CULMINATING ASSESSMENT

How Do Fireworks Get Their Colors?

SCIENCE

Developing and Using Models, Analyzing and Interpreting Data, and Engaging in Argument From Evidence

ENGLISH LANGUAGE ARTS

Reading Informational Text, Writing an Explanation

GRADE 8

90-120 minutes

PURPOSE

Throughout the unit students have learned about matter, chemical reactions, and energy. The culminating assessment is designed to provide students with the opportunity to synthesize their learning of these concepts to explain how fireworks produce the variety of colors seen today. The culminating assessment is comprised of two parts: a laboratory experiment and an argumentation writing task. In Part I, students work with a partner or group to conduct an investigation that helps them understand the amount of energy required to produce the variety of colors observed during fireworks displays. In Part II, students independently use the Claim-Evidence-Reasoning format to construct an argument in response to the question, "How do fireworks get their colors? Explain the chemical reactions that occur when a firework is ignited using what you have learned in this unit."

STANDARDS

- **Common Core State Standards**
  - Cite specific textual evidence to support analysis of science and technical texts. CCSS.ELA-LITERACY.RST.6-8.1
  - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. CCSS.ELA-LITERACY.RST.6-8.3
  - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table. CCSS.ELA-LITERACY.RST.6-8.7

STANDARDS CONTINUED

Common Core State Standards

- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. CCSS.ELA-LITERACY.RST.6-8.9
- Write arguments focused on discipline-specific content. CCSS.ELA-LITERACY.WHST.6-8.1
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-LITERACY.WHST.6-8.2.B
- Use precise language and domain-specific vocabulary to inform about or explain the topic. CCSS.ELA-LITERACY.WHST.6-8.2.D

Next Generation Science Standards

- Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS-1-1
- Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS-1-2
- Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. MS-PS-1-5
- Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. MS-PS-4-1

Science and Engineering Practices

- Developing and using models
- Analyzing and interpreting data
- Engaging in argument from evidence

LEARNING GOALS

- Understand that the visible colors in fireworks are produced as a result of chemical reactions.
- Understand that wavelength, frequency, and amplitude can be measured and used to identify elements.

SUCCESS CRITERIA

1. Use data to drive inquiry and investigation.
2. Apply conceptual understandings of pure substances and chemical reactions to identify unknown elements.
3. Analyze and interpret data.
4. Construct a written argument explaining the process of color production in fireworks.
5. Use evidence to support claims.

ASSESSMENT TASK

This is a two-part assessment. In part I, you work with a group to conduct an investigation to collect data that helps you understand the amount of energy required to produce the variety of colors observed during fireworks displays. In part II of the assessment, you will use what you have learned in the unit and in the investigation to construct an argument that supports your answer to the question, "What is the relationship between the amount of energy released and the variety of colors observed in fireworks displays?"

PART I: INTRODUCTION

INTRODUCE THE TWO-PART CULMINATING ASSESSMENT TASK Explain that today students will begin the culminating assessment for the unit. Give students an overview of the assessment task and explain that the assessment will consist of two parts: an investigation and an argumentation writing task.

PART II: GUIDED PRACTICE

READ AND ANNOTATE Provide students with a copy of Fireworks! by Kathy De Antonis (https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/articlesbytopic/oxidationandreduction/chemmatters-oct2010-fireworks.pdf). Give students time to read the text and annotate.

READ PRE-INVESTIGATION HANDOUT Give students a copy of the Flame Test Pre-Lab handout (abbreviated version of Kate Dickinson's, UCSB, original activity at http://www.mrl.ucsb.edu/education/ret-research-experience-teachers/kate-dickinson). Each student completes the handout independently.

READ AND CONDUCT INVESTIGATION Give students the investigation handouts. Students should read and annotate the texts prior to completing the investigation. (Original handouts: http://www.nsta.org/publications/news/story.aspx?id=50902 and Kate Dickinson, UCSB). Give students the investigation handouts. Students should read and annotate the texts prior to completing the investigation.

PART III: CULMINATING TASK

WRITE AN ARGUMENT When students have completed their investigation and identified the substances based on wavelength, they write an argument in response to the question, "How do fireworks get their colors?" Students use the data from the assessment investigation and what they have learned throughout the unit about atoms, molecules, and chemical reactions to explain the process that occurs when a firework is ignited. Argumentation task includes:

- a clear claim that answers the question
- evidence that includes data and graphs from the Flame Test investigation
- reasoning that includes reference to information in the readings or notes supporting the claim
- an illustrated model with clearly labeled components that help to explain the relationship between the amount of energy released in a chemical reaction and the colors observed in fireworks
- appropriate use of content vocabulary
- appropriate and relevant references to texts and sources

ARGUMENTATION WRITING TASK RUBRIC

	4 Exemplary	3 Proficient	2 Needs Improvement	1 Critical Area
CLAIM	• Accurately states that the colors of fireworks are the result of the amount of energy required for specific elements' electrons to reach high-energy level • Uses domain-specific language to respond to the question	• Accurately states that the colors of fireworks are the result of the amount of energy required for specific elements' electrons to reach high-energy level • Uses language that generally responds to the question	• Answers the question but uses imprecise language that corresponds to the question • Inaccurately or incompletely answers the question	• Does not make a claim, or makes completely inaccurate claims

EVIDENCE	• Provides specific, appropriate, and ample data or observations that support the claim related to:
	  • light spectrum
	  • wavelength
	  • energy
	• Uses detailed and well-chosen text references to fully support argument
		• Provides specific, appropriate, and sufficient data or observations that support the claim
		• May include some inappropriate evidence
		• Addresses major points from Exemplary
		• Uses accurate and detailed references to text to solidly support argument
			• Provides appropriate, but insufficient or unclear data or observations to support claim
			• May include some inappropriate evidence
			• Minimally addresses major points from Exemplary
			• Uses few accurate or detailed references to support argument
				• Does not provide data or observations, or only provides inappropriate evidence (evidence that does not support the claim)
				• Uses little or no accurate and detailed references to text to support argument

