Welcome!

Flinn Scientific

Guided-Inquiry Labs for AP* Chemistry

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Six Big Ideas – More Great Labs!

• Integrate scientific inquiry and reasoning through a series of student-directed, inquiry-based laboratory investigations.

• Model the inquiry process and demonstrate activities from new guided inquiry labs for AP Chemistry.

• Share proven strategies for improving students’ ability to design controlled experiments and develop reasoning skills to analyze the evidence.
Today’s Workshop

• Transitioning a “classic” lab to inquiry
  ▪ Molar Volume of a Gas

• New advanced inquiry labs from Flinn Scientific
  ▪ Designing a Hand Warmer
  ▪ Rate of Decomposition of Calcium Carbonate

• Alignment with AP Chemistry Curriculum Framework

• Critical Thinking and Inductive Reasoning
The Nature of Science – A Vision for Inquiry in AP Chemistry

- Students “construct” or discover knowledge with an understanding of how scientists study the natural world.

- Inquiry learning extends beyond experiments to develop science practice and process skills in addition to science content.
Levels of Scientific Inquiry

• Confirmation – verify a principle through activities with known results
• Structured inquiry – investigate a teacher-presented question following a prescribed procedure
• Guided inquiry – research and design a procedure to investigate a teacher-presented question
• Open inquiry – investigate topic-related questions formulated through student-designed or selected procedures
AP Chemistry Lab Investigations

• A continuum!
• The goal is for students to become proficient exploring concepts and applying reasoning skills via **guided-inquiry** laboratory investigations.

• Role of structured inquiry
  – Review prerequisite knowledge
  – Introduce techniques
  – Develop laboratory skill proficiency
Science Practice and Process Skills – Promote Inquiry

The world is full of obvious things, which nobody by any chance ever observes. – Sherlock Holmes

• Reviewing known facts, models and theories
• Observations based on experience, demonstrations, and interactive or preliminary experiments
• Making predictions
• Planning the investigation
Science Practice and Process Skills – Support Inquiry

There’s more to a good experiment than samples, specimens, chemicals, and test tubes!

- Introductory or baseline activities
- Variables and controls
- Gather and analyze data
- Construct explanations
- Create, critique and revise models
- Scientific arguments and communication

Reasoning based on the evidence!
Molar Volume of a Gas

• Classic lab
  – Generate H₂ by reacting known mass of Mg with excess HCl in inverted gas-measuring tube filled with water
  – Measure V, T, and P

• Calculations
  – Dalton’s law \( (P_{H2} + P_{H2O}) \)
  – Combined gas law (correct V to STP)
  – Stoichiometry (number of moles of H₂)
Transitioning the Lab to Inquiry

• Asking the question
  – How much gas is needed to fill a container (air bag, hot air balloon, lungs, etc.)

• Promote inquiry
  • Review prior knowledge (the gas laws)

• Science practice skills
  – Mathematical reasoning and data analysis
Opportunities for Inquiry

• Take away the data tables and post-lab questions!

• Start with a demonstration!
  – Given the setup, design controlled experiment
  – Inquiry guidance: what data is needed to calculate molar volume; identify independent and dependent variables, other factors that will affect results

• Make it a challenge!
  – Generate specific $V$ of gas at experimental $T$, $P$
Challenge or Target Labs

• Approach may be used with ALL quantitative labs! Increase student engagement and their ownership of the procedure and the results.

• Set “target,” work backwards, applying the principles to calculate \( n \), moles of Mg needed
  – Target: 45 mL of gas in the tube
  – Barometric \( P = 740 \text{ mm Hg} \), \( T = 22 ^\circ \text{C} \)
  – Dalton’s law \( P_T = P_{\text{H}_2} + P_{\text{H}_2\text{O}} \)
  – Vapor pressure of water (look up) = 19.8 mm Hg at 22 ^\circ\text{C}
  – Calculate \( n \) using ideal gas law for partial pressure of \( \text{H}_2 \)
Opportunities for Inquiry – Error Analysis

• Promote reasoning and problem-solving skills.
• What if a bubble of air leaked into gas measuring tube as it was inverted?
  – Would calc’d molar volume be high or low?
• What if Mg had been black and dull rather than silver and shiny?
  – Would calc’d molar volume be high or low?
Design a Hand Warmer – Applying the Science Practices to Connect Lab Experiences to the Real World

• **New Advanced Inquiry Lab!**
• Big Idea 5 (Thermodynamics), Investigation 12
• Investigate and measure energy changes accompanying formation of solutions from common laboratory salts using calorimetry.

**Learning Objectives**
- Models of solution formation, interactions between solvent and solute particles
- Energy changes, system versus surroundings
- Calorimetry
Format for Advanced Inquiry Labs

• Introduction and Background
  * Experiment Overview

• Pre-Lab Questions – principles and calculations, e.g., calorimeter constant, heat of solution (J/g and kJ/mole)

• Introductory Activity – introduce lab technique, develop skills, “rough” exp’t to select range, etc.

• Guided Inquiry Design and Procedure – inquiry guidance provided by leading questions

• AP Chemistry Review Questions – integrate inquiry, content, and reasoning
Designing a Hand Warmer – Inquiry Guidance and Challenge

• What data is needed to calculate $\Delta H_{\text{soln}}$?
  – Independent and dependent variables
  – Controlled variables
  – Accuracy and precision in measurements

• Determine heat of soln for six solids

• Design a hand warmer
  – 10 g of solid, 40 mL of water, must increase temp by at least 20 °C
  – Choose most cost-effective, and least hazardous
### Design a Hand Warmer – Data and Results

<table>
<thead>
<tr>
<th>Solid</th>
<th>Cost ($/kg)</th>
<th>ΔT (experimental) 5 g/45 mL</th>
<th>ΔT (extrapolated) 10 g/40 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride</td>
<td>0.0079</td>
<td>−1.4°C</td>
<td>N/A</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>0.0131</td>
<td>14.4°C</td>
<td>31.9°C</td>
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<tr>
<td>Sodium Acetate</td>
<td>0.0258</td>
<td>4.7°C</td>
<td>10.3°C</td>
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<tr>
<td>Lithium Chloride</td>
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<td>19.2°C</td>
<td>43.2°C</td>
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<tr>
<td>Ammonium Nitrate</td>
<td>0.0181</td>
<td>−8.0°C</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Rate of Decomposition of Calcium Carbonate – Advanced Inquiry Lab

• Big Idea 4 (Kinetics), Investigation 10
• Investigate effect of acid concentration on rate of reaction of CaCO₃ with HCl
• Two parallel techniques
  – Mass loss due to production of CO₂
  – Volume of gas collected
Decomposition of Calcium Carbonate
Generation of $\text{CO}_2$ Gas
16 New Advanced Inquiry Lab Kits Available from Flinn Scientific!

Pre-order now!

Flinn Catalog No. AP7655

Meets AP Chemistry Curriculum Guidelines

Optimized for guaranteed success!