Problem 7: Iodination inquiry

Teacher and Technician Pack

Pre-Lab answers

1.

a) i. zero order wrt A; ii. first order wrt A; iii. second order wrt A

b) Step one, the slow step is the rate-determining step

2a.

I. Mg + 2 HCl → MgCl₂ + H₂
   Measure the time taken to produce a certain amount of H₂ gas
II. Na₂S₂O₃ + 2 HCl → 2 NaCl + S + SO₂ + H₂O
   Measure the time taken for the solution to turn sufficiently cloudy as a result of the colloidal suspension of sulphur that forms that you cannot see through the flask
III. CH₃CH₂Cl + OH⁻ → CH₃CH₂OH + Cl⁻

Add a certain amount of silver nitrate solution to the reaction and measure the time taken for a white precipitate (of AgCl) to form

Alternatively, the rate of each of the reactions above could be measured using a pH meter to determine the change in concentration of H⁺ with unit time.

2b) The reaction rate is defined as the change in concentration of reactants or products per unit time. Therefore to convert the reaction time into a reaction rate you would need to determine the change in concentration of the reactant / product at the point when you stopped the clock and divide this concentration (mol dm⁻³) by the time (s) it took for this change to occur.

3.

a) By comparing exp 1 and 2, the reaction is second order wrt [Q]
   By comparing exp 1 and exp 3, the reaction is first order wrt [R]
   Therefore the rate equation for the reaction is rate = k[Q]²[R]

b) 5.24 × 10⁻³ mol dm⁻³ s⁻¹ = k × 0.300² mol² dm⁻⁶ × 0.300 mol dm⁻³
   Hence, k = 0.194 mol⁻² dm⁶ s⁻¹
NOTE The choice of the observed change in [I₂] as a method for measuring the initial rate of this reaction only works because the reaction is zero order with respect to iodine. Therefore the concentration of iodine does not affect the reaction rate and hence we can study the rate by making iodine the limiting reagent present in a large excess of propanone and acid. If iodine was involved in the rate determining step, as its concentration decreased the reaction would become slower and slower and the results would be skewed.

You may wish to discuss this point with your more able students.
Equipment list

Each group will need;

- 100 cm$^3$ of 2.0 M propanone solution [Highly flammable; Irritant]
- 100 cm$^3$ of 1.0 M HCl solution [Low hazard]
- 30 cm$^3$ of 0.005 M Iodine solution in aqueous potassium iodide [Low hazard]
- Distilled water
- 4 × burettes, burette stands and clamps and funnels (1 for each solution and water) (these can be shared)
- between groups if needed
- 2 × 100 cm$^3$ conical flask
- Test tubes (for storage of acid and iodine solutions before addition)
- Stopwatch
- 2 × white tile or white paper

Health and safety note
The product of the reaction, iodopropanone, is a lachrymator (strongly irritant to eyes). The reaction mixture must therefore be disposed of as soon as measurements have been taken by flushing down a fume cupboard sink with lots of running water.