Creating High-Quality AP Science Courses Using Digital and Hands-On Learning Tools

CAST21

AP Science Courses - Goals

To enable “willing and academically prepared students to pursue college-level studies—with the opportunity to earn college credit, advanced placement, or both—while still in high school.”

AP Science Courses - Goals

"Individual teachers are responsible for designing their own curriculum for AP courses, selecting appropriate college-level readings, assignments, and resources."

Courses and Lab Solutions

- AP Chemistry
- AP Biology
- AP Physics 1
- AP Environmental Sciences

Features

- Practice Tests
  - Timed and untimed
  - Reteach videos
  - Multimedia instruction
- Multimedia Instruction
  - Videos and animations
  - Step-by-step solutions
  - Quick quizzes
  - Foundational and advanced topics

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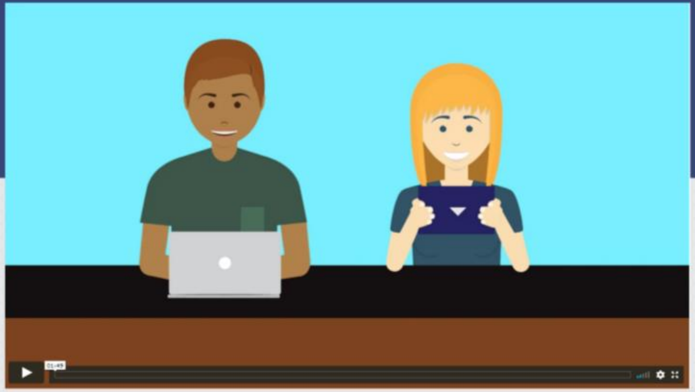
Preparing for AP Science Exams

Why FLINN*PREP*™?

Developed in collaboration with teacher and student focus groups, Flinn*PREP*™ online courses and lab solutions help strengthen the AP® learning experience.

Courses



Each course features easy-to-understand content, curated OER, videos and games, formative and summative assessments, and full-length practice exams aligned to the Learning Objectives. Students have year-round course access to review, practice, and prepare for AP® exams on their own time and at their own pace.

AP® BIOLOGY

AP® CHEMISTRY

AP® ENVIRONMENTAL SCIENCE

AP® PHYSICS 1

Lab Solutions

AP® Inquiry Labs aligned to the Big Ideas, Learning Objectives and Science Practices offer blended learning options that combine the benefits of classroom, laboratory, and digital learning. AP® Chemistry and AP® Biology both include **virtual reality simulations**. Everything comes together as students apply their knowledge and practice with exam style questions.

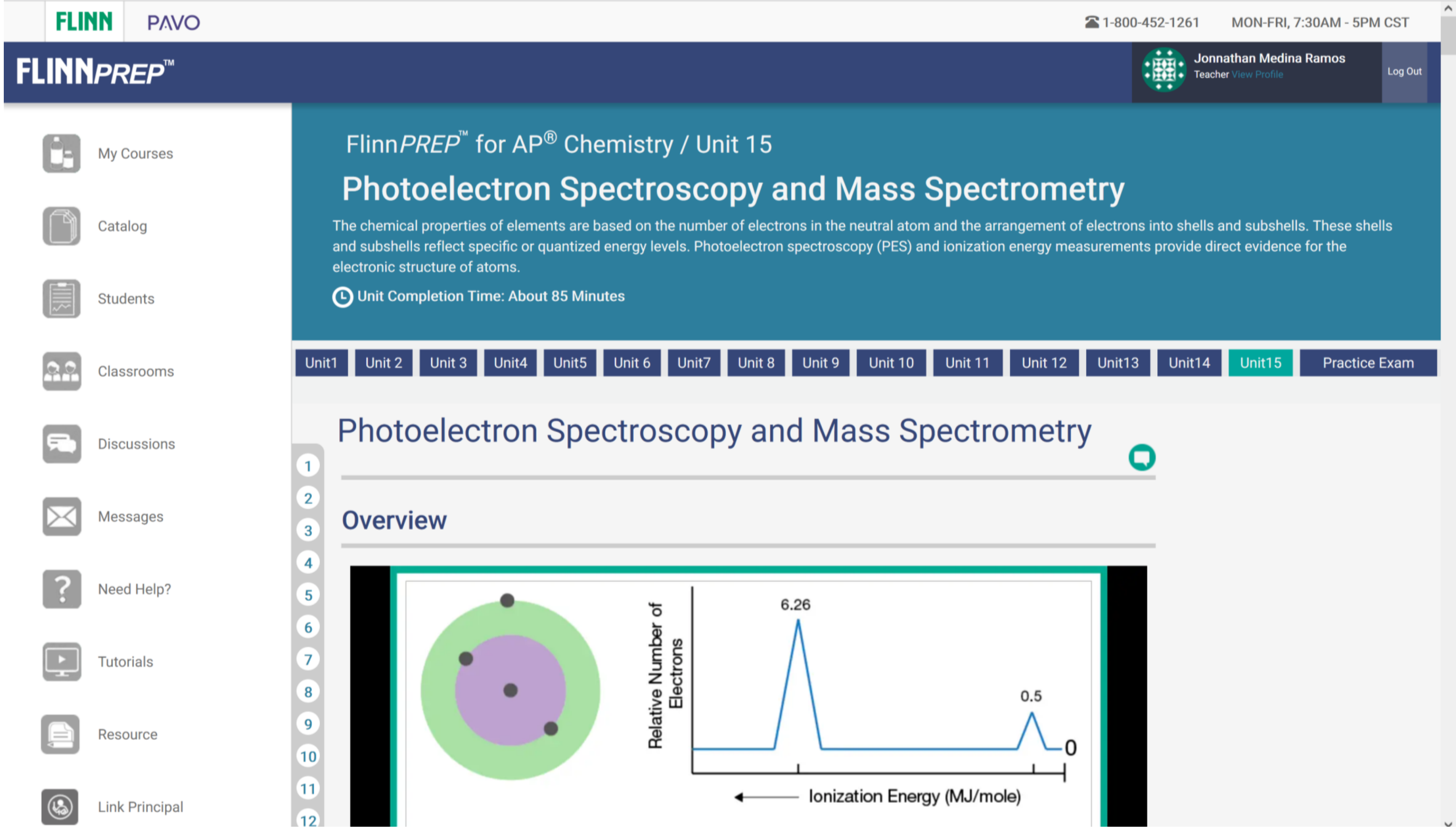
AP® BIOLOGY

AP® CHEMISTRY

AP® ENVIRONMENTAL SCIENCE

AP® PHYSICS 1

Multimedia Content

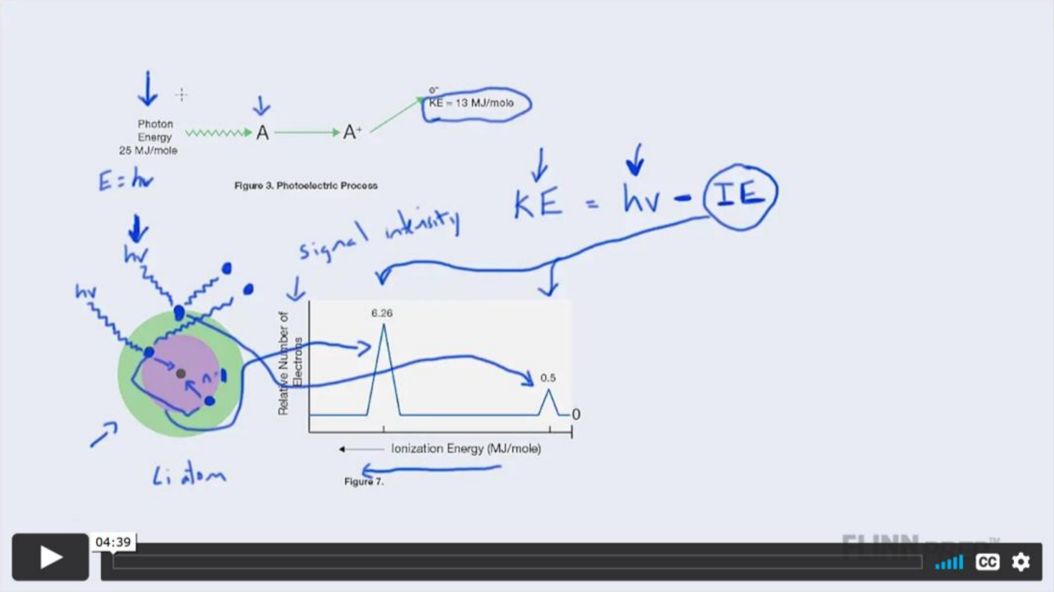


Videos and Animations

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Because the incident light is of sufficient energy to ionize both core and valence electrons, there is an equal probability that each electron in an atom will be ejected. The number of electrons ejected is proportional to the number of electrons present at each energy level.

