

16.1 Rates, catalysts and reliable endpoints

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS rate • activation energy

Objective

Rates, catalysts and reliable endpoints. Supported SL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

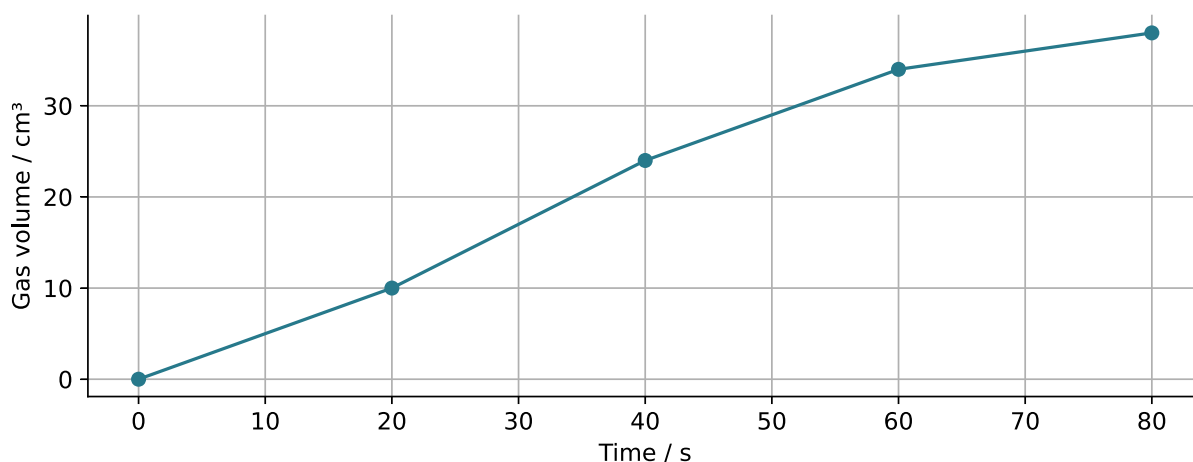
1 Key knowledge and worked examples

■ What would explain this observation?

- A faster reaction finishes sooner, but it need not make more product. **Rate** and final yield answer different questions.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- Reaction rate describes reactant used or product formed per time. Higher temperature increases the fraction of collisions with enough energy. A catalyst provides an alternative pathway with lower **activation energy**.
- activation energy: The energy barrier for a reaction pathway; rate: Change in a measured quantity per unit time.



■ Choose evidence that can test it

- A product-time graph has a steeper gradient where rate is larger. A tangent estimates instantaneous rate; a secant gives average rate over an interval. The final plateau reflects the total collected product under the stated conditions.
- For gas production, check apparatus for leaks, start timing consistently and record volume at regular intervals. Keep concentration, reactant amount and surface area controlled when changing temperature.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: gas volume increases from 10 to 34 cubic centimetres between 20 and 60 s. Average rate = change in volume/change in time. Rate = $(34 - 10)/(60 - 20) = 0.60$ cubic centimetres per second. This is not necessarily the instantaneous rate at 40 s.

Example:

A reaction makes 24 cubic centimetres of gas in 40 s. Find average rate. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ Check the conclusion and its limits

- A catalyst does not change the equilibrium constant at a fixed temperature. A mass-loss method cannot detect all reactions, and losing gas through a leak biases a collection experiment.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A faster reaction always produces a larger final amount of product. This claim is false: A catalyst does not change the equilibrium constant at a fixed temperature. A mass-loss method cannot detect all reactions, and losing gas through a leak biases a collection experiment.

Key:

Rates, catalysts and reliable endpoints: A product-time graph has a steeper gradient where rate is larger. A tangent estimates instantaneous rate; a secant gives average rate over an interval. The final plateau reflects the total collected product under the stated conditions.

2 Practice

2.1 Two reactions reach the same final gas volume. Which can still differ? Choose one answer.

- **A** Their rates
- **B** The balanced equation must be different
- **C** The product must have different molar mass

[1]

2.2 A reaction makes 24 cubic centimetres of gas in 40 s. Find average rate. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: A faster reaction always produces a larger final amount of product.

[2]

2.4 The energy barrier for a reaction pathway: write the technical term.

[1]

3 Exam-style questions

3.1 Fictional gas volumes at 0, 20, 40 s are 0, 18, 24 cm³. Compare interval rates. Can the 0–40 s average be called the instantaneous rate at 20 s? [4]

Solutions

2.1 A A product-time graph has a steeper gradient where rate is larger. A tangent estimates instantaneous rate; a secant gives average rate over an interval. The final plateau reflects the total collected product under the stated conditions.

2.2 average rate=volume/time= $24/40=0.60\text{ cm}^3/\text{s}$.

2.3 False. A catalyst does not change the equilibrium constant at a fixed temperature. A mass-loss method cannot detect all reactions, and losing gas through a leak biases a collection experiment.

2.4 activation energy. activation energy means The energy barrier for a reaction pathway.

3.1 0.90 then $0.30\text{ cm}^3/\text{s}$; overall 0.60. A secant does not in general give the tangent at 20s. More closely spaced data are needed for the instantaneous estimate.