InkChemistry

ANSWER BOOK

Measuring the rate of a reaction

Kinetics · Unit C05

AQA 3.1.5.3 (RP3) · OCR A 3.2.2; PAG 9, PAG 10

15 questions · 46 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 MR-Q10

B1 a light sensor connected to a data logger, placed under the flask or beside it, or a colorimeter. **B1** it records the light passing through the mixture, so the end point is a set value of transmitted light, the same in every run. [2]

A2 MR-Q12

B1 bromine is the only coloured species, so the absorbance of the mixture falls as the bromine is used up. **B1** readings can be taken at intervals through one run, and a calibration curve turns absorbance into bromine concentration. [2]

A3 MR-Q15

B1 the plug lets the carbon dioxide escape, so the mass falls as the gas is given off. **B1** it stops droplets of acid thrown up by the bubbles leaving the flask, which would add to the mass lost and make the rate too high. [2]

A4 MR-Q20

M1 each reading is uncertain by one in the last digit, ±0.01 g, so the difference of two readings is uncertain by ±0.02 g. **A1** 0.02 ÷ 0.18 × 100 = 11%, to two significant figures; allow 5.6% from ±0.005 g a reading. [2]

SECTION B · Standard, 3 to 5 marks

B1 MR-Q5

B1 the cross disappears when a fixed amount of sulfur has formed, the same in every run, so rate = fixed amount ÷ t is proportional to 1/t. **M1** 1/t = 1 ÷ 47 and 1 ÷ 18. **A1** 1/t = 0.021 s^{-1} and 0.056 s^{-1}, to two significant figures, with the unit s^{-1}. **A1** factor = 47 ÷ 18 = 2.6, a ratio with no unit, to two significant figures; allow 0.056 ÷ 0.021 = 2.7. [4]

B2 MR-Q19

B1 the same volume in the same flask gives the same depth of liquid over the cross. **B1** so the cross is hidden by the same amount of sulfur in every run, and 1/t stays proportional to the rate. **B1** the concentration of the acid in the mixture is also the same, so thiosulfate concentration is the only variable changed. **B1** 0.020 × 50 ÷ 0.050 = 20 cm^3 of thiosulfate solution, made up with 30 cm^3 of water. [4]

B3 MR-Q2

B1 the precipitate is sulfur, S, which forms as a pale yellow solid and makes the mixture cloudy. **B1** the gas is sulfur dioxide, SO_2, which is toxic and irritates the eyes and lungs. **B1** work in a well-ventilated room or fume cupboard and pour each mixture away as soon as the time is recorded; eye protection alone is not credited, as it answers the acid. [3]

B4 MR-Q4

B1 amount of magnesium = 0.10 ÷ 24.3 = 4.1 × 10^{-3} mol, so 4.1 × 10^{-3} mol of hydrogen forms. **B1** the mass of hydrogen is 4.1 × 10^{-3} × 2.0 = 0.0082 g. **B1** that is less than the 0.01 g resolution of the balance, so the whole reaction changes the reading by less than one division. [3]

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B5 MR-Q6 **M1** amount of $CaCO_3$ = 0.500 ÷ 100.1 = 5.00×10^{-3} mol, which gives the same amount of CO_2. **M1** volume = $5.00 \times 10^{-3} \times 24\,000$ cm^3 mol^{-1}. **A1** 1.20×10^2 cm^3, to three significant figures, which is more than the 100 cm^3 the syringe holds. [3]

B6 MR-Q9 **B1** if either solution were colder or warmer, the mixture would start at a temperature different from the one being investigated. **B1** the mixture loses heat once it stands on the bench, most quickly in the hottest runs. **B1** recording the starting and final temperatures and using the mean gives the temperature at which the reaction ran. [3]

B7 MR-Q11 **B1** hydrogen is given off, so collect it in a gas syringe connected to a bunged conical flask. **B1** start a stopwatch as the zinc meets the acid and read the gas volume at regular intervals, such as every 15 s. **B1** plot volume against time; the gradient of a tangent gives the rate at any time, since hydrogen is too light to follow by mass loss. [3]

B8 MR-Q16 **B1** the volume and concentration of the sodium thiosulfate solution. **B1** the volume and concentration of the hydrochloric acid. **B1** the depth of liquid over the cross, through using the same flask, the same cross and the same observer. [3]

B9 MR-Q17 **B1** continuous monitoring takes readings at intervals through a single run, so one experiment gives a whole curve. **B1** a method timed to an end point gives one time per run, so the run is repeated at each value of the variable. **B1** gas volume in a syringe is an example of continuous monitoring; the disappearing cross is an end-point method. [3]

B10 MR-Q23 **M1** $n(H_2)$ = 48.0 ÷ 24 000 = 2.00×10^{-3} mol, with the molar gas volume converted to cm^3 first; allow 0.0480 ÷ 24.0. **M1** mean rate = amount formed ÷ time = $2.00 \times 10^{-3} \div 40$. **A1** = 5.0×10^{-5} mol s^{-1}, with the unit, and the working shown in full because the answer is given. [3]

SECTION C · Long, 6 marks or more

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C1 [6]
MR-Q8

Indicative content

B1 measured volumes of sodium thiosulfate solution, for example 50 cm^3, in a conical flask and of hydrochloric acid, for example 10 cm^3, in a separate tube. **B1** both are warmed separately in a water bath to the chosen temperature, checked with a thermometer. **B1** the flask stands on paper marked with a cross; the acid is added and a stopwatch started at the moment of mixing. **B1** the watch is stopped when the cross can no longer be seen looking down through the liquid, and the temperature of the mixture is recorded. **B1** the experiment is repeated at about five temperatures, for example 20 to 60 °C, with repeats at each, keeping volumes, concentrations, flask, cross and observer the same. **B1** 1/t is calculated as a measure of rate and plotted against temperature, in a well-ventilated room because sulfur dioxide is given off.

Levels

Level 3 (5–6 marks) the volumes, the separate warming of both solutions, the cross and the timing from mixing to disappearance, the range of temperatures with repeats, the variables kept the same and the processing as 1/t against temperature are all present, with the ventilation precaution.

Level 2 (3–4 marks) the cross method and the timing are described over a range of temperatures; the two solutions are not warmed separately, the controls are not named, or the results are not processed into 1/t.

Level 1 (1–2 marks) the solutions are mixed and timed at different temperatures, with the time itself taken as the rate and no controls or repeats.

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