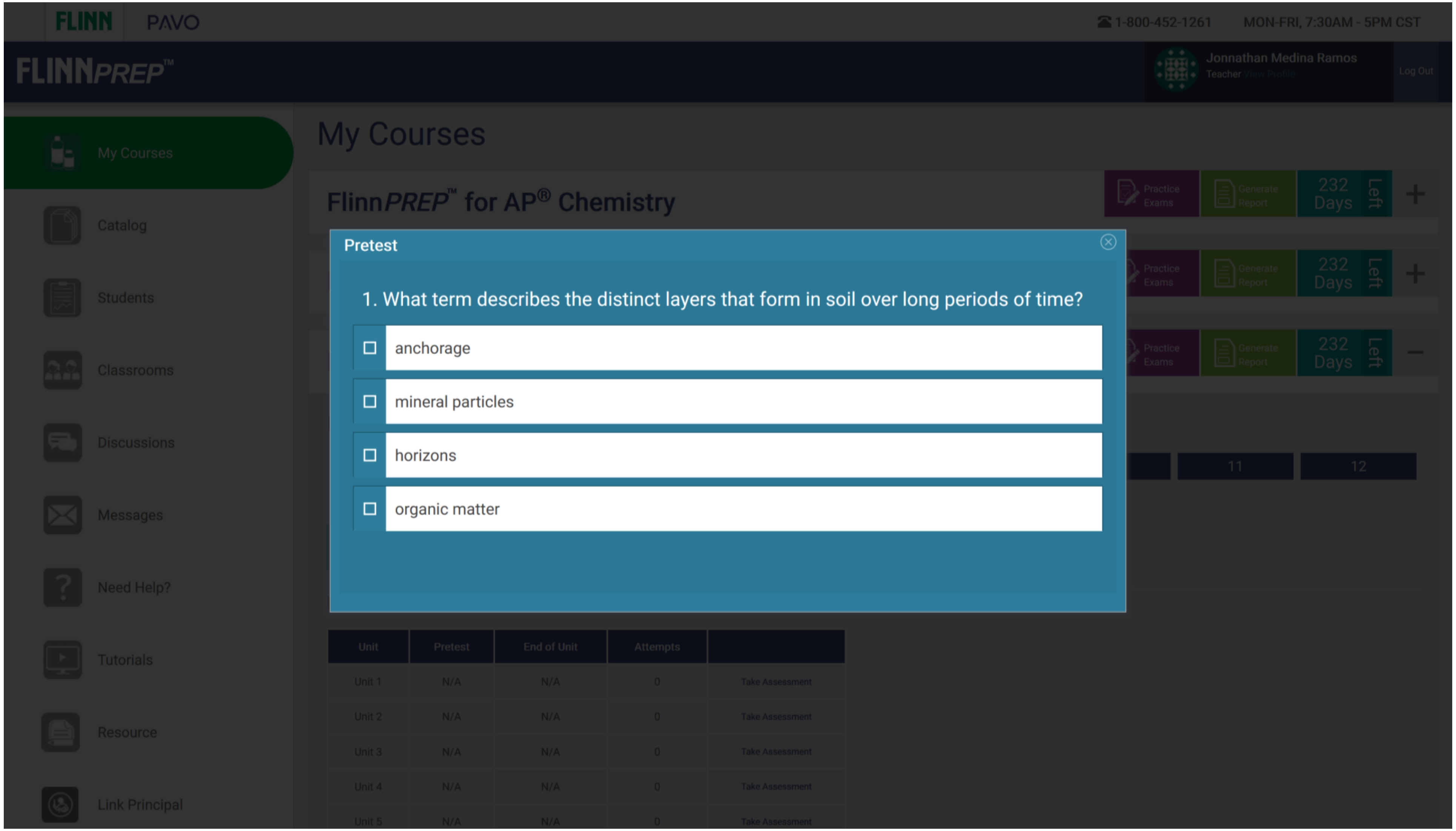
This video illustrates how photoelectron spectrophotometers are used to experimentally determine ionization energies.



Interpreting Photoelectron Spectra

The information gathered by a photoelectron spectrophotometer is transformed into a graph called a *photoelectron spectrum*, which displays the signal intensity versus ionization energy for a sample of atoms (see Figure 5)

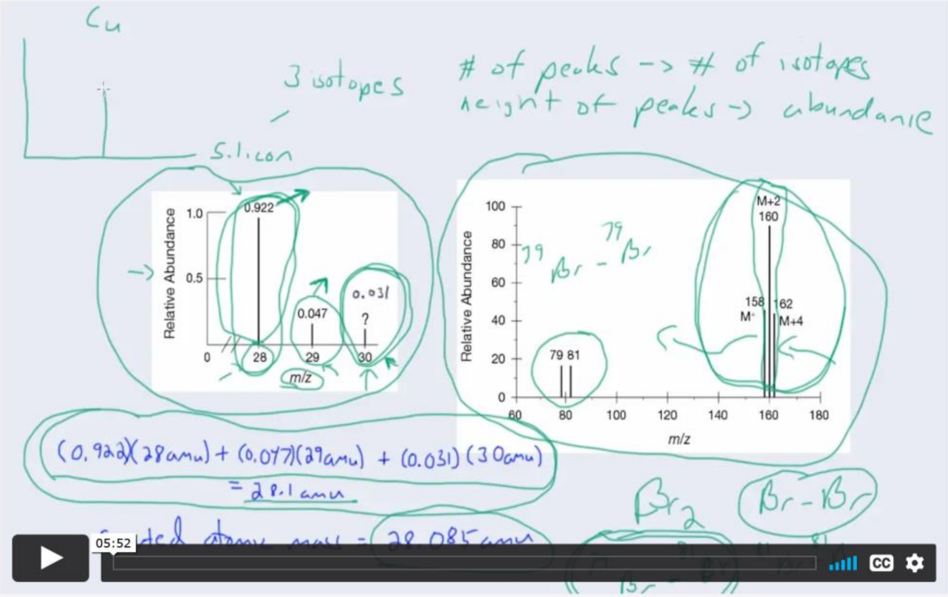
Pretest – At the Start of Each Unit



Quick Quizzes

The isotopic composition of the molecular ion responsible for the M^+ peak at 158 is $^{79}Br{-}^{79}Br$. The M^{+2} peak at 160 is due to $^{79}Br{-}^{81}Br$, while the M^{+4} peak at 162 is due to $^{81}Br{-}^{81}Br$.

Watch the video below for a tutorial on interpreting mass spectra.



