times (0.0050)} = k$ $k = 0.014$

$\frac{\cancel{mol\,dm^{-3}}\,s^{-1}}{\cancel{mol\,dm^{-3}} \times mol\,dm^{-3}}$

$0.014\ mol^{-1}\,dm^{3}\,s^{-1}$

③ Using the data in the table, find the order of reaction with respect to A and B, and the overall order of reaction. Write the rate equation and calculate a value for the rate constant including units.

Experiment	Concentrations ($mol\,dm^{-3}$) A	B	Rate of loss A ($mol\,dm^{-3}s^{-1}$)
1	0·10	0·10	$2{\cdot}5\times10^{-5}$
2	0·20	0·10	$2{\cdot}5\times10^{-5}$
3	0·30	0·20	$5{\cdot}0\times10^{-5}$

A = zero order B = 1st order

Rate = k [B]

$$\frac{2{\cdot}5\times10^{-5}}{0{\cdot}10} = k$$

$k = 2{\cdot}5\times10^{-4}$

$$\frac{\cancel{mol\,dm^{-3}}\,s^{-1}}{\cancel{mol\,dm^{-3}}}$$

$\underline{2{\cdot}5\times10^{-4}\,s^{-1}}$

④ Using the data in the table, find the order of reaction with respect to A and B.

Experiment	Concentrations (mol dm^{-3}) A	B	Rate of loss of A (mol dm^{-3} s^{-1})
1	0·10	0·10	$1{\cdot}0 \times 10^{-3}$
2	0·10	0·20	$2{\cdot}0 \times 10^{-3}$
3	0·30	0·30	$9{\cdot}0 \times 10^{-3}$

×3 ×2

A = 1st order B = 1st order

$$\text{Rate} = k[A][B] \qquad \frac{\text{Rate}}{[A][B]} = k$$

$$k = \frac{1{\cdot}0 \times 10^{-3}}{(0{\cdot}1) \times (0{\cdot}1)} \qquad k = 0{\cdot}1 \qquad \frac{\cancel{mol\,dm^{-3}}\,s^{-1}}{\cancel{mol\,dm^{-3}} \times mol\,dm^{-3}}$$

$$k = 0{\cdot}1\,mol^{-1}\,dm^{3}\,s^{-1}$$

⑤ Using the data in the following table, find the order of reaction with respect to A and B, and overall order of reaction. Write the rate equation and calculate a value for the rate constant including units.

	Experiment 1	Experiment 2	Experiment 3
2nd [A] (mol dm⁻³)	0.12	0.36	0.36
2nd [B] (mol dm⁻³)	0.04	0.04	0.20 zero
Rate of loss of A (mol dm⁻³ s⁻¹)	9.0×10^{-5}	8.1×10^{-4}	8.1×10^{-4}

$\times 3$

$$Rate = k[A]^2 \qquad \frac{Rate}{[A]^2} = k$$

$$\frac{9.0\times10^{-5}}{(0.12)^2} = k \qquad k = 6.25\times10^{-3}\ mol^{-1}dm^3s^{-1}$$

$$\frac{\cancel{mol\,dm^{-3}s^{-1}}}{\cancel{mol\,dm^{-3}}\,mol\,dm^{-3}}$$

(6) The reaction between P and Q has the rate equation.

$$Rate = k[P][Q]^2$$

The rate constant was found to be $1.60 \times 10^{-6} mol^{-2} dm^6 s^{-1}$ at a particular temperature. Calculate the rate of the reaction at that temperature if the concentration of P was $0.15 mol dm^{-3}$ and that of Q was $0.30 mol dm^{-3}$.

$Rate = k[P][Q]^2$ $\quad$ $Rate = 1.6 \times 10^{-6} \times 0.15 \times (0.3)^2$

$Rate = 2.16 \times 10^{-8} mol dm^{-3} s^{-1}$

⑦ A reaction between N and M was first order with respect to each. The rate constant was found to be $0.048 mol^{-1} dm^3 s^{-1}$ at a particular temperature. If the concentration of N was $0.10 mol dm^{-3}$, what concentration of M would be needed to give a rate of reaction of $2.4 \times 10^{-4} mol dm^{-3} s^{-1}$?

$Rate = K[N][M]$ $\quad 2.4 \times 10^{-4} = 0.048 \times 0.1 \times M$

$\frac{2.4 \times 10^{-4}}{0.048 \times 0.1} = M \quad M = 0.05 mol dm^{-3}$

(8) The rate equation for the reaction between D and E had the form:

$$Rate = k[D][E]^2$$

fill in the blanks in the following table.

Experiment	Concentration (mol dm^{-3}) D	Concentration (mol dm^{-3}) E	Rate of loss of D (mol dm^{-3} s^{-1})
1	0·100	0·100	1.2×10^{-5}
2	0·200	0·100	A
3	0·100	B	1.08×10^{-4}
4	C	0·100	6.00×10^{-5}

$A = 2.4 \times 10^{-5}$

$B = \frac{1.08 \times 10^{-4}}{1.2 \times 10^{-5}} = 9 \therefore 3^2!$ 0·300

C = 0·500