	• Correctly and clearly connects the evidence to the claim, showing how it supports explanation of the relationship between amounts of energy released and light emitted which corresponds to the spectrum • Discusses in depth the concepts of energy, visible light spectrum, and atomic structure • Applies concepts that go beyond the prompt, as appropriate	• Correctly and adequately connects the evidence to the claim, showing how it supports explanation of the relationship between amounts of energy released and light emitted which corresponds to the spectrum • Discusses the concept of energy, the visible light spectrum, and atomic structure	• Correctly connects the evidence to the claim, but leaves out important details, and/or • Restates the evidence without connecting it to the claim • Partially discusses the concepts of energy, light, and atomic structure	• Does not provide reasoning, or only provides reasoning that does not connect evidence to the claim, and/or • Provides an incomplete generalization or does not apply appropriate scientific concepts.

WRITING	• Maintains an organizational structure that intentionally and effectively enhances the presentation of information as required by the prompt • Maintains clear and logical focus on claim throughout the response • Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the audience, purpose, and specific requirements of the prompt • Consistently cites sources using an appropriate format	• Maintains an appropriate organizational structure to address the specific requirements of the prompt • Maintains clear focus on claim throughout the response • Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the audience, purpose, and specific requirements of the prompt • Cites sources using an appropriate format with only minor errors	• Uses an appropriate organizational structure to address the specific requirements of the prompt, with some lapses in coherence or awkward use of the organizational structure • Maintains a general or inconsistent focus on the purpose or the claim throughout the response • Demonstrates an uneven or inconsistent command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven consideration to audience, purpose, and specific requirements of the prompt • Inconsistently cites sources	• Attempts to organize ideas, but lacks control of structure • Lacks a clear purpose • Attempts to demonstrate command of standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics • Sources are used without citation

CULMINATING ASSESSMENT TASK

TEACHER VERSION

PRE-LAB ACTIVITY

VOCABULARY AND KEY CONCEPTS

Explain these big ideas in complete sentences.

1 What do wavelength and frequency measure?

Wavelength measures the distance between two peaks in a wave while frequency measures the number of times a wave repeats itself per unit time.

2 How can you find the energy of a wave?

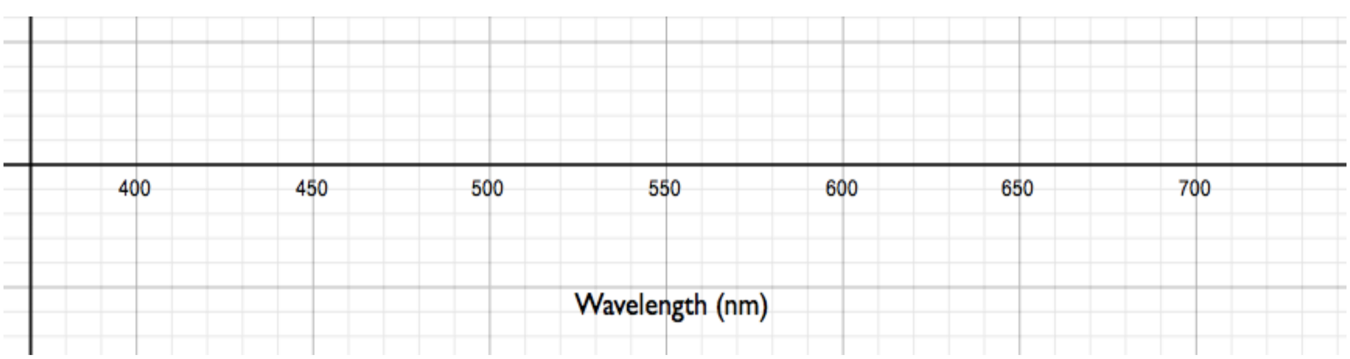
Once wave frequency has been calculated, wave energy can then be determined using the wave energy formula, $E = h\nu$, where E is energy, h is Planck's constant and ν is frequency.

3 What is a flame test? What does the Law of Conservation of Energy have to do with this type of experiment?

A flame test uses the concept of electron excitation to identify an element. By adding energy to a sample and observing the specific wavelength light that is produced, frequency and energy can be calculated. While the flame test relies on electron excitation to produce light, the light emitted is a direct result of the Law of Conservation of Energy which states that energy can not be created nor destroyed but can change forms. This applies to the flame test because as heat energy goes into the unknown solution, it is converted into light energy, which is the observable measurement.

ELECTROMAGNETIC SPECTRUM

Use color pencils or markers to shade and label the complete visible spectrum.



SOURCE Abbreviated from Kate Dickinson (UCSB) and FOCUS! (UCI)

FLAME TEST BASICS

Complete the table below predicting what will happen to a Li atom Before, During and After steps of a flame test.

	Before Flame Test Ground State Li Atom	During Flame Test Excited Li Atom	After Flame Test Ground State Li Atom
What happens to the electrons in the atom?	Electrons occupy the lowest possible energy level	Electrons absorb energy and become excited to the next energy level	Excited electrons return to ground state; energy is released in the form of light

SOURCE Abbreviated from [Kate Dickinson (UCSB)](http://www.mrl.ucsb.edu/education/ret-research-experience-teachers/kate-dickinson), available at http://www.mrl.ucsb.edu/education/ret-research-experience-teachers/kate-dickinson., and FOCUS! (UCI)

LAB INVESTIGATION

INTRODUCTION

You will conduct a flame test of 4 unknown solution samples. You will observe the flame color and use known value references to measure wavelengths and calculate frequency. You will also graph the wavelengths and energy calculations for each sample. Finally, you will use your data and graph to identify the unknown samples.