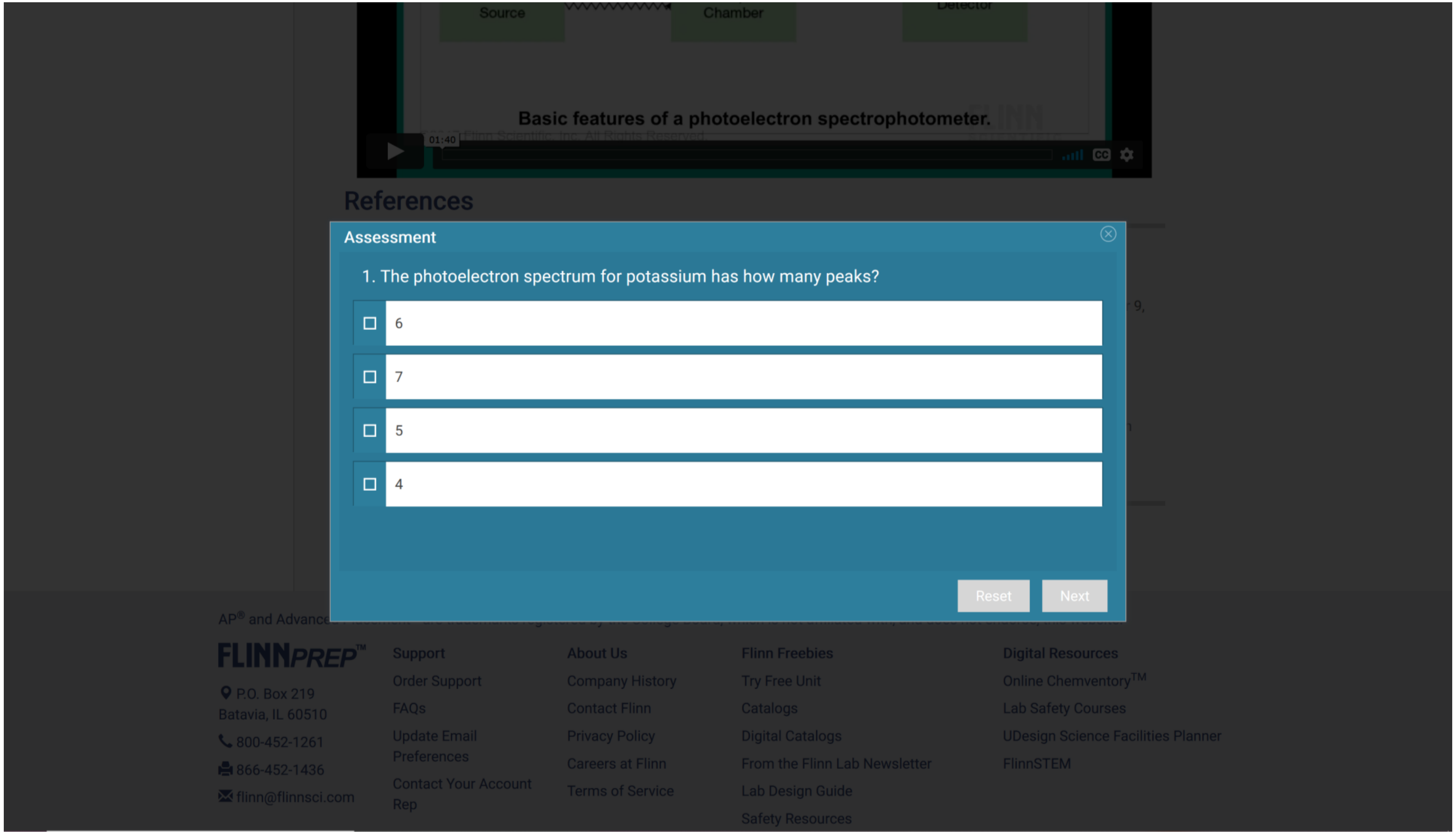
Quick Quiz

Electronic and Vibrational Spectroscopy

When atoms or molecules interact with electromagnetic radiation such as visible or ultraviolet light the result is an increase in their energy caused by the absorption of a photon. At the molecular or atomic level, these increases in energy are due to the following types of absorption.

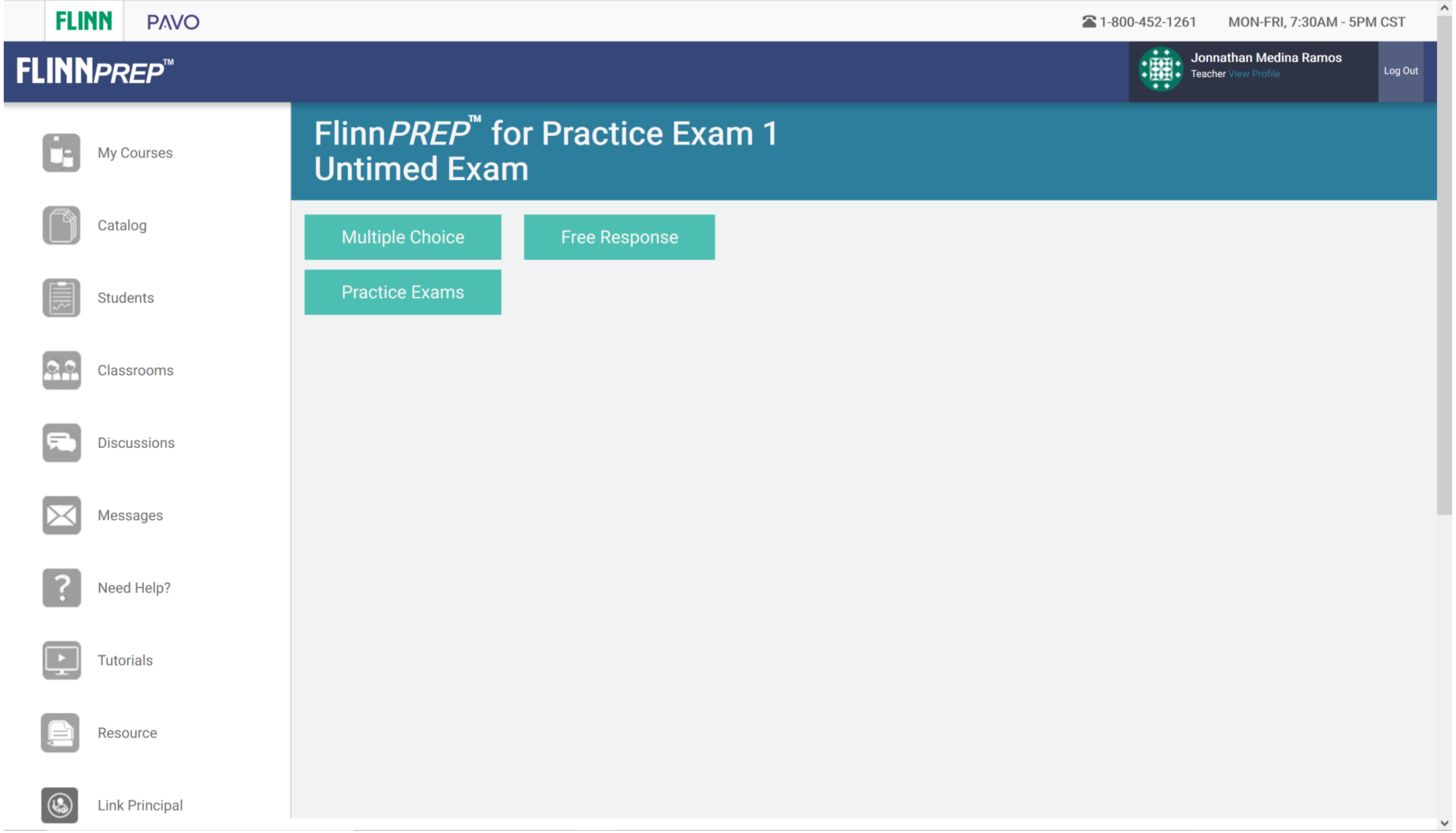
- Promotion of an electron in an atom or molecule (A) from a lower energy state to a higher energy, excited state, which is denoted A*. See Figure 12. The wavelength of radiation needed to cause electronic transitions is in the range of ultraviolet and visible light, 10 nm to 700 nm (1 nm = 1 nanometer = 1×10^{-9} m).

