TITLE
Exploring interactions of matter with light

AUTHORS
Alycia M. Palmer (Ohio State University)

COURSE
General Chemistry or Upper-division Inorganic Chemistry Laboratory

TYPE
Recitation / Tutorial Activity

TEACHING MODE
Facilitated Group Inquiry

LEARNING GOALS
Students will be able to:

- Describe how a set of example molecules interacts with light of varying energy
- Identify characteristics of molecules associated with an interaction with light
- Construct a set of guidelines that generalize how molecules react with light of varying energy
- Apply these guidelines to predict the reactivity with light for any small molecule

EXPLORING INTERACTIONS OF MATTER WITH LIGHT

LEARNING GOALS

- Describe how a set of example molecules interacts with light of varying energy
- Identify characteristics of molecules that are associated with an interaction with light
- Construct a set of guidelines that generalize how molecules react with light of varying energy
- Apply these guidelines to predict the reactivity with light for any small molecule

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PART 1: GETTING STARTED

A. Download the Molecules and Light simulation:
http://phet.colorado.edu/en/simulation/molecules-and-light

B. Working in groups of 3, **explore** all of the controls in the simulation for about 5 minutes. Click on different things and figure out what each one does. Discuss with your partners and decide on a brief (1-2 sentences) summary of what the simulation does and shows.

PART 2: "LIGHT" IN THE SIMULATION

Rank the electromagnetic radiation in the simulation in terms of energy, wavelength, and frequency.

A. Energy

B. Wavelength

C. Frequency

Commented [A1]: In this activity, students investigate light-matter interactions through an interactive simulation. The activity is designed as a warm-up exercise for an upper level inorganic chemistry laboratory, but could also be adapted for an introductory-level spectroscopy lesson.

Commented [A2]: Before doing the laboratory, students complete this activity to generalize which features in a molecule make it respond to light. During the lab, students can use this generalization to make sense of more complex molecules.

Commented [A3]: This initial exploration time encourages students to use the simulation in a way that is natural to them, so that they quickly become comfortable with the tool. Here, students may begin to ask themselves why only certain molecules react with each kind of light.

Commented [A4]: This task encouraged students to reflect on the purpose of the simulation before moving on to answer questions regarding its content.

Commented [A5]: This prompt helps students to connect "light" used in the simulation to real light which follows $E=hc/\lambda$. Students may use the "Show Light Spectrum" button to answer this question, or they may recall the answer from memory.

PART 3: INTERACTION OF LIGHT AND MATTER

A. Examine how different photons in the simulation affect each molecule. Record your observations for each combination in a few descriptive words.

	Microwave	Infrared	Visible Light	Ultraviolet
CO				
N_2				
O_2				
CO_2				
H_2O				
NO_2				
O_3				

B. Which molecule(s) were **not** affected by **any** of the radiation in the sim?
Why might this be important? (Hint: think about what molecules are commonly found in our air and atmosphere)

C. Examine your observations above and summarize the effects of each kind of radiation on the molecules in the simulation.

	Microwave	Infrared	Visible Light	Ultraviolet
Effect(s) on Molecules				

Commented [A6]: One of the goals for this prompt is to have students make sense of the physical response using their own words. One way to introduce technical vocabulary at a later time is to present it alongside the student responses from this table. Refer to the accompanying lecture slides for an example.

Commented [A7]: This question encourages students to think about how molecules in the atmosphere respond to different wavelengths of light and begin to question how changes to the atmosphere could be detrimental to our health.

Commented [A8]: This is a good point for the instructor to pause students and discuss their answers to part 3B. Here, the instructor can also probe for their responses in this table so that student who are lagging can catch up.

PART 4. MOLECULES IN THE SIMULATION

The interaction of light with a molecule depends on characteristics of the molecule. The presence of nonbonding lone-pair electrons or bond dipoles are two examples. Identify at least 2 more characteristics.

Commented [A9]: Students may find this task challenging because it requires them to reflect on things they learned in prior classes. We recommend completing it as a whole class discussion – this allows the instructor to gently guide students to think about certain characteristics (bond order, geometry, resonance, non-bonding electrons etc.) That way, all students will have the same list to use for Part 5.

PART 5: GENERALIZED OBSERVATIONS

Return to your earlier classification and try to identify molecular characteristics associated with a particular interaction with electromagnetic radiation.

Commented [A10]: This table is useful for Part 6, where students have to predict the reactivity of light with a new set of molecules.

Type of Radiation	Which Molecules were affected? Hint: Drawing Lewis structures may help.	General Rule to Predict Activity
Microwave		
Infrared		
Visible		
Ultraviolet		

Commented [A11]: Lewis structures help students search for the characteristics that they listed in Part 4. Inorganic chemistry students, having gone through general and organic chemistry, are often good at drawing structures, so this task proceeds quickly.

PART 6: PREDICTING REACTIVITY WITH LIGHT

Consider the molecule assigned to your group and predict how it will interact with light based on your observations in the simulation with other molecules.

Hint: It may be helpful to use the "Molecule Polarity" simulations to explore the shape and polarity of your molecule: http://phet.colorado.edu/en/simulation/molecule-polarity

Assigned Molecule	Microwave	Infrared	Visible	Ultraviolet

Commented [A12]: Students can choose to complete this prompt with NH_3, HCN, CH_2O, CH_4, CF_4, CH_2F_2, or CCl_3F. This list is provided to students on slide #2. The last molecule (CCl_3F) is not in the Molecule Polarity simulation but was included because it is reactive with UV light and is a notorious CFC.

Commented [A13]: This resource is optional and provides nice visuals of the molecules listed above, but some students may not need this tool.

Commented [A14]: Students can write their responses on the chalkboard so that the instructor can check them. If time allows, the instructor can use slide #3 to discuss molecules in the atmosphere and to comment on the reactivity of CFCs.