MATERIALS

- 250 mL beaker
- Laboratory burner
- Colored drawing pencils
- Chemical splash goggles, aprons, and gloves
- Wooden splints, soaking separately in unknown solutions

METHODS

Safety note: Wear approved chemical splash goggles and chemical-resistant gloves and apron. The metal salts used allow the burned splints to be safely disposed of in the trash, but the teacher, to avoid any possibility of a trashcan fire, should do this.

1. Don gloves, aprons, and chemical splash goggles. Fill a 250 mL beaker with tap water and place it at your workstation. This will be used to extinguish wooden splints.
2. Obtain a wooden splint from one of the solutions.
3. Carefully light laboratory burner and slowly pass the wooden splint back and forth through the flame. After carefully observing the flame, immerse the wooden splint in the tap water, and make sure it is fully extinguished. At the end of the experiment, return all extinguished splints to the teacher for proper disposal.
4. Record observations.
5. Repeat steps 1–4 with another solution, until you have tested four solutions.
6. Once the laboratory work is complete, wash hands with soap or detergent.
7. Perform calculations and answer all questions.

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

OBSERVATIONS AND DATA

Use the following table to help you organize your data observations.

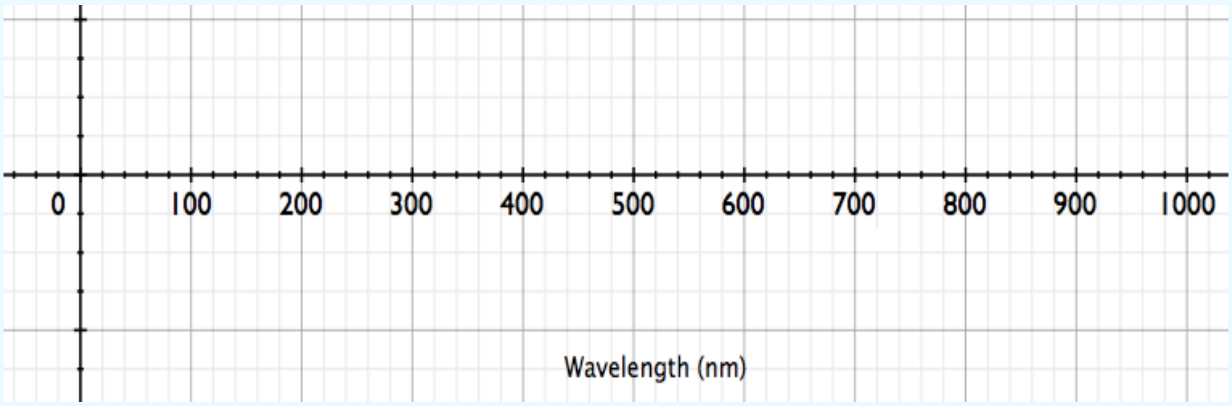
Flame Test Solution #	Color Description	Estimated Wavelength (nm)
1		
2		
3		
4		

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

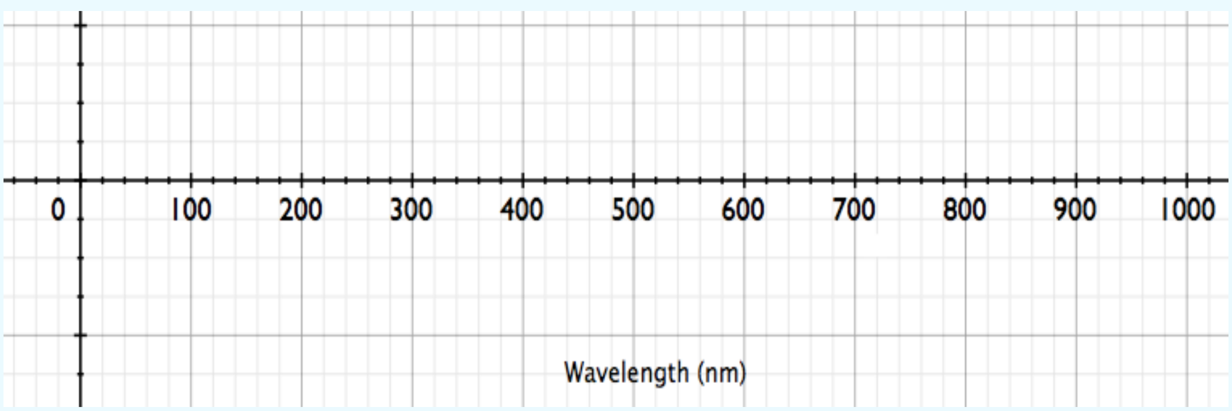
WAVELENGTH COMPARISON

Draw each observed wavelength below.