End-of-Unit Quizzes

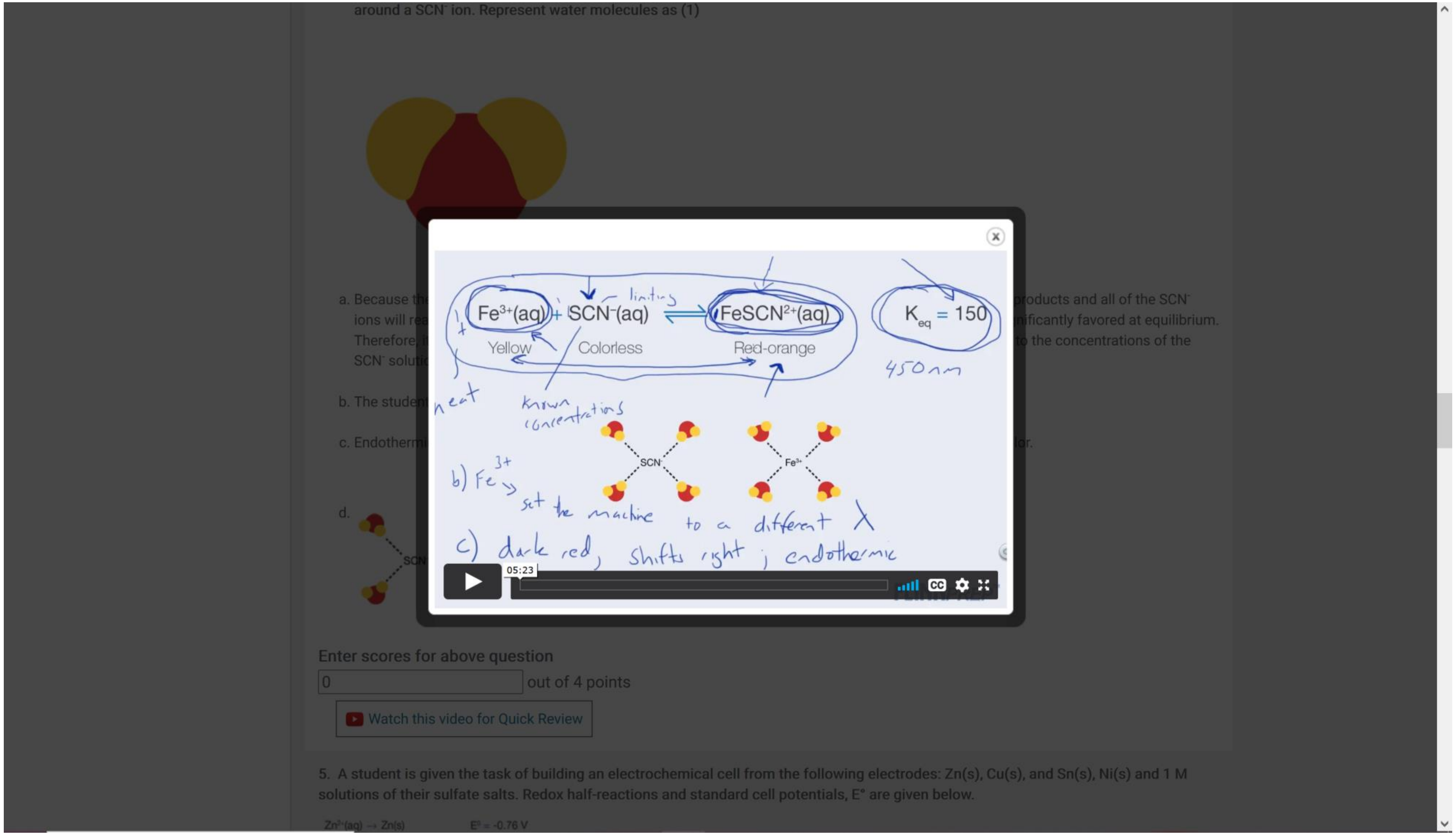


Reteach Videos

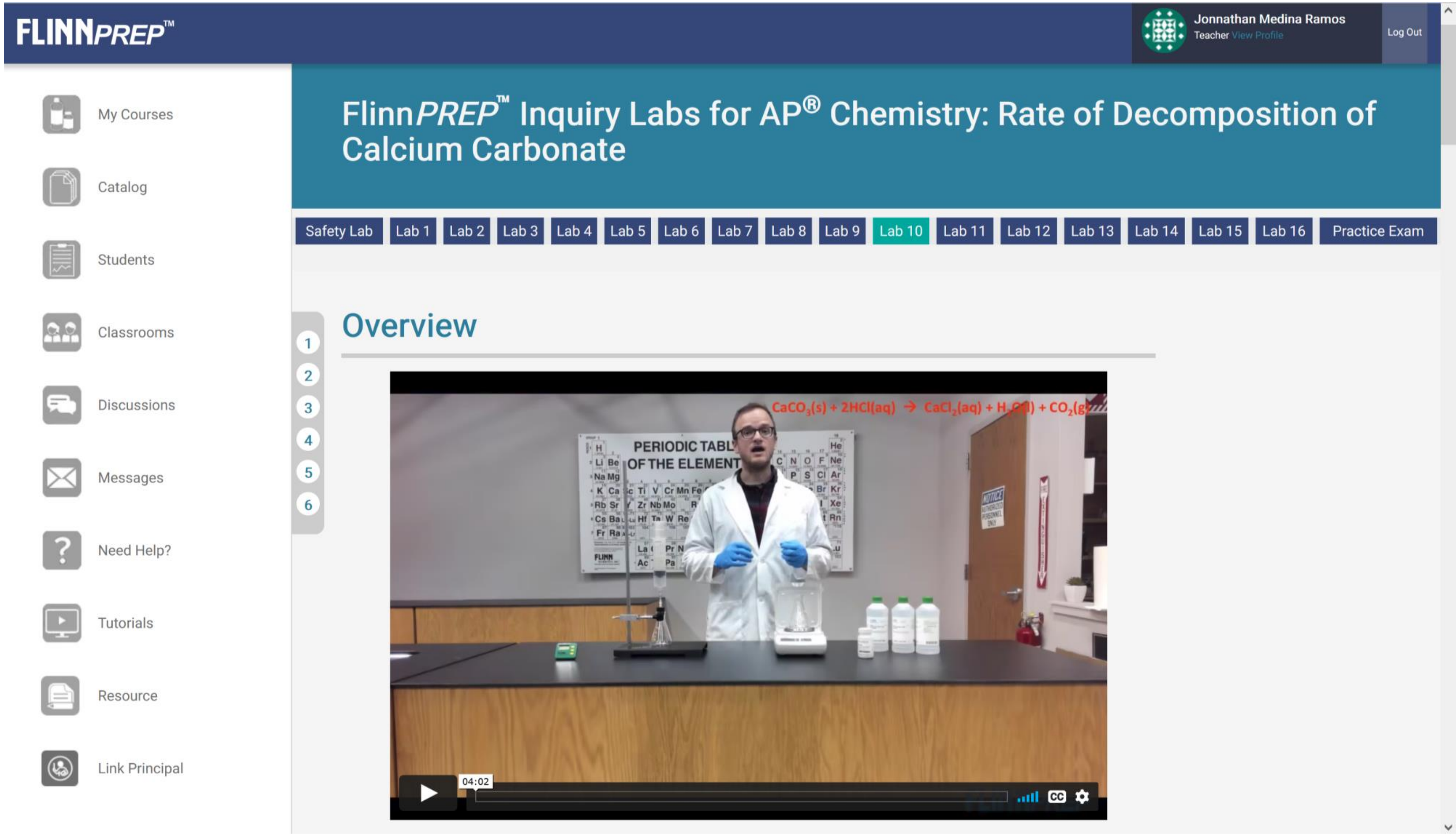
Free Response Questions



Solution Videos



Lab Solutions



Lab Solutions

PDFs

Step-By-Step Procedure

Printable Lab Guide

Teacher Tutorial

Show All Reteach Videos

1. Overview
   - Overview
2. Background
3. Safety Precautions
4. Introductory Activity
   - Setting Up Your Experiment
5. Guided-Inquiry Design and Procedure
6. Summary
   - How This Lab Topic May Appear on the AP Exam

