

How fast do reactions go?

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab answers

Use the sample data to check your working. The exact times from your own group will differ, but the times should shorten steadily as the water gets hotter and the rate should grow by about 1.5 to 2 times for each 10 °C rise.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-5

Question 1 Calculate the rates

5 °C: $1 \div 190 = 0.00526 \text{ s}^{-1} = 5.26 \times 10^{-3} \text{ s}^{-1}$. 20 °C: $1 \div 80 = 12.5 \times 10^{-3} \text{ s}^{-1}$. 40 °C: $1 \div 25 = 40.0 \times 10^{-3} \text{ s}^{-1}$. 60 °C: $1 \div 9 = 111 \times 10^{-3} \text{ s}^{-1}$. **5.26, 12.5, 40.0 and 111 × 10⁻³ s⁻¹.**

Question 2 Graph and shape

The rate rises as the temperature rises, and the line curves upwards, getting steeper at higher temperature. **An upward curve.**

Question 3 Factor per ten degrees

Factor from 20 °C to 40 °C = $40.0 \div 12.5 = 3.2$. That covers two rises of 10 °C, so the average factor per 10 °C is $\sqrt{3.2} = 1.8$. This is slightly lower than 2, so the doubling rule is only approximate. **3.2 overall; about 1.8 per 10 °C.**

Question 4 Explain with collisions

At higher temperatures the particles have more energy and move faster, so they collide more often. A much larger fraction of collisions has at least the activation energy, so more collisions succeed and the rate rises. **More successful collisions.**

Question 5 Control variables

Volume of water (200 cm³), the type and mass of tablet, and whether it is whole or crushed. Each of these changes the number of particles or the surface area exposed, so it would change the rate and make the comparison unfair. **Volume, tablet and size.**

Question 6 Timing uncertainty

9 s: $1 \div 9 \times 100 = 11\%$. 190 s: $1 \div 190 \times 100 = 0.53\%$. The 9 s result is less reliable because reaction time of the person is a much larger fraction of the time. **11% and 0.5%.**

Question 7 Improvements

The rate of reaction increases as temperature increases, by roughly 1.8 times for each 10 °C rise here. Improvements: repeat each temperature three times and take a mean; keep the water at constant temperature with a water bath, or use a data logger to detect when fizzing stops. **Higher temperature gives a higher rate.**