Flame Test Solution #	Color	Estimated Wavelength (nm)[1]
		λ =

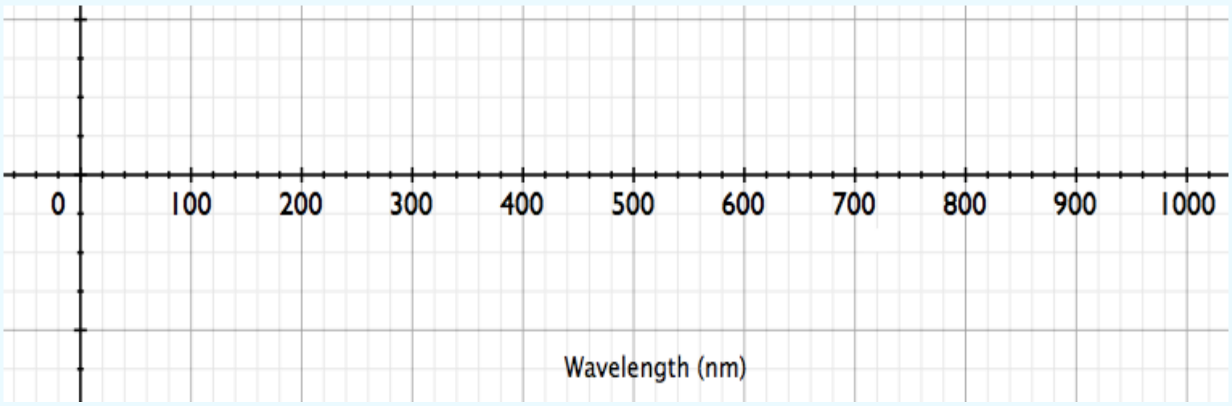


Flame Test Solution #	Color	Estimated Wavelength (nm)
		λ =

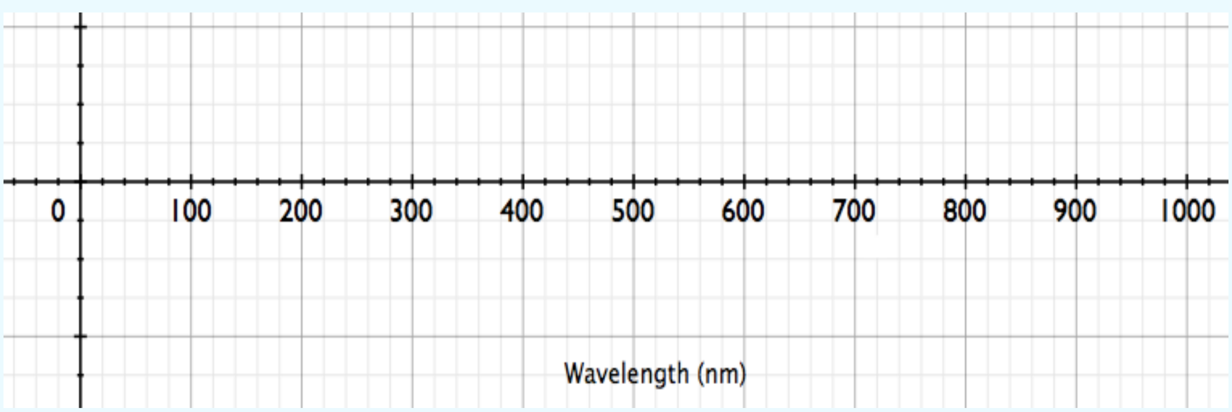


[1] Emphasize the importance of detail since students' final element identification depends on this step.
Li = 660 nm Sr = 630 nm Na = 590 nm B = 525 nm Cu = 475 nm K = 430 nm

Flame Test Solution #	Color	Estimated Wavelength (nm)
		λ =



Flame Test Solution #	Color	Estimated Wavelength (nm)
		λ =



SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

CALCULATIONS

Use your estimated wavelength data to solve for frequency and energy of each sample.

FREQUENCY EQUATION	WAVE ENERGY EQUATION
$\nu = \frac{c}{\lambda}$	$E = \nu h$

Flame Test Solution # ________	Wavelength (nm) λ = ______________
Frequency Calculation	Wave Energy Calculation

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Flame Test Solution # ________	**Wavelength (nm) λ = ______________**
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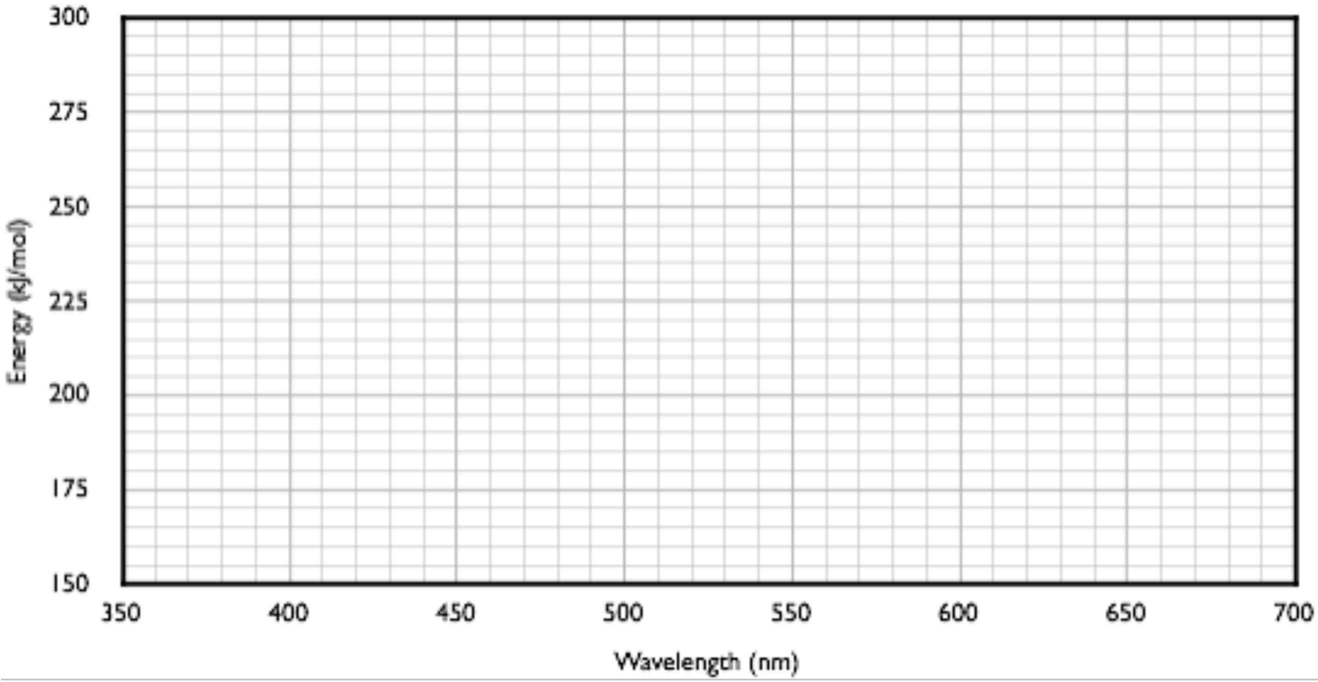
GRAPH ANALYSIS

Graph Wavelength (nm) vs. Energy (kJ/mol)



1 What do you notice about the graph?
The wavelength versus energy graph shows a decreasing linear relationship. This means that the shorter the wavelength, the higher the energy released when the element is heated. Elements with longer wavelengths release lower amounts of energy.