1 2 3 4 5 6

Background

Calcium carbonate, $CaCO_3$, is one of the most abundant minerals on the Earth. More than 4% of the Earth's crust is composed of calcium carbonate. It is a major component in limestone, marble, seashells, bedrock, etc. Limestone and marble have been among the most widely used building materials for more than 5000 years, from the pyramids in Egypt to the Parthenon in Greece and the Taj Mahal in India. In many places, limestone is also the foundation of our Earth—literally, since it forms both bedrock and mountain ranges. Calcium carbonate dissolves in water to only a limited extent, but its solubility is greatly enhanced when the water is acidic. The gradual dissolution of marble and limestone, as well as coral and seashells, in acids is due to acid-base neutralization. The products of the neutralization reaction between calcium carbonate and hydrochloric acid are calcium chloride and carbonic acid, or H_2CO_3. Carbonic acid is unstable, decomposing to give carbon dioxide gas and water.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2CO_3(aq) \qquad \textit{Equation 1}$$

$$H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l) \qquad \textit{Equation 2}$$

The rate of the overall reaction (Equation 3) and its dependence on the concentration of HCl are important concerns in environmental chemistry due to the combined effects of acid rain and ocean acidification.

$$CaCO_3(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l) \qquad \textit{Equation 3}$$

Kinetics is the study of the rates of chemical reactions. As reactants are transformed into products in a chemical reaction, the amount of reactants will decrease and the amount of products will increase. The rate of the reaction can be determined by measuring the amounts or concentrations of reactants or products as a function of time. In some cases, it is possible to use a simple visual clue to determine a reaction rate. Some of the "clues" that may be followed to measure a reaction rate include color intensity, amount of precipitate that forms, or amount of gas generated. In the case of the reaction of $CaCO_3$ with HCl, one of the products is a gas. Since either volume or mass of the gas is proportional to moles, the rate can be followed by measuring the time it takes for a specific volume or mass of carbon dioxide to be released. The reaction rate is calculated by dividing the quantity of carbon dioxide produced by the time. The rate of a reaction describes how fast the reaction occurs—the faster the rate, the less time that is needed for a specific amount of reactants to be converted to products.

$$\text{Rate} = \frac{\text{Change in the number of moles of } CO_2}{\text{Time}}$$

Some factors that affect the rates of chemical reactions include the nature of the reactants, their concentration, the reaction temperature, the surface area of solids, and the presence of catalysts. The relationship between the rate of a reaction and the concentration of reactants is expressed in a mathematical equation called a rate law. For a general reaction of the form

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Safety Precautions

Hydrochloric acid is corrosive to skin and eyes and toxic by inhalation or skin absorption. Avoid contact with eyes and skin and clean up all spills immediately. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. For the gas collection experiment, do not use more than 0.4 g of calcium carbonate. The concentration of hydrochloric acid must not exceed 6 M in any experiment. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

Introductory Activity

Watch this video to learn how to set up and use rate-monitoring equipment.

1. Read the entire procedure before beginning. This activity may be done as an individual experiment or an interactive classroom demonstration to encourage participation and discussion.

(minutes) on the *x*-axis.

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Guided-Inquiry Design and Procedure

Form a working group with other students and discuss the following questions.

1. Analyze the graph from the *Introductory Activity*. Does the amount of CO_2 increase linearly with time, or does it level off as the reaction proceeds? Explain the shape of the curve based on the rate of the reaction and the concentration of HCl versus time.
2. Initial rates are generally used to compare reaction rates for different concentrations of reactants. The initial rate is calculated from the slope or linear portion of the graph of the amount of product versus time. Estimate the initial rate for the reaction of $CaCO_3$ with HCl, and express in units of volume of CO_2 per minute.
3. Calculate the number of moles of $CaCO_3$ and HCl used in the *Introductory Activity*. Determine the limiting reactant and use the ideal gas law to estimate the maximum volume of CO_2 that could be produced. Use the average room temperature and barometric pressure in the calculations.
4. Is the volume of the syringe sufficient to contain all of the CO_2 that could be produced? What was the average percent of reaction completion after 10 minutes? Explain in terms of potential sources of error in the experiment.
5. Two alternative procedures may be used to compare the effect of concentration on reaction rate. The first was demonstrated in the *Introductory Activity*. The second procedure involves the change in mass of the reaction mixture versus time. How will the mass of the system change as the reaction proceeds? What quantity will be proportional to the amount of CO_2 produced?
6. What is the theoretical mass of CO_2 that can be produced from (*a*) 0.40 g of $CaCO_3$ and (*b*) 0.80 g of $CaCO_3$? Which reactant quantity is more suitable for the mass loss procedure? Explain based on the precision of the balance and other factors, and discuss how this choice would affect the volume of HCl that is used.
7. Identify the measurements that must be made for both procedures to investigate the effect of HCl concentration on the reaction rate and to determine the reaction order with respect to HCl. Name the independent and dependent variables for each series of experiments, and choose some suitable values for the independent variable.
8. Discuss how the size or surface area of the marble chips might affect the purpose or design of the experiments. What is the best way to control this variable so that it remains constant and does not affect the analysis?
9. Write a step-by-step procedure for two alternative series of experiments to investigate the effect of HCl concentration on the reaction of $CaCO_3$ with HCl. Include the materials, glassware and equipment that will be needed, required safety precautions, concentrations and amounts of reactants, etc.
10. Review additional variables that may affect the accuracy or reproducibility of the experiments.
11. Carry out the experiment and record results in an appropriate data table.

Analyze the Results

Graph the results for each trial and calculate the average or initial rate for each concentration of HCl. Plot or analyze the rate versus HCl concentration to determine the reaction order. Compare and contrast the results obtained using the two alternative procedures and discuss any discrepancies as well as potential sources of experimental error in each procedure.

Lab Solutions

1
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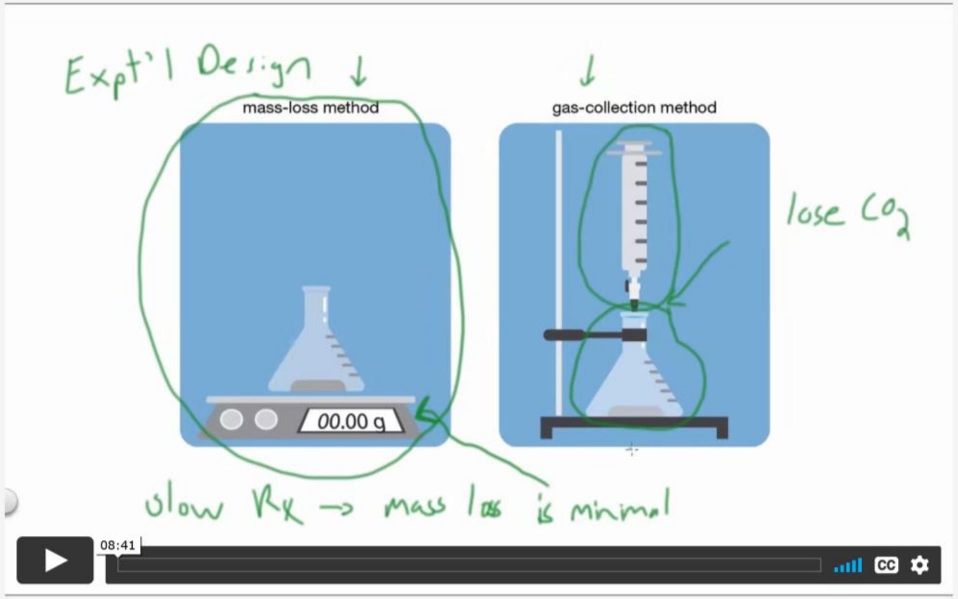
Summary



Next Lab

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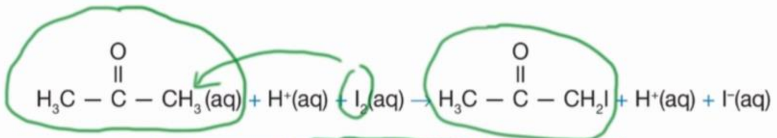
More Practice Opportunities!

