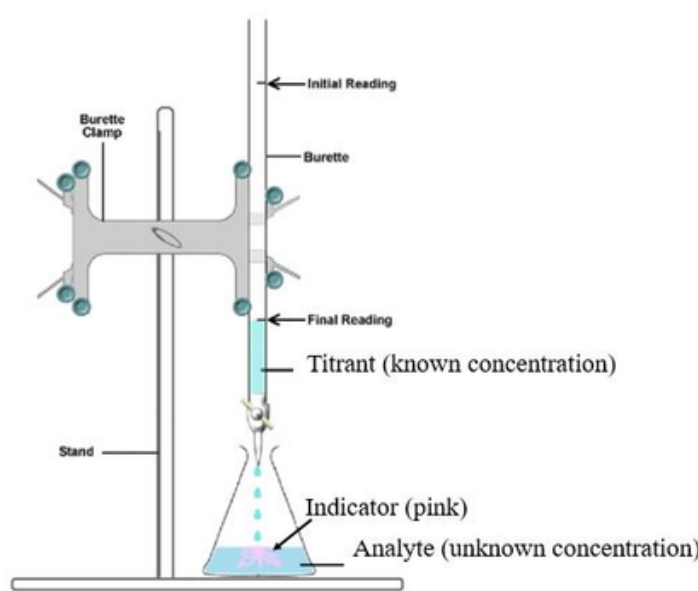


ABSTRACT



This investigation examines the effect of temperature on the outcome of a back titration used to determine the percentage composition of calcium carbonate in Gallus gallus domesticus eggshells. While collision theory predicts that increasing temperature enhances reaction rates through more frequent and energetic particle collisions, this study evaluates whether such changes meaningfully influence titration results.

A back titration method was employed in which powdered eggshell samples were reacted with excess hydrochloric acid at three controlled temperatures (14°C, 22°C, and 35°C). The remaining acid was subsequently titrated with standardized sodium hydroxide solution. The volume of titrant required to reach the endpoint was recorded and used to calculate the amount of calcium carbonate present.

Results demonstrated minimal variation in titrant volume across temperature conditions, with a weak positive trend and a negligible coefficient of determination ($R^2 \approx 0.005$). These findings indicate no significant correlation between temperature and titrant volume, suggesting that temperature does not meaningfully affect the measured outcome in this system.

The hypothesis, based on collision theory, was therefore not supported. However, this does not invalidate the theory; rather, it highlights a conceptual limitation, as back titration measures the extent of reaction rather than the reaction rate. Significant experimental errors, including inconsistent endpoint detection and incomplete sample preparation, contributed to a high percent error (97%).

Overall, this study underscores the importance of aligning experimental design with theoretical frameworks when investigating kinetic effects.

INTRODUCTION

Why Eggshells?

- Eggshells are composed primarily of calcium carbonate (CaCO_3)
- Determining calcium carbonate content also has applications in agriculture, environmental chemistry, food science, and pharmaceuticals.

Why Back Titration?

- Can then be used to calculate the amount of CaCO_3 that reacted.

Collision Theory

↑ Temperature → ↑ Kinetic Energy → ↑ Successful Collisions → ↑ Reaction Rate

This investigation asked whether that temperature-dependent change in reaction kinetics would affect the measured outcome of a back titration.

Research Question

How does temperature affect the accuracy of back titration when determining the calcium carbonate content of eggshells?

Hypothesis

Increasing the temperature of the hydrochloric acid was expected to increase reaction kinetics and potentially alter the volume of NaOH required to reach the endpoint.

METHODS

Experimental Design

- Independent variable:** Temperature (14°C, 22°C, 35°C)
- Dependent variable:** NaOH volume required for endpoint
- Trials: 3 per temperature

Procedure

- Prepared: 2.250 g powdered eggshell.
- Reacted: Added 1.0 M HCl; allowed reaction for ~96 h.
- Temperature: Samples tested at 14°C, 22°C, and 35°C.
- Titrated: 12.5 mL sample with 0.1 M NaOH using phenolphthalein.
- Analyzed: Compared NaOH volume across temperatures.