2 What does this say about the electromagnetic spectrum? What end of the spectrum has high energy? Which end has low energy?
Waves that have longer wavelengths have lower energies and waves with shorter wavelengths have higher energies.

3 If the wavelength is longer, then the amount of energy released is ________________?

4 If the wavelength is longer, then the amount of energy released is higher. **T or F**

5 Explain your reasoning for number 4.

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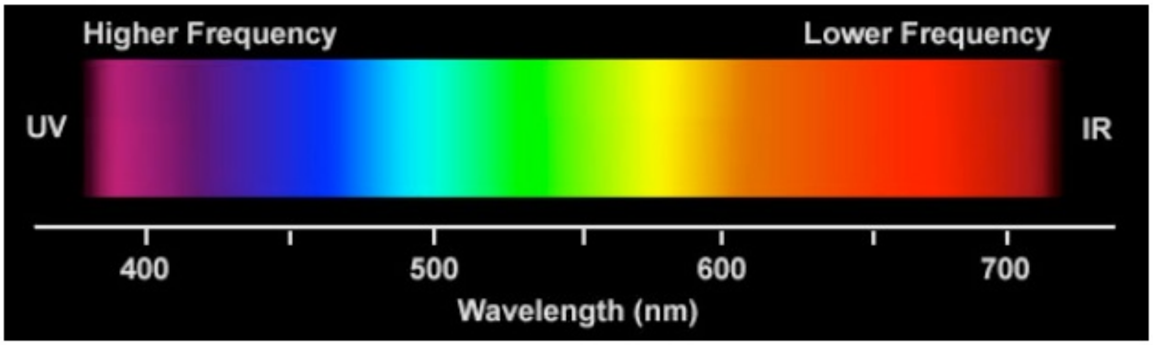
ELEMENT IDENTIFICATION

Determine the unknown element in each sample by comparing your calculated energies to the known energy values given on the Visible Light Spectrum Card.

Flame Test Solution	Calculated Energy Values (kJ/mol)	Known Energy Values (kJ/mol)	Element Responsible

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

Visible Light Spectrum



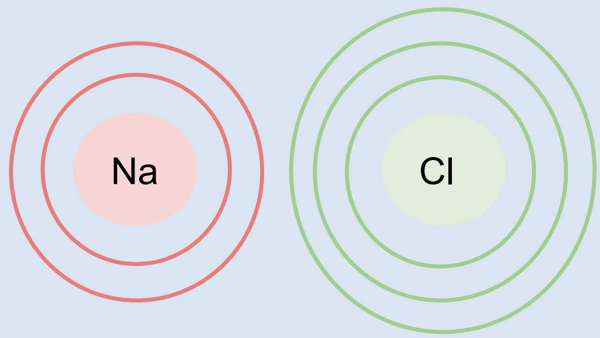
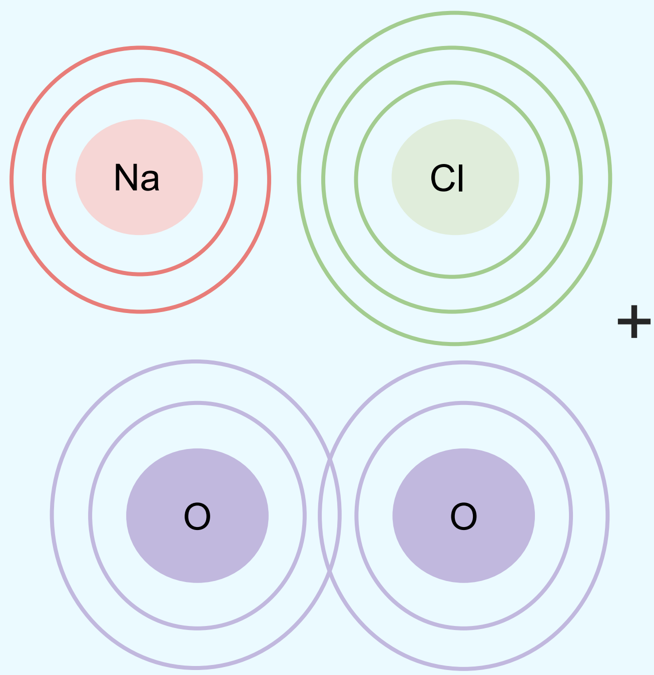
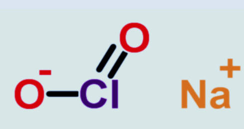
Energies by Element

Photon Energy (kJ/mol)	Element
181.2	Lithium
228.6	Boron
203.4	Sodium
279.1	Potassium
252.6	Copper
190.5	Strontium

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

ANALYSIS

1 In the space below, develop a model that describes what happens to a sodium chloride (NaCl) before, during, and after a flame test experiment like the one you have just performed.

NaCl: before flame test	 NaCl
NaCl: during flame test	 **NaCl + O_2**
NaCl: after flame test	

2 Use the model you developed to explain conservation of matter in this example.

Matter is conserved because atoms are conserved in physical and chemical processes. The transfer of energy (electrons) can be tracked. In this case, the energy transfer occurs in emittance of light.

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ARGUMENTATION TASK

EXAMPLE STUDENT RESPONSE

How do fireworks get their colors? Explain the chemical reactions that occur when a firework is ignited using what you know about the conservation of matter and energy.