10. Review additional variables that may affect the accuracy or reproducibility of the experiments.
11. Carry out the experiment and record results in an appropriate data table.

Analyze the Results

Graph the results for each trial and calculate the average or initial rate for each concentration of HCl. Plot or analyze the rate versus HCl concentration to determine the reaction order. Compare and contrast the results obtained using the two alternative procedures and discuss any discrepancies as well as potential sources of experimental error in each procedure.

Summary



Run	[Acetone], M	[HCl], M	$[I_2]$, M	Reaction rate (M/min)
1	1	0.25	0.00125	4.17×10^{-4}
2	2	0.25	0.00125	8.93×10^{-4}
3	1		0.00125	8.34×10^{-4}
4	1	0.25	0.0025	
5	1	0.25	0.00125	3.79×10^{-4}

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Next Lab

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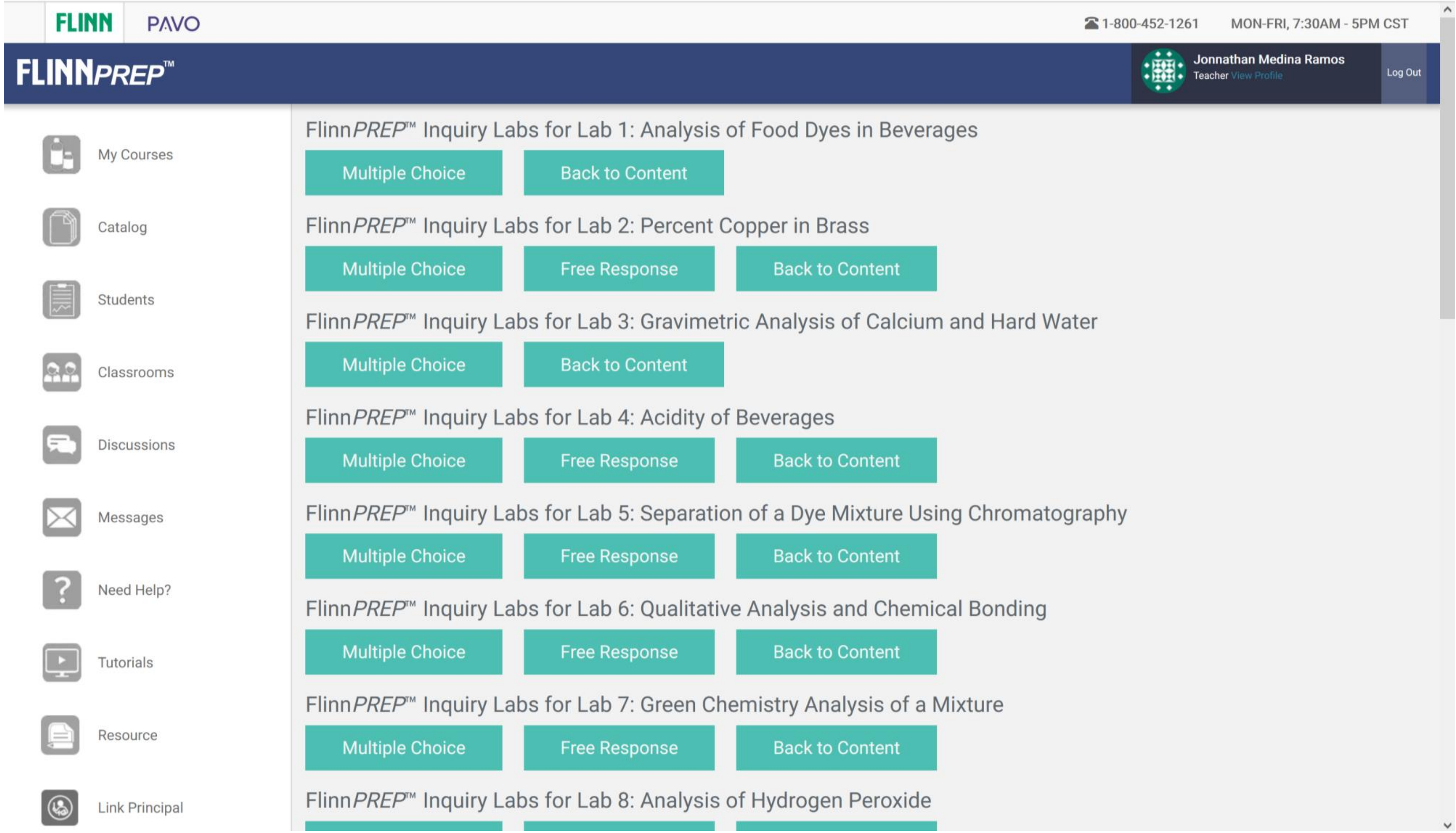
More Free Response Practice



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More Solution Videos

Resource

Link Principal

(a) Explain how the data in the table above provides evidence that HA is a weak acid rather than a strong acid. (1 point)
(b) Calculate the molar mass of HA. (2 points)
(c) Assume that the initial concentration of the HA solution is 0.15 M. Determine the pH of the initial HA solution. (3 points)

Free Response

A 1.72 g sample of pure monoprotic acid, HA ($K_a = 6.3\times10^{-5}$), was dissolved in distilled water. The HA solution was then titrated with 0.45 M NaOH. The pH was measured throughout the titration, and the equivalence point was reached when 25.0 mL of the NaOH solution had been added. The data from the titration are recorded in the table below.

a) Explain how the data in the table above provides evidence that HA is a weak acid rather than a strong acid.

Volume of NaOH Added (mL)	pH of Titrated Solution
0.00	?
5.00	3.56
10.00	4.37
15.00	5.25
20.00	?
25.00	8.55
30.00	12.61

