

Rate laws, orders and half-lives

AP Chemistry · Test answers (mark scheme)

Each model answer is followed by a marking guide. Award method marks even if a final number is slightly off through rounding, and do not penalise a correct alternative route such as using half-lives instead of the logarithm.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 5

Question 1 Rate law from data (3 marks)

(a) (1)→(2): $[ICl] \times 2$, rate $\times 2$: order **1**. (2)→(3): $[H_2] \times 4$, rate $\times 4$: order **1**.

(b) $k = 1.5 \times 10^{-3} / (0.10 \times 0.10) = \mathbf{0.15 \text{ M}^{-1} \text{ s}^{-1}}$.

Marking: 1 mark for each order with reasoning; 1 mark for the value and units of k .

Question 2 Units (2 marks)

(a) Overall order **2**; k in $\mathbf{M^{-1} s^{-1}}$.

(b) $\mathbf{s^{-1}}$.

Marking: 1 mark each.

Question 3 First-order calculation (3 marks)

(a) $[A] = 0.250 \times e^{(-5.0 \times 10^{-4} \times 1200)} = 0.250 \times e^{(-0.60)} = 0.250 \times 0.549 = \mathbf{0.137 \text{ M}}$.

(b) $t_{1/2} = 0.693 / 5.0 \times 10^{-4} = \mathbf{1.39 \times 10^3 \text{ s}}$.

Marking: 1 for the correct equation and substitution, 1 for the answer, 1 for the half-life.

Question 4 Graph reading (2 marks)

(a) $1.20 \rightarrow 0.60 \text{ M}$ takes 30 s, and $0.60 \rightarrow 0.30 \text{ M}$ takes another 30 s: constant half-life of **30 s**, so **first order**.

(b) $k = 0.693 / 30 = \mathbf{0.023 \text{ s}^{-1}}$.

Marking: 1 for half-life and order, 1 for k .

Question 5 Second-order time (3 marks)

$1/[A] = 1/[A]_0 + kt \rightarrow t = (1/0.10 - 1/0.30) / 0.40 = (10.0 - 3.33) / 0.40 = \mathbf{16.7 \text{ s}}$.

Marking: 1 for the second-order equation, 1 for $10.0 - 3.33$, 1 for the answer with unit.

Question 6 Explaining the effect of concentration (2 marks)

More particles in the same volume means collisions between reactant particles are **more frequent**, so more successful collisions per second occur and the rate rises. The fraction of collisions with enough energy does not change.

Marking: 1 for greater collision frequency, 1 for linking it to more successful collisions per unit time.

Question 7 Plots (2 marks)

(a) **First order.**

(b) The slope is $-k$: negative, with magnitude equal to the rate constant (units s^{-1}).

Marking: 1 each.

Question 8 Order from half-lives (3 marks)

(a) The half-life doubles each time $[A]_0$ is halved, so $t_{1/2} \propto 1/[A]_0$: **second order.**

(b) $k = 1/(t_{1/2}[A]_0) = 1/(40 \times 0.80) = \mathbf{0.031 \text{ M}^{-1} \text{ s}^{-1}}$.

Marking: 1 for order with reasoning; 1 for the formula; 1 for the value and units.