Some people may think that it is a simple process to add colors to fireworks, maybe like adding food coloring to frosting on a cake, but it's much more complicated than that. The color that we see whenever a firework explodes is actually energy being released in the form of light during a chemical reaction. As we have learned, every element is unique (reference to text). It makes sense that because each element is unique, then it gives off a different color. In the Flame Tests Lab Experiment, I was able to identify unknown elements because each element produced a different color when it burned. Chemically speaking, light is produced when the atoms in an element are heated. Because we know that atoms of the same element share characteristics (cite reference from lessons), we know that the colors each element emits exists along the Visible Light Spectrum. But, how does this happen?

In "Fireworks!", the author states that when heat is added to a particular element, the electrons become excited. When the electrons in these elements have become very excited, they eventually reach their highest state and explode. This explosion is energy, in the form of light, that is given off when electrons begin to move to a lower energy level. The different colors that we see are related to the amount of energy needed to reach that highest excited electron state. The graph shows that there is a linear relationship between wavelength and energy specific to each element. For example, in the Flame Tests Lab Experiment I found that elements like Lithium and Sodium had longer wavelengths but lower energies. These elements give off a reddish light. The elements with shorter wavelengths, but higher energies, were elements like copper and sodium.

CULMINATING ASSESSMENT TASK

STUDENT VERSION

PRE-LAB ACTIVITY

VOCABULARY AND KEY CONCEPTS

Explain these big ideas in complete sentences.

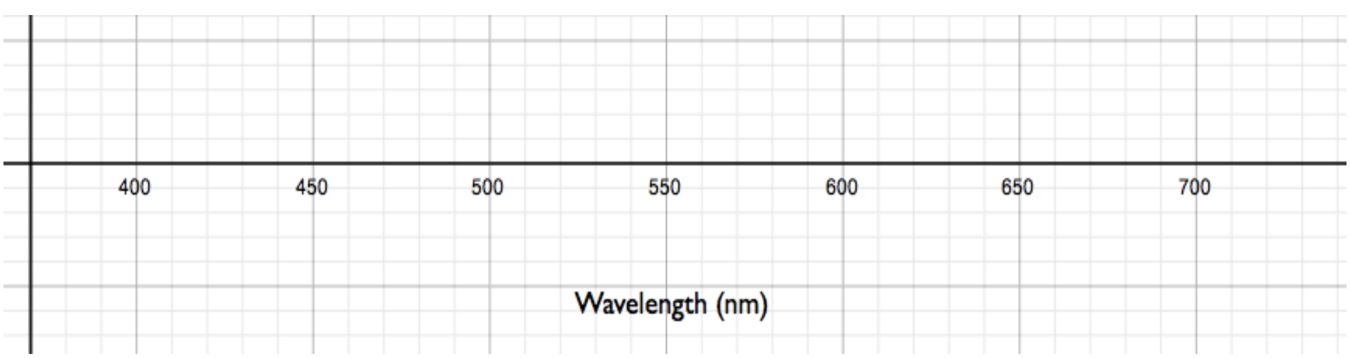
1. What do wavelength and frequency measure?

2. How can you find the energy of a wave?

3. What is a flame test? What does the Law of Conservation of Energy have to do with this type of experiment?

ELECTROMAGNETIC SPECTRUM

Use color pencils or markers to shade and label the complete visible spectrum.



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FLAME TEST BASICS

Complete the table below predicting what will happen to a Li atom Before, During and After steps of a flame test.

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What happens to the electrons in the atom?			

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LAB INVESTIGATION

INTRODUCTION

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MATERIALS

- 250 mL beaker
- Laboratory burner
- Colored drawing pencils
- Chemical splash goggles, aprons, and gloves
- Wooden splints, soaking separately in unknown solutions

METHODS

Safety note: Wear approved chemical splash goggles and chemical-resistant gloves and apron. The metal salts used allow the burned splints to be safely disposed of in the trash, but the teacher, to avoid any possibility of a trashcan fire, should do this.

1. Don gloves, aprons, and chemical splash goggles. Fill a 250 mL beaker with tap water and place it at your workstation. This will be used to extinguish wooden splints.
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4. Record observations.
5. Repeat steps 1–4 with another solution, until you have tested four solutions.
6. Once the laboratory work is complete, wash hands with soap or detergent.
7. Perform calculations and answer all questions.

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WAVELENGTH COMPARISON

Draw each observed wavelength below.

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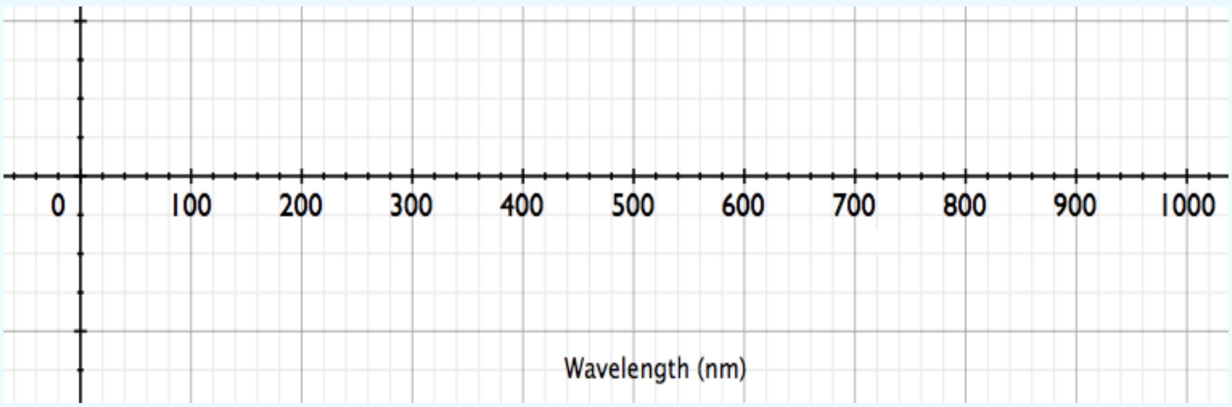
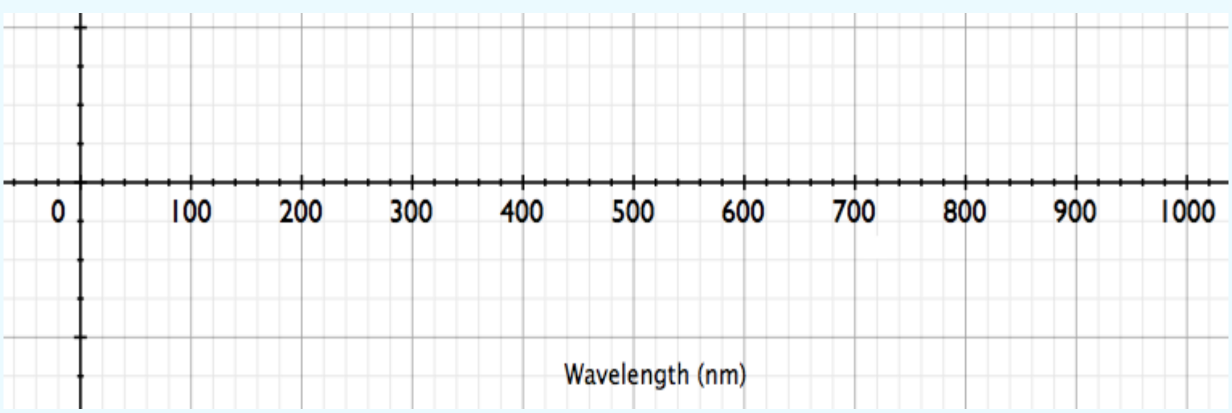
		λ =