02:00

Enter scores for above question

0 out of 6 points

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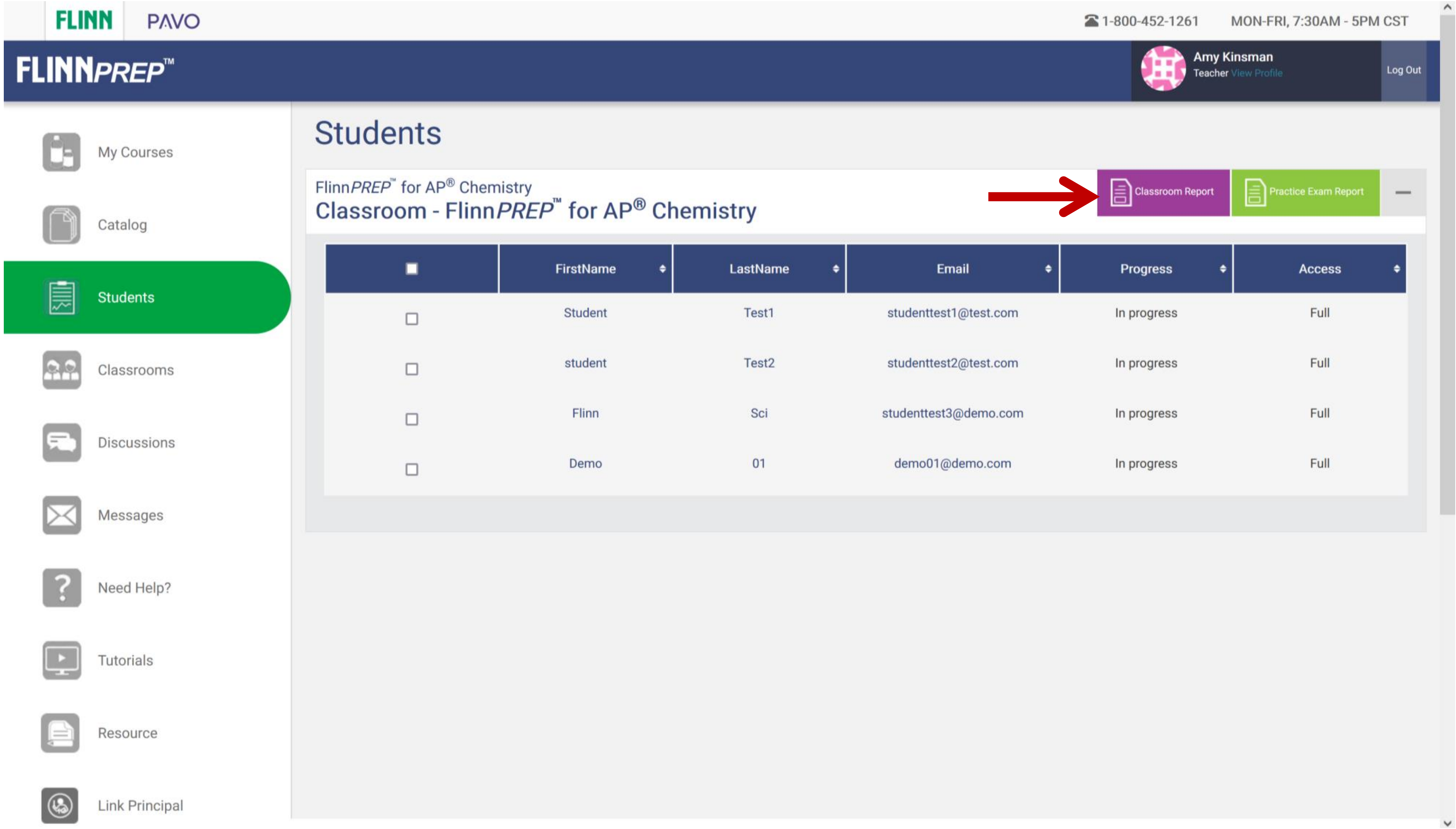
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Course: FlinnPREP™ for AP® Chemistry
Classroom: Classroom - FlinnPREP™ for AP® Chemistry

Students Attending this Classroom
4

Class Results Breakdown (Highest score earned shown) | Topic Breakdowns

Class Results Breakdown (Highest score earned shown)

	Foundational Topics										AP Level Topics						
Student	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Unit 14	Unit 15	Total	Overall Percentage
Demo 1	20/20	16/20	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	36/40	90%
Previous Attempts	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
Student 3	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0%
Previous Attempts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Student Test1	0/0	0/0	0/0	0/0	4/20	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	4/20	20%
Previous Attempts	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		
Student Test2	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0%
Previous Attempts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Reporting – Student Report

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- Discussions
- Messages
- Need Help?
- Tutorials
- Resource
- Link Principal

Students / Performance

Demo 01

demo01@demo.com

Classroom - Flinn*PREP*™ for AP® Chemistry

Flinn*PREP*™ for AP® Chemistry Review

Unit	Pretest	End Of Unit	Previous Attempts
1	10/10	20/20	1
2	N/A	16/20	1
3	N/A	N/A	0
4	N/A	N/A	0
5	N/A	N/A	0
6	N/A	N/A	0
7	N/A	N/A	0
8	N/A	N/A	0
9	N/A	N/A	0
10	N/A	N/A	0
11	N/A	N/A	0
12	N/A	N/A	0
13	N/A	N/A	0
14	N/A	N/A	0
15	N/A	N/A	0

Generate Report

Personalized Learning

- Catalog
- Students
- Classrooms
- Discussions
- Messages
- Need Help?
- Tutorials
- Resource
- Link Principal

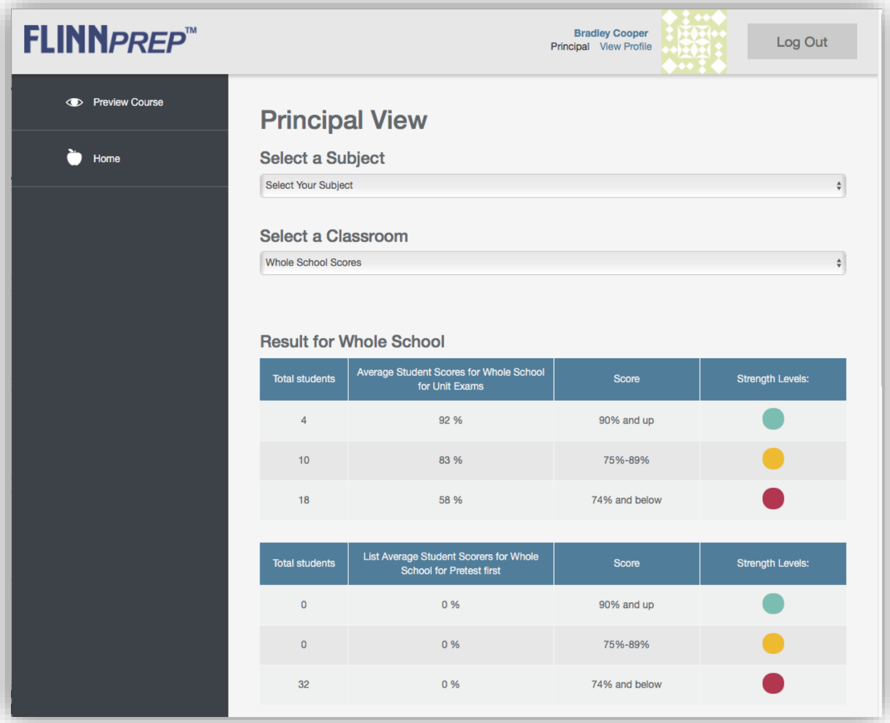
Topic Breakdowns

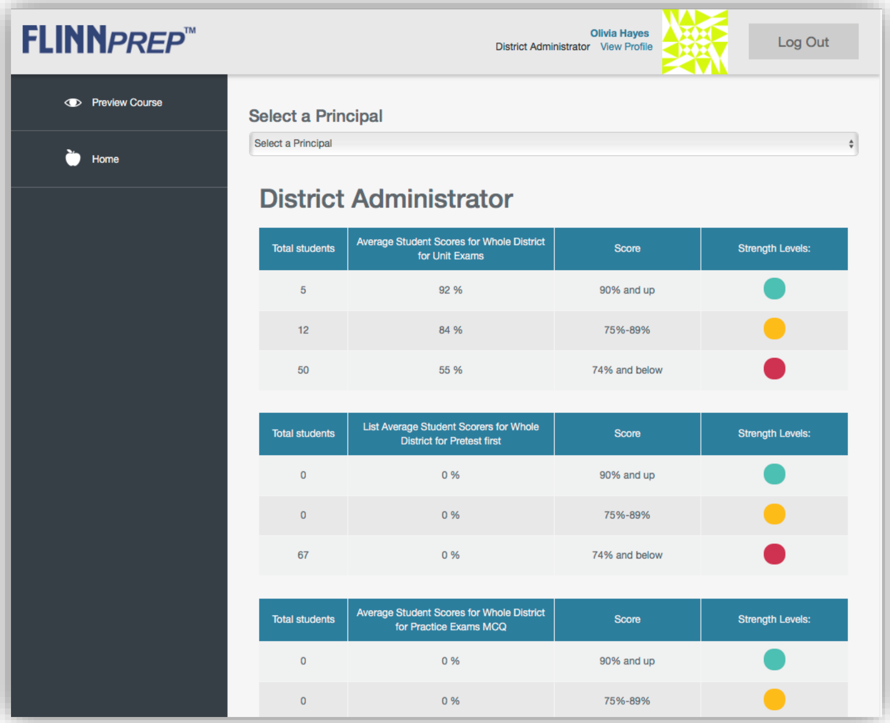
Each Unit is broken up into sub topics. Below are the compiled results for each one of those topics along with the strength level of your class. Each assessment taken by your students is factored into these results, not just the final passing assessment.