Reaction:



THE EFFECT OF TEMPERATURE ON BACK-TITRATION ACCURACY

Investigating Calcium Carbonate Content in Eggshells Through Collision Theory

Souad Dennis

RESULTS

- 14°C: 0.37 mL NaOH
- 22°C: 0.93 mL NaOH*
- 35°C: 0.53 mL NaOH
- $R^2 = 0.005$
- CaCO_3 measured: 2.57%
- Percent error: 97%

*Room-temperature result influenced by an outlier.

DISCUSSION

- Temperature showed minimal effect on titrant volume.
- The ~96-hour reaction period likely allowed the reaction to approach completion at all temperatures.
- Thus, temperature may have affected reaction rate without changing reaction extent.
- Major error sources: endpoint detection, eggshell particle size, temperature control, and small titrant volumes.

CONCLUSION:

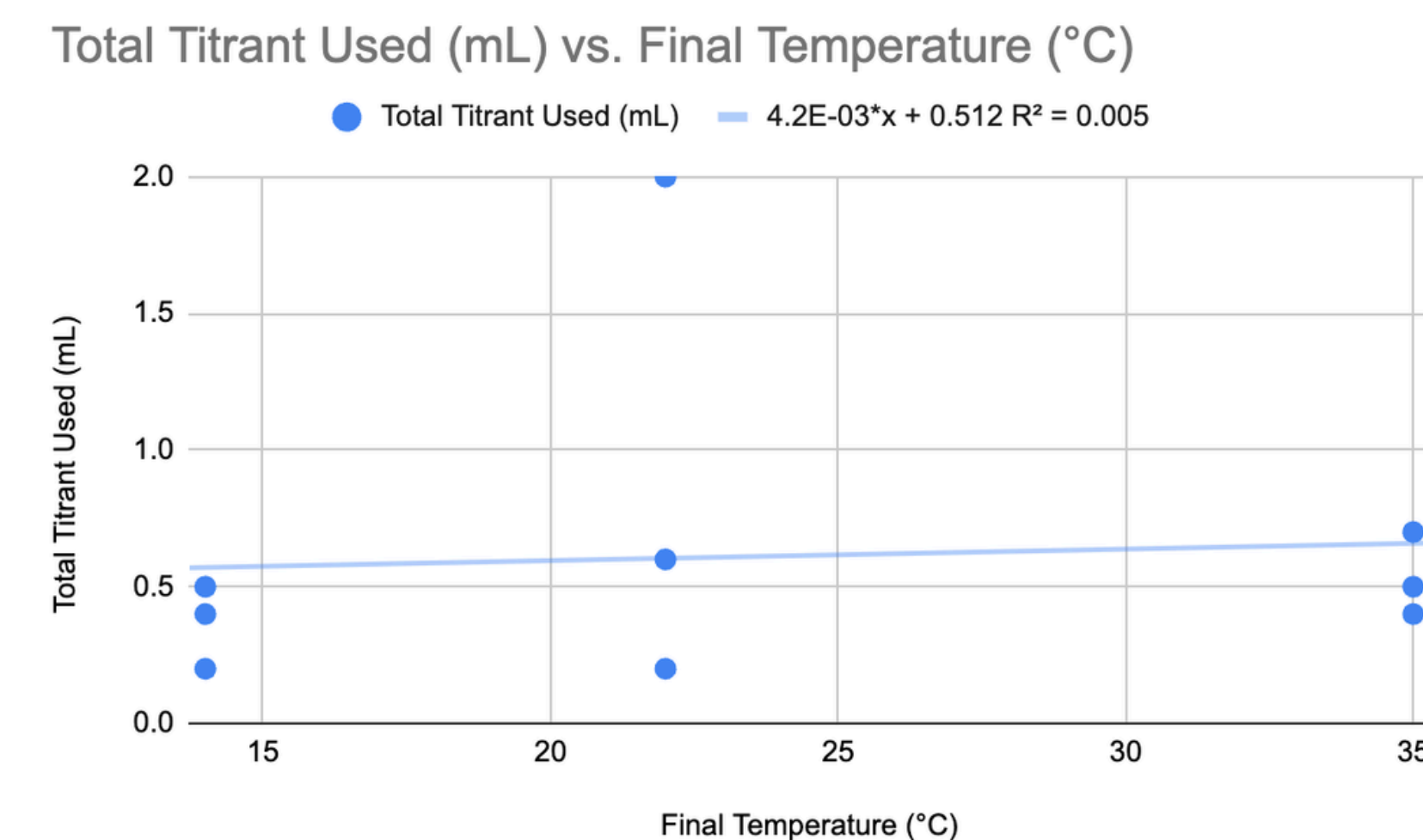
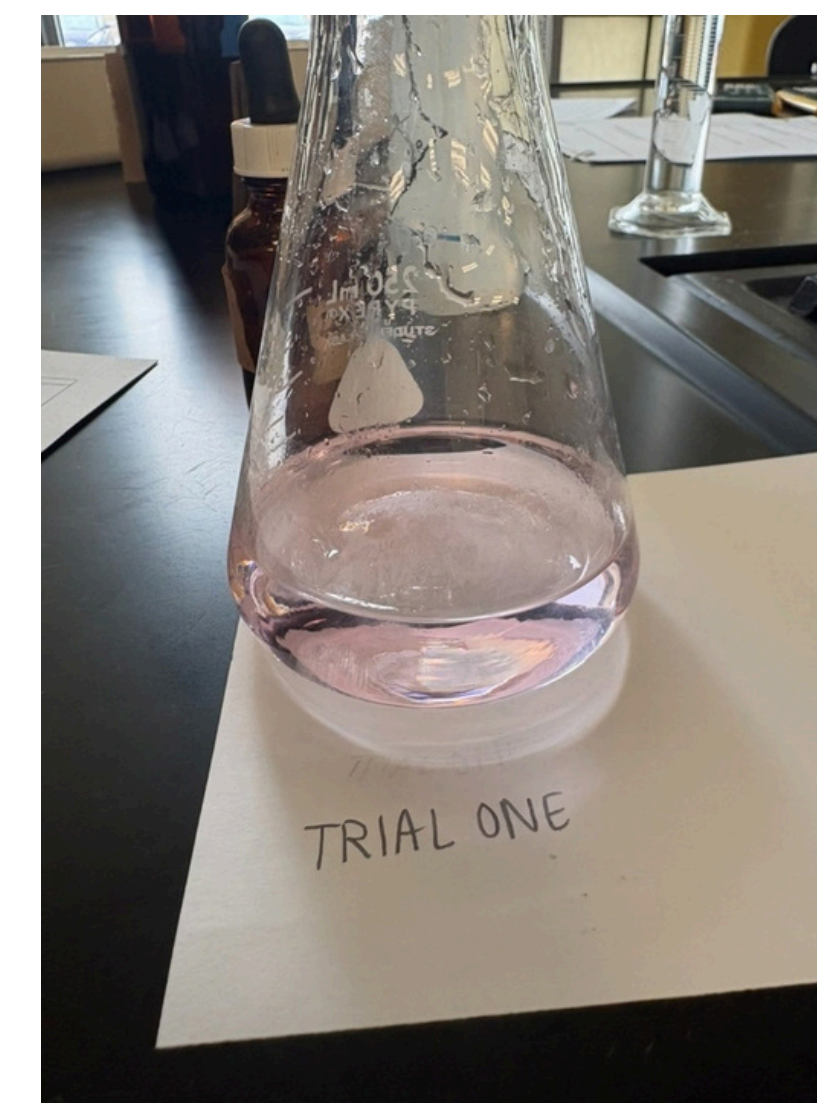
- The hypothesis was not supported. Temperature had essentially no measurable effect on back-titration results ($R^2 = 0.005$), highlighting the difference between measuring reaction rate and reaction extent.

FUTURE RESEARCH

- Measure reaction rate directly
- Test a wider temperature range (5–45°C)
- Increase the number of trials
- Standardize eggshell particle size
- Use a pH probe for endpoint detection

BIGGEST TAKEAWAY

- Temperature had essentially no measurable effect on titrant volume ($R^2 = 0.005$).
- The experiment measured reaction extent rather than reaction rate.



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