Flame Test Solution #	Color	Estimated Wavelength (nm)
		λ =



[2] Emphasize the importance of detail since students' final element identification depends on this step.
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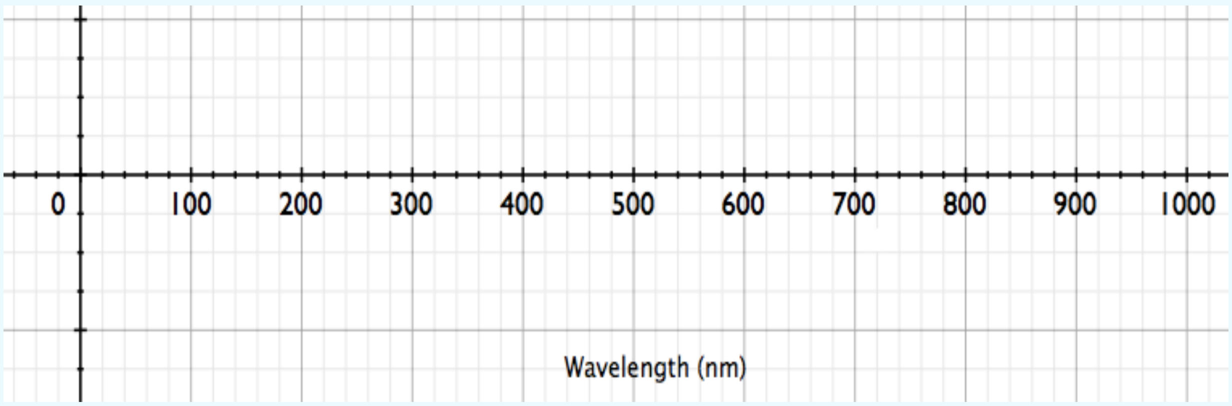
Flame Test Solution #	Color	Estimated Wavelength (nm)
		λ =



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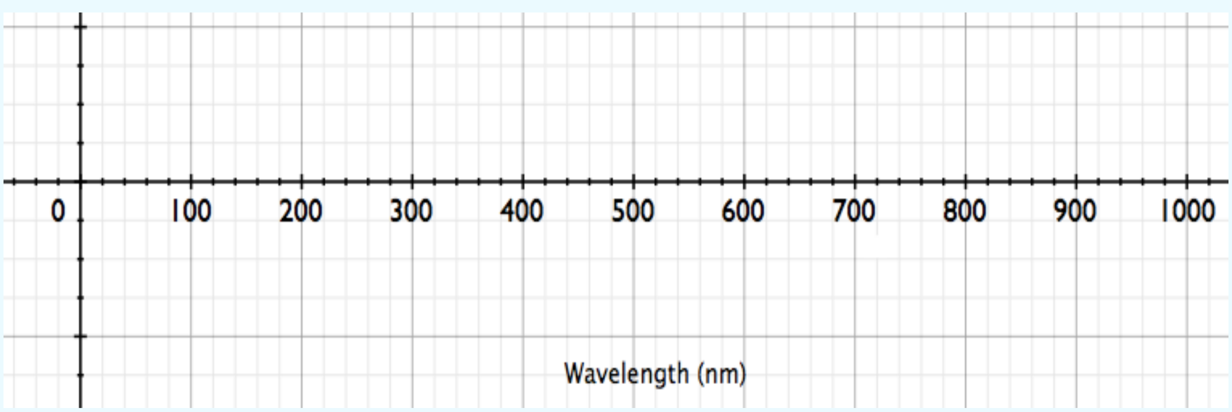

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CALCULATIONS

Use your estimated wavelength data to solve for frequency and energy of each sample.