Strength Levels: 90% and up 75%-89% 74% and below

Subject - Foundational Topics	Total Questions	Answered Correctly	Strength Level
Unit 1 - Nomenclature			
Naming and Formula Writing of Acids	3	3	
Naming Ionic Compounds	5	5	
Naming Molecular Compounds	4	4	
Writing Formulas of Ionic Compounds	3	3	
Writing Formulas of Molecular Compounds	5	5	
Unit 2 - Atomic Structure and the Periodic Table			
Average Atomic Mass Calculations	8	7	
Electron Configurations	3	3	
Electronegativity and Electron Affinity	2	2	
Ionization Energy	2	1	
Protons, Neutrons, Electrons, and Isotope Identification	2	2	
Radius Trends (Ionic and Atomic)	3	1	

Principal and District Administrator Reporting





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- Determination of the Empirical Formula of Silver Oxide
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- Molar Mass by Freezing Point Depression
- Determining the Molar Volume of a Gas
- Acid–Base Titrations
- Oxidation–Reduction Titrations
- Determining the Stoichiometry of Chemical Reactions
- Determination of the K_a of Weak Acids
- Selecting Indicators for Acid–Base Titrations
- Kinetics of a Reaction
- Thermodynamics—Enthalpy of Reaction and Hess's Law
- Separation and Qualitative Determination of Cations and Anions
- Synthesis and Analysis of a Coordination Compound
- Gravimetric Analysis of a Metal Carbonate
- The Determination of K_{eq} for $FeSCN^{2+}$
- Liquid Chromatography
- pH Properties of Buffer Solutions
- An Activity Series
- Electrochemical Cells
- Synthesis, Isolation and Purification of an Ester

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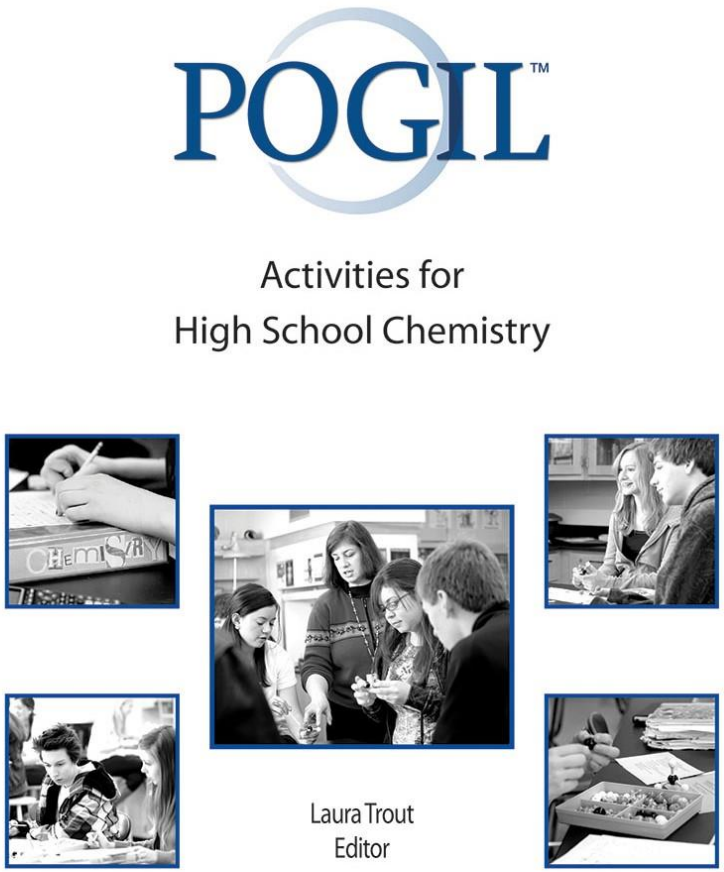
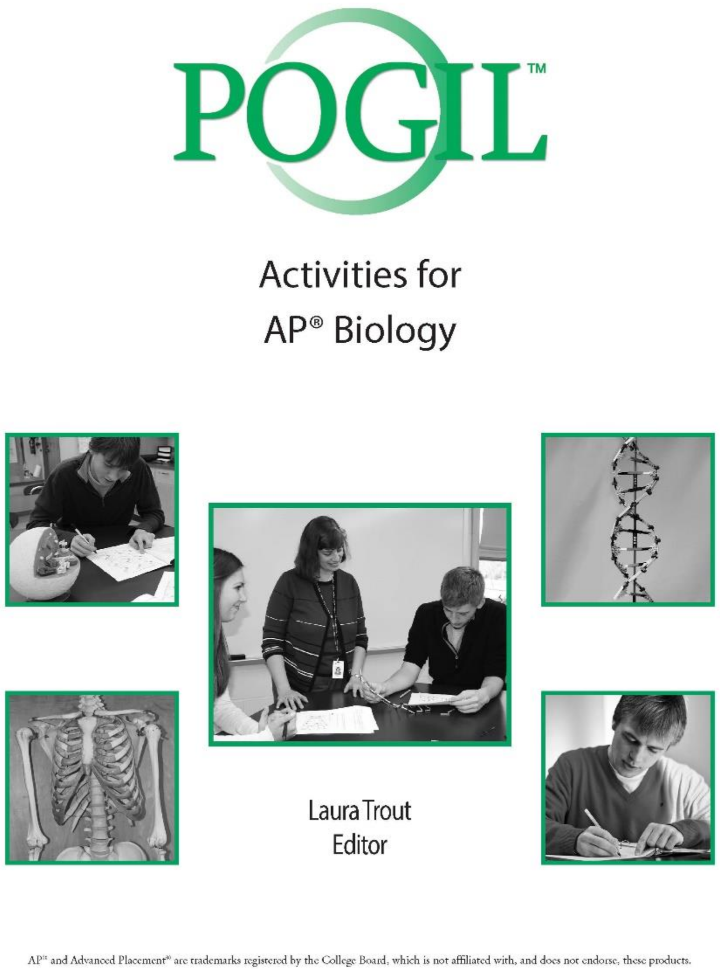
POGIL





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POGIL – All Digital via PAVO

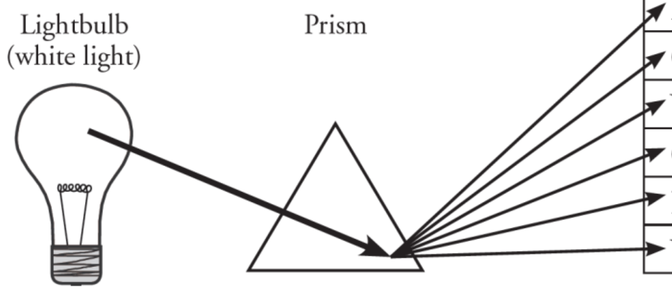
Electron Energy and Light

How does light reveal the behavior of electrons in an atom?

Why?

From fireworks to stars, the color of light is useful in finding out what's in matter. The emission of light by hydrogen and other atoms has played a key role in understanding the electronic structure of atoms. Trace materials, such as evidence from a crime scene, lead in paint or mercury in drinking water, can be identified by heating or burning the materials and examining the color(s) of light given off in the form of bright-line spectra.

Model 1 – White Light



Color	Photon Energy ($\times 10^{-21}$) (J)	Wavelength Range (nm)	Speed (m/s)
Reds	269–318	625–740	3.00×10^8
Oranges	318–337	590–625	3.00×10^8
Yellows	337–352	565–590	3.00×10^8
Greens	352–382	520–565	3.00×10^8
Blues	382–452	440–520	3.00×10^8
Violets	452–523	380–440	3.00×10^8

1. Trace the arrows in Model 1 and shade in the table with colored pencils where appropriate.
2. What happens to white light when it passes through a prism?

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If you have any questions, give us a call or

send us an email!

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Thank You!