Rates and Maxwell-Boltzmann distributions

OCR A H032 and H432 · AS and A level

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Gas syringe readings

A gas syringe reads 17.0 cm^3 at 10.0 s and 48.0 cm^3 at 40.0 s. Calculate the average rate of gas production over this interval in $cm^3\ s^{-1}$. Give your answer to three significant figures.

2. Compare two ways to follow a reaction

Calcium carbonate and dilute acid release carbon dioxide. Suggest two measurements that could be recorded at regular intervals to follow the progress of this reaction. Explain why each changes.

3. Most collisions are unsuccessful

In a reacting gas, only a small proportion of collisions lead to a reaction. Define activation energy and use it to explain this observation.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/ocr-a-rates-and-maxwell-boltzmann

Rates and Maxwell-Boltzmann distributions

OCR A H032 and H432 · AS and A level

4. Concentration at constant temperature

A solution reacts with a solid. A second run uses the same volume of a more concentrated solution and an identical piece of solid. The starting temperature is the same. Predict and explain how the initial rate changes.

5. The same gas with and without a catalyst

Two samples of a reacting gas have the same temperature and number of molecules. One has a catalyst. Use a Maxwell-Boltzmann diagram to compare the two samples. Label the axes and any activation energies you show.

6. Two temperatures

Sketch Maxwell-Boltzmann curves for a fixed number of gas molecules at two temperatures. Label the axes and mark the activation energy. Use the curves to explain the difference in reaction rate.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/ocr-a-rates-and-maxwell-boltzmann

Rates and Maxwell-Boltzmann distributions

OCR A H032 and H432 · AS and A level

7. Concentration against time

At a chosen time, a tangent to a reactant concentration curve passes through (20 s, 0.162 mol dm^{-3}) and (70 s, 0.082 mol dm^{-3}). Calculate the rate of disappearance of the reactant.

8. Two activation energies

At a fixed temperature, 1.6% of molecules have energy at or above the uncatalysed activation energy. With a catalyst, 8.0% have at least the new activation energy. By what factor does the fraction change? Explain why the rate increases.

9. Extra challenge · Assess a particle-size result

Equal masses of calcium carbonate from the same sample react completely with excess acid. Run A uses chips and run B uses powder. Gas volumes for A after 0, 10 and 120 s are 0, 18 and 42 cm^3. For B they are 0, 32 and 66 cm^3. Neither volume changes after 120 s.

Compare the mean rates for the first 10 s. Explain why the final volumes suggest a problem with the comparison. Suggest one flaw that fits the pattern, and one way to check it.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/ocr-a-rates-and-maxwell-boltzmann

Worked answers

Rates and Maxwell-Boltzmann distributions · OCR A H032 and H432 · AS and A level

1. Gas syringe readings

Average rate = change in volume ÷ time interval = (48.0 − 17.0) ÷ (40.0 − 10.0) = 1.03 cm^3 s^{-1}.

2. Compare two ways to follow a reaction

Record the volume in a gas syringe. It increases as more CO_2 is collected.

Alternatively record the mass of the reaction vessel and its contents while the gas is allowed to escape. The mass decreases as CO_2 leaves.

3. Most collisions are unsuccessful

Activation energy is the minimum energy that colliding particles need to react. Many particles collide with less than this energy, so the collisions are unsuccessful.

4. Concentration at constant temperature

The number of dissolved reactant particles per unit volume increases. They collide with the solid surface more often, giving more successful collisions per second and a higher rate.

5. The same gas with and without a catalyst

Plot number of molecules per energy interval against energy. Use the same curve for both samples because temperature and number of molecules are the same.

Mark the catalysed activation energy to the left of the uncatalysed one. The catalyst provides an alternative pathway with a lower activation energy.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/ocr-a-rates-and-maxwell-boltzmann

Worked answers

Rates and Maxwell-Boltzmann distributions · OCR A H032 and H432 · AS and A level

6. Two temperatures

Plot number of molecules per energy interval against energy. Both curves start at the origin and approach the baseline at high energy.

The hotter distribution has a lower, broader peak farther right and the same total area. Its larger area beyond the unchanged activation energy shows why more collisions have sufficient energy to react.

7. Concentration against time

The gradient is $(0.082 - 0.162) \div (70 - 20) = -1.6 \times 10^{-3}$ mol dm^{-3} s^{-1}.

Rate of disappearance is positive: 1.6×10^{-3} mol dm^{-3} s^{-1}. The negative gradient shows that the concentration falls.

8. Two activation energies

The fraction is $8.0 \div 1.6 = 5.0$ times as large. The distribution is unchanged at this temperature.

The catalyst provides an alternative pathway with lower activation energy. A larger fraction of collisions has sufficient energy, so successful collisions are more frequent.

9. Extra challenge · Assess a particle-size result

The rates over 0-10 s are 1.8 cm^3 s^{-1} for A and 3.2 cm^3 s^{-1} for B. Powder should have a higher initial rate because more carbonate surface is exposed.

With complete reaction and measurements at the same temperature and pressure, equal carbonate masses produce the same amount and volume of CO_2. A leak in the apparatus for A could lower both its early readings and its final volume. Check the seal and repeat with the same gas syringe and fittings in both runs.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/ocr-a-rates-and-maxwell-boltzmann