FREQUENCY EQUATION	WAVE ENERGY EQUATION
$\nu = \frac{c}{\lambda}$	E = vh

Flame Test Solution # ________	Wavelength (nm) λ = ______________
Frequency Calculation	Wave Energy Calculation

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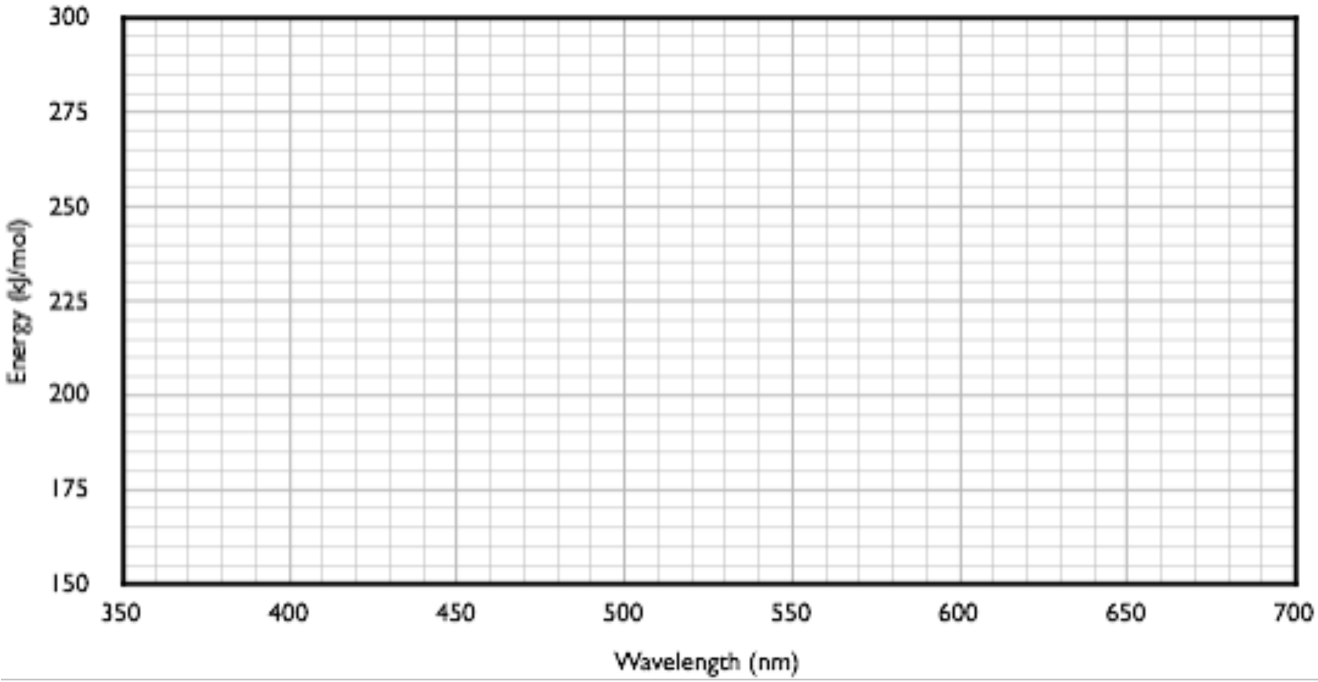
GRAPH ANALYSIS

Graph Wavelength (nm) vs. Energy (kJ/mol)



1 What do you notice about the graph?

2 What does this say about the electromagnetic spectrum? What end of the spectrum has high energy? Which end has low energy?

3 If the wavelength is longer, then the amount of energy released is ______________________?

4 If the wavelength is longer, then the amount of energy released is higher. **T or F**

5 Explain your reasoning for number 4.

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

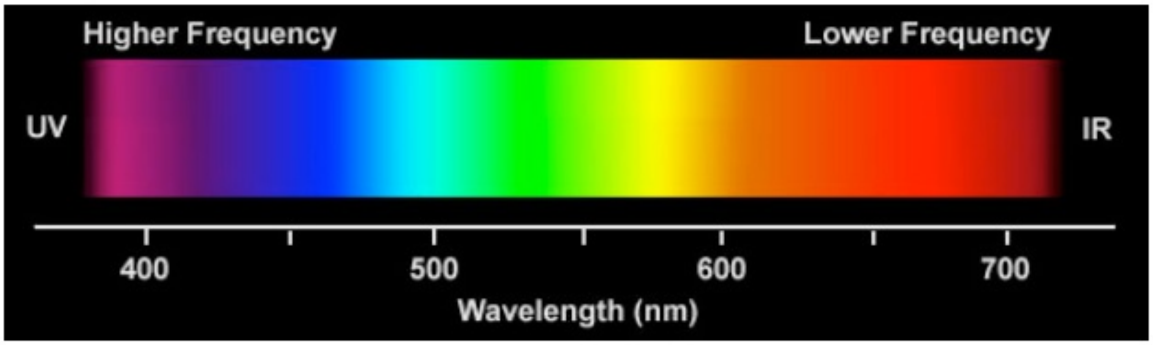
ELEMENT IDENTIFICATION

Determine the unknown element in each sample by comparing your calculated energies to the known energy values given on the Visible Light Spectrum Card.

Flame Test Solution	Calculated Energy Values (kJ/mol)	Known Energy Values (kJ/mol)	Element Responsible

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

Visible Light Spectrum



Energies by Element

Photon Energy (kJ/mol)	Element
181.2	Lithium
228.6	Boron
203.4	Sodium
279.1	Potassium
252.6	Copper
190.5	Strontium

SOURCE These materials have been adapted from http://www.nsta.org/publications/news/story.aspx?id=50902, Kate Dickinson (UCSB), and FOCUS! (UCI).

ANALYSIS

1 In the space below, develop a model that describes what happens to a sodium chloride (NaCl) before, during, and after a flame test experiment like the one you have just performed.

NaCl: before flame test	
NaCl: during flame test	
NaCl: after flame test	

3 Use the model you developed to explain conservation of matter in this example.

SOURCE

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ARGUMENTATION TASK

Study the data you collected and the graphs you created during the Flame Tests Lab Experiment. Use your data and graphs to answer the following question.

How do fireworks get their colors? Explain the chemical reactions that occur when a firework is ignited using what you know about the conservation of matter and energy.

Remember to include:

- Claim: Answer the question.
- Evidence: Use data from your experiment and from the graphs you created to support your claim.
- Reasoning: Use information from readings or notes to explain why your evidence supports your claim.
- Model: Illustrate and clearly label the components of a model that helps explain the relationship between the amount of energy released in a chemical reaction and the colors observed in fireworks.