

How fast do reactions go?

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

Each answer shows the formula, the working and the result in bold. In explanation problems, check that your answer links the factor to the number of successful collisions per second and not only to the word faster. Check units of rate carefully.

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

Problem 1 Defining rate

1. The amount of reactant used up, or product formed, per unit time. 2. Collect the gas in a gas syringe and record the volume against time; or weigh the flask and record the mass loss against time. **Rate = amount ÷ time.**

Problem 2 Four ways to speed up

Increase the temperature, increase the concentration of a solution (or pressure of a gas), increase the surface area of a solid by crushing it, and add a catalyst. **Temperature, concentration, surface area, catalyst.**

Problem 3 Reading a gas graph

1. Experiment 1 (steeper). 2. Experiment 1 finishes at about 50 s and experiment 2 at about 110 s. 3. The same amount of magnesium reacts in both, so the same amount of gas forms. **Experiment 1 is faster.**

Problem 4 Collision words

1. Collide. 2. Activation. 3. More. **Collide; activation; more.**

Problem 5 Everyday rates

1. Lower temperature slows the reactions of bacteria. 2. Dust has a very large surface area. 3. Higher pressure raises the boiling point of water, so the food is cooked at a higher temperature. **Temperature, surface area, temperature.**

Problem 6 Choose a method

1. Gas syringe, measuring volume against time. 2. Time how long it takes for a cross under the flask to disappear. 3. Weigh the flask and record the mass loss. **Syringe, cross, balance.**

Problem 7 Mean rate of gas

1. $36 \div 90 = 0.40 \text{ cm}^3/\text{s}$. 2. $0.40 \times 60 = 24 \text{ cm}^3/\text{min}$. 3. $0.40 \times 60 = 24 \text{ cm}^3$. **0.40 cm³/s.**

Problem 8 Losing mass

1. $0.88 \div 4.0 = 0.22 \text{ g/min}$. 2. $0.88 \div 240 = 3.7 \times 10^{-3} \text{ g/s}$. 3. $0.88 \div 44 = 0.020 \text{ mol}$. **0.22 g/min.**

Problem 9 Concentration data

1. $1 \div 120 = 0.0083 \text{ s}^{-1}$; $1 \div 60 = 0.017 \text{ s}^{-1}$; $1 \div 40 = 0.025 \text{ s}^{-1}$; $1 \div 30 = 0.033 \text{ s}^{-1}$. 2. The rate is proportional to the concentration, because doubling the concentration doubles $1 \div$ time. 3. More particles per cm^3 means more frequent collisions. **Rate $\propto$ concentration.**

Problem 10 Cutting a cube

1. $6 \times (3 \times 3) = 54 \text{ cm}^2$. 2. Each small cube has 6 cm^2 , so $27 \times 6 = 162 \text{ cm}^2$. 3. The area triples, so the rate increases. **54 cm² $\rightarrow$ 162 cm².**

Problem 11 Picture the concentration

1. The right box. 2. It has three times as many particles in the same volume, so they collide more often. 3. The rate is higher at high pressure. **Right box, higher rate.**

Problem 12 Two effects of heat

1. The particles move faster so they collide more often; a larger fraction of the particles has at least the activation energy. 2. The second reason, because many more collisions are successful. **More energy matters most.**

Problem 13 Catalyst in peroxide

1. Manganese(IV) oxide. 2. A catalyst is not used up. 3. It gives an alternative pathway with lower activation energy, so more collisions succeed. **MnO₂ is the catalyst.**

Problem 14 Doubling every ten degrees

1. Three rises: $2 \times 2 \times 2 = 8$ times. 2. $160 \div 8 = 20 \text{ s}$. 3. At 10°C the rate is halved, so the time is $160 \times 2 = 320 \text{ s}$. **8 times faster; 20 s.**

Problem 15 Design for speed

1. Use warmer water (about 30°C) and finer ingredients or more yeast. 2. Warmer dough gives more energetic particles, so more collisions are successful. 3. Very high temperatures

destroy enzymes, so the catalyst stops working. **Warm, not hot.**

Problem 16 Gradient at 20 seconds

1. 27.5 cm^3 . 2. $27.5 \div 20 = 1.4 \text{ cm}^3/\text{s}$. 3. Gradient = $(46 - 10) \div (40 - 0) = 36 \div 40 = 0.90 \text{ cm}^3/\text{s}$. 4. The reactants get used up, so the concentration falls and the curve flattens, so the rate at 20 s is lower than the average over the steep start. **Rate at 20 s = $0.90 \text{ cm}^3/\text{s}$.**

Problem 17 Magnesium powder versus ribbon

1. $n(\text{Mg}) = 0.24 \div 24 = 0.010 \text{ mol}$, so $n(\text{H}_2) = 0.010 \text{ mol}$ and $V = 0.010 \times 24\,000 = 240 \text{ cm}^3$. 2. $240 \div 60 = 4.0 \text{ cm}^3/\text{s}$. 3. $240 \div 15 = 16 \text{ cm}^3/\text{s}$, which is $16 \div 4.0 = 4$ times faster. 4. $0.010 \div 60 = 1.7 \times 10^{-4} \text{ mol/s}$. **$4.0 \text{ cm}^3/\text{s}$ for the strip; $16 \text{ cm}^3/\text{s}$ for the powder.**

Problem 18 Cross disappearing

1. $1 \div 96 = 0.0104 \text{ s}^{-1}$; $1 \div 12 = 0.0833 \text{ s}^{-1}$. 2. Each 10°C rise halves the time (96, 48, 24, 12), so the rate doubles. 3. $12 \div 2 = 6 \text{ s}$. 4. A yellow sulfur precipitate forms and makes the mixture cloudy. **Rate doubles per 10°C ; 6 s at 60°C .**

Problem 19 Which catalyst is best?

1. $2 \div 30 = 0.067 \text{ cm}^3/\text{s}$; $14 \div 30 = 0.47 \text{ cm}^3/\text{s}$; $45 \div 30 = 1.5 \text{ cm}^3/\text{s}$. 2. Manganese(IV) oxide. 3. Mass of catalyst, volume and concentration of peroxide, temperature (and particle size). 4. Each catalyst may work better in other reactions or conditions, and only one test was done for each. **Rates 0.067 , 0.47 and $1.5 \text{ cm}^3/\text{s}$.**

Problem 20 Spot the errors

1. Heating also gives many more particles at least the activation energy, which is the main reason. 2. A catalyst is not used up and does not change the amount of product. 3. A steeper gradient shows a faster reaction. 4. Doubling the pressure puts more particles in the same volume, which increases collisions. **Four corrections.**