

CIE A-Level Chemistry 9701 Paper 5 Practice

Paper (Planning, Analysis and Evaluation) -

ANSWERS

Total: 30 marks · 1 h 15 min · 2 questions · 11 parts

Q	Part	Answer	Mark points	marks
1	(a)	Independent variable: the temperature (20 C to 60 C). Dependent variable: the rate of reaction, measured by the time t for the black cross to disappear (rate is proportional to $1/t$). Control variables: the concentration and volume of sodium thiosulfate solution, the concentration and volume of dilute hydrochloric acid, the depth of the cross and the observer eye level, the same conical flask.	1 mark: temperature independent, rate (time t or $1/t$) dependent 1 mark: three controls (concentration, volumes, depth of the cross)	2
1	(b)	Heat a thermostatted water bath to the target temperature. Stand the tube of sodium thiosulfate solution and the tube of dilute acid in the bath for 5 minutes so both reach the bath temperature. Read the temperature with a thermometer graduated to 0.5 C dipped in the solution, and mix only when the reading is within 0.5 C of the target. Use five temperatures: 20, 30, 40, 50 and 60 C.	1 mark: thermostatted water bath, 5 min equilibration 1 mark: thermometer in the solution, read to within 0.5 C 1 mark: at least five temperatures between 20 and 60 C	3
1	(c)	Pipette 25.0 cm ³ of sodium thiosulfate solution into a conical flask and add 25.0 cm ³ of distilled water; stand the flask on white paper carrying a black cross. Measure 5.0 cm ³ of dilute acid in a measuring cylinder and equilibrate it with the flask in the water bath. Pour the acid into the flask, start the stopwatch at the same moment, cover with a watch glass and swirl; look vertically down through the flask and record the time t when the cross just disappears. Repeat three times at each temperature and take the mean.	1 mark: fixed volumes measured accurately 1 mark: acid added and stopwatch started together 1 mark: viewed vertically from above 1 mark: three repeats	4

			averaged at each temperature	
1	(d)	Columns: temperature / °C; T / K; t ₁ , t ₂ , t ₃ / s; mean t / s; 1/t or ln (1/t) / s ⁻¹ ; 1/T / K ⁻¹ .	1 mark: three timings plus a mean column 1 mark: T/K, 1/T and 1/t (or ln 1/t) with correct units	2
1	(e)	Plot ln (1/t) against 1/T, with 1/T in K ⁻¹ . From the Arrhenius equation $k = A \exp(-E_a/RT)$, $\ln k = \ln A - (E_a/R)(1/T)$; since the rate is proportional to 1/t, the gradient equals $-E_a/R$, so $E_a = -\text{gradient} \times R$ with $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$, divided by 1000 for kJ mol ⁻¹ .	1 mark: ln (1/t) against 1/T 1 mark: gradient = $-E_a/R$ 1 mark: $E_a = -\text{gradient} \times 8.31$, converted to kJ mol ⁻¹	3
1	(f)	Dilute hydrochloric acid is corrosive, so wear eye protection; the reaction releases sulfur dioxide, so work in a fume cupboard or a well-ventilated room; take care with the hot water bath.	1 mark: any two (eye protection / ventilation / hot water)	1
2	(a)	T / K = 293, 303, 313, 323, 333; $10^3/T = 3.41, 3.30, 3.19, 3.10, 3.00 \text{ K}^{-1}$; t = 95.00, 46.95, 24.27, 13.07, 7.30 s; ln (1/t) = -4.554, -3.849, -3.189, -2.570, -1.988.	2 marks: all five T/K and $10^3/T$ values 2 marks: all five ln (1/t) values (3 s.f.)	4
2	(b)	Plot ln (1/t) on the y axis against 1/T in K ⁻¹ on the x axis, x from 3.00×10^{-3} to 3.50×10^{-3} and y from -4.6 to -1.9. The five points should lie close to a straight line; draw the best-fit line with a transparent ruler so the points scatter evenly about it, and re-measure any temperature whose point deviates by more than one small square.	1 mark: 1/T on x, ln (1/t) on y, axes labelled with units 1 mark: suitable scales, five points plotted 1 mark: best-fit line drawn 1 mark: straightness judged from the scatter	4
2	(c)	Gradient = change in ln (1/t) / change in 1/T = $(-1.988 - (-4.554)) / (3.00 \times 10^{-3} - 3.41 \times 10^{-3})$, which is about -6259 K, i.e. $-6.25 \times 10^3 \text{ K}$.	1 mark: gradient from change in y / change in x 1 mark: unit K, negative sign kept	2

2	(d)	$E_a = -\text{gradient} \times R = 6259 \times 8.31 = 52012 \text{ J mol}^{-1}$, which is about 52.0 kJ mol ⁻¹ .	1 mark: $E_a = -\text{gradient} \times R$ substituted 1 mark: about 52 kJ mol ⁻¹ with the correct unit	2
2	(e)	The moment of disappearance is judged by eye, so different observers react at different times; use one observer, or a light sensor / time-lapse camera instead of the eye. There is a delay between pouring the acid and starting the stopwatch, and the temperature falls slightly on mixing; equilibrate in the bath, pour quickly and start the watch at once, and record the actual temperature after mixing. Each temperature is only timed once; take three repeats and more temperatures to reduce random error.	1 mark: one valid source of error 1 mark: a second source 1 mark: a matching improvement	3