

HL Answers to Rate expression questions

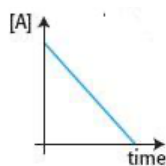
1. In terms of units, $\frac{\text{rate}}{k} = \text{concentration}^x$

$$\frac{\text{mol dm}^{-3} \text{ s}^{-1}}{\text{dm}^6 \text{ mol}^{-2} \text{ s}^{-1}} = \text{mol}^3 \text{ dm}^{-9} = (\text{mol dm}^{-3})^3 = \text{concentration}^3$$

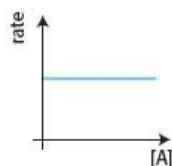
Hence the units of the rate constant show that the reaction is third order overall

2. i. From experiments 3 and 1, doubling $[\text{CH}_3\text{COCH}_3(\text{aq})]$ causes the rate to double hence the order of the reaction with respect to propanone is one.
 ii. From experiments 1 and 2 doubling $[\text{Br}_2(\text{aq})]$ has no effect on the initial rate hence the order of the reaction with respect to bromine is zero.
 iii. From experiments 3 and 4, doubling $[\text{H}^+(\text{aq})]$ causes the rate to double hence the order of the reaction with respect to hydrogen ions is one.
 iv. The overall order is two, i.e. a second order reaction.
 v. $\text{Rate} = k[\text{CH}_3\text{COCH}_3(\text{aq})][\text{H}^+(\text{aq})]$
 vi. Substituting the values from experiment 4 into the rate expression
 $5.0 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1} = k \times (1.0 \times 10^{-1} \text{ mol dm}^{-3}) \times (10^{-1} \text{ mol dm}^{-3})$
 $k = 5.0 \times 10^{-3} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
 (Note: You can use any of experiments 1 to 4 to give the same result.)
 vii. $\text{Rate} = 5.0 \times 10^{-3} \times (1.7 \times 10^{-1}) \times (2.9 \times 10^{-1}) = 2.5 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$

3. i.



(i)



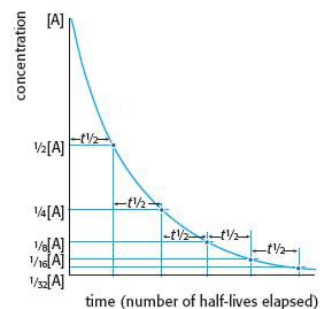
(ii)

The graph of concentration of reactant against time (i) will show the straight line sloping downwards as the reactant is used up.

The graph of rate of reaction against concentration of reactant (ii) will show the straight line staying at the same level as the rate is independent of the concentration.

- ii. $\text{Rate} = k$, so units of $k = \text{mol dm}^{-3} \text{ s}^{-1}$

4. For a first order reaction (right) the line slopes downwards and the time is constant each time the concentration is halved. The slope is even steeper for a second order reaction.



5. i. First order reaction: $\text{rate} = k \times \text{concentration}$ so units of $k = \text{s}^{-1}$
 ii. second order reaction: $\text{rate} = k \times \text{concentration}^2$,
 so units of $k = \text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$