

Solutions

2.1 $0.48 \div 60 = 0.008 \text{ g/s}$.

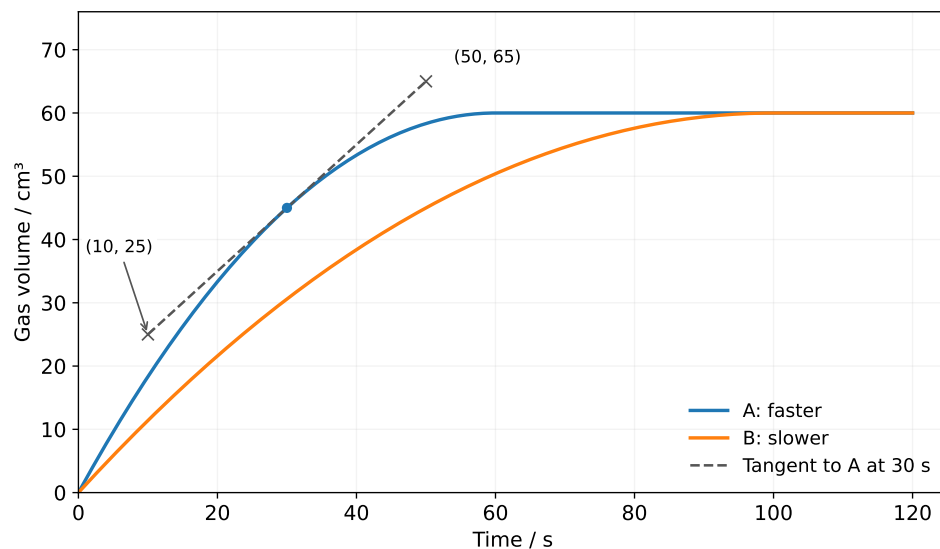
2.2 Powder has a larger surface-area-to-volume ratio; more particles are exposed to the acid, so collisions are more frequent.

2.3 It lowers the activation energy – a lower hump; the overall energy change is unchanged.

3.1 At 60°C particles have more kinetic energy; they collide more frequently; and a greater proportion of collisions exceeds the activation energy; both effects raise the successful-collision rate, so the reaction is faster.

3.2 Time from adding acid until the same cross is no longer visible; a shorter time to the same threshold indicates a faster relative rate, not completion of reaction. Any two controls: acid volume/concentration, total mixture volume/viewing depth, temperature, flask or consistent lighting/observer. Thiosulfate concentration is varied and cannot be a control.

3.3



Curve rises then flattens; draw a tangent touching the curve at 30 s; the gradient of the tangent = change in quantity $\div$ change in time along it, giving the rate at 30 s.

3.4 Volume change = $36 - 12 = 24 \text{ cm}^3$ and time interval = $30 - 10 = 20 \text{ s}$; rate = $24/20 = 1.2 \text{ cm}^3/\text{s}$. $36/30$ uses the whole period from zero, not the specified 10–30 s interval.

3.5 (a) Tangent gradient = $(65 - 25)/(50 - 10) = 1.0 \text{ cm}^3/\text{s}$. Mean from zero = $45/30 = 1.5 \text{ cm}^3/\text{s}$; mean over an interval need not equal the rate at its end. (b) Amount used = $0.018 - 0.006 = 0.012 \text{ mol}$; divide by $40 \text{ s} = 0.00030 \text{ mol/s}$. The positive consumption amount is required; a chord is not a tangent.

3.6 Original guidance, any six method points: matched cleaned magnesium mass/length; fixed acid volume and starting temperature; two provided acid concentrations with an

unobstructed collection path into a gas syringe or inverted water-filled measuring cylinder; fit bung/start timer consistently and promptly; record gas volumes at fixed intervals until constant; repeat and plot comparable volume–time curves, comparing initial slopes. Eye protection, clamping and no ignition sources near hydrogen; never seal without an outlet. Lower recorded final volume can result from a leak, delayed bung, unequal limiting magnesium or insufficient acid, so it alone cannot establish slower chemistry. Actual supervised practical remains separate.

3.7 (a) Pre-acid concentration = $40 \times 30/50 = 24 \text{ g/dm}^3$. This is not the final 60 cm^3 mixture concentration. (b) Mean = $(48 + 50 + 52)/3 = 50 \text{ s}$; proxy = $1/50 = 0.020$ per second; second = $1/25 = 0.040$ per second, twice the proxy at the same visual threshold. (c) The cross disappears at a chosen cloudiness threshold while reaction may continue. Sulfur dioxide can aggravate breathing difficulties; use approved ventilation/teacher controls and do not inhale fumes. Repeats cannot fix a systematic viewing-depth difference.

3.8 Compression increases particles per volume and collision frequency; temperature and average kinetic energy are unchanged. Original cube area = $6 \times 2^2 = 24 \text{ cm}^2$ and volume = $2^3 = 8 \text{ cm}^3$, ratio 3 per cm^3 . Eight small cubes have total area $8 \times 6 = 48 \text{ cm}^2$ and the same volume 8 cm^3 , ratio 6 per cm^3 . More exposed solid surface permits more frequent reactant–surface collisions, increasing rate under matched conditions. Total mass is unchanged; no exact universal factor-of-two rate law follows from the geometry alone.

3.9 X increases the rate and is not used up overall, consistent with catalytic action; absence from the overall equation supports the identification together with those observations. The alternative pathway has lower activation energy, with unchanged reactant/product levels and overall energy change. Different reactions need suitable catalysts: this experiment alone cannot establish action in another reaction. The equal final gas volumes show faster production, not extra product from the same limiting amount. Mass alone would not prove chemical identity unchanged.