DEVIL   PHYSICS
BADDEST CLASS ON CAMPUS

PhET Light Emission and Lasers
(27 points available x 2/3 = 18 points max score)

GETTING STARTED:

- Go to https://phet.colorado.edu/
- Click on "*Play With Simulations*"
- Select "*Physics*" and "*Quantum Phenomena*"

MODELS OF THE ATOM: ABSORPTION AND EMISSION OF PHOTONS

Find and open the simulation: "***Models Of The Hydrogen Atom***" and click on the play button.

1. Turn the spectrometer and white light source on, and make sure the dial is set to "Experiment". Turn on the light gun. Each dot represents a photon of different wavelength/frequency. It may help to either speed up or slow down the simulation. For more absorption/emission events, it helps to run fast, but for more clarity, it might help to slow down until you're used to observing. Observe when photons are absorbed by the box and emitted by the box.

   A. (___/1) When photons are absorbed, are all the absorbed photons the same color? _____

   B. (___/1) When photons are emitted, do they always have the same color as the originally absorbed

   photons? _____

   C. (___/1) When photons are emitted, do they always have the same direction as that of the absorbed

   photons? _____

2. When you turn the spectrometer on, notice that it records the color of the emitted photons, regardless of what direction the emitted photons travel in after the emission process. Turn the speed to fast, and then allow the spectrometer take data for at least three minutes. Make observations about the emitted photons according to color, energy, and number of photons of different energies.

   A. (___/1) Draw or screenshot the spectrometer results below

B. (___/1) Explain the results of the spectrometer readings. _____

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3. The de Brogie model of the atom is a fairly refined model that shows lot conceptually without being TOO complex. Switch to the de Broglie model and reset the spectrometer. Also note that since the electrons are in orbitals, you can click on an extra feature called the "electron energy diagram." Run the simulation with a white light source.

A. (___/1) What do you notice about the energy transition when the atom absorbs a photon? _____

_____

_____

B. (___/1) Are all the absorbed photons always the same wavelength (same colored dots)? _____

C. (___/1) What do you notice about the energy transition when the atom emits a photon? _____

_____

_____

D. (___/1) Are all the emitted photons always the same wavelength? _____

E. (___/1) Are all emitted photons the same wavelength as the photon absorbed that caused the last

energy transition? _____

F. (___/1) When absorption events occur from the ground state, what is the energy of the absorbed

photons? (In the light controls box, click on "Show absorption wavelengths". As you move the

index, its border will turn white when you hit an absorption wavelength.) _____

_____

_____

Notes:

- The Bohr model is similar to the de Broglie model, but your text talks about the electrons in orbitals having standing wave characteristics, and this model shows that well.

- The lifetime of an excited state is the amount of time it stays in the upper state before decaying to a lower energy state. Here, all states have about the same lifetime, but that is not the case in real life.

- This simulation is also specific to the hydrogen atom (in "unperturbed" form). It has certain distinct absorption and emission characteristics. The absorption and emission of all atoms is determined by their energy states which are MOSTLY defined by the nature of the atom itself, but can be "perturbed" (or shifted) by the environment the atom is in (what atoms it may be bonded too, etc.).

Interestingly, only the unperturbed hydrogen atom can be modeled exactly using quantum mechanics (but some approximation techniques are pretty good for other atoms, or even for whole molecules).

LASER MEDIUM BASICS

Find and open the simulation: "*Lasers*" and click on the play button.

- Click on "View Picture of Actual Laser" and read the description then close it.

4. Pumping A Two State System

A. (___/1) This simulation uses an "optical pump" as an energy source for a laser. Turn the light source on a medium level with the preset wavelength. What do you observe about the emitted photons? (Are they spontaneous emissions, stimulated emissions or both … and how can you identify this?)

B. (___/1) When you change the intensity of the light source to a very low level, what do you notice about the emitted photons?

C. (___/1) When you change the intensity of the light source to a very high level, what do you notice about the emitted photons?

D. (___/1) When you have the intensity at a medium level but decrease the lifetime, what do you notice about emissions?

E. (___/1) When you have the intensity at a medium level but increase the lifetime, what do you notice about emissions?

F. (___/1) When you tune the light to a color that has a lower energy than the preset color, what do you observe?

G. (___/1) When you tune the light to a color that has a higher energy than the preset color, what do you observe?

5. Pumping A Three State System

- Select "Reset All" and select 3 energy levels.

A. (___/1) Set the upper lamp control to a low setting while the left lamp control is off. Describe in detail what happens. _____

_____

_____

_____

B. (___/1) What characteristics do you observe about the emission events when you pump with the additional color? (Are all emissions the same color, are they stimulated, spontaneous, etc.?) _____

_____

_____

C. (___/1) Click on "display photons emitted from upper state." What transition do these photons represent, what color are they and what region of the electromagnetic spectrum do you think they come from? *If you are not sure, turn off the lamp control on the left.* _____

_____

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D. (___/1) When you in decrease the lifetime of the lower state what happens to the emission events?

_____

_____

6. Making a laser with a three state system.

A. (___/1) It is ideal to have a four-state system when making a laser, but a three state system isn't bad. Select "Reset All", "Three Energy Levels" and set the lamp controls to high. Are you able to achieve lasing power? _____

B. (___/1) Now "Enable Mirrors" and set lower transition to "Wave View". It may take a while, but what happens in the center of the laser when lasing power is achieved? _____

_____

C. (___/1) In real life, the energy levels of an atom are pre-determined by its electron configuration. If you wanted to use the simulator investigate other atoms in order to optimize the laser's energy, how would you change the atomic energy levels in the simulator?

_____

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D. (___/1) When you do this, what must be done to the frequency of the light? _____

_____

_____

E. (___/1) Use what you have learned to build a high powered laser (danger power levels). What are the conditions (settings) you used to make this occur? _____

_____

_____

7. Bonus Challenge (3 pts): This is a chance to do what you've wanted to do from the start -- blow something up. Click on the "Multiple Atoms (Lasing)" tab. Create a laser that will generate more energy than it can handle and paste a screen shot of it below just before it blows.