References:

- OpenStax Chemistry: Section 6.1
- OpenStax Chemistry (Atoms First): Section 3.1
- OpenStax Astronomy: Section 5.5
- OpenStax Physics: Chapter 24

Objectives:

- Explain how emission line and absorption line spectra are formed.
- Use appropriate equations to calculate related light-wave properties such as frequency, wavelength, and energy.

Light comes from electronic transitions within an atom. Hydrogen is easy to study because this atom contains only one electron, and the electronic energy levels within an atom are degenerate.

The energy levels in an atom are described by the equation: $E = \frac{-R_H}{n^2}$

Where E = energy

R_H = Rydberg constant for hydrogen (2.179×10^{-18}J)

n = energy level

Working in a group of 4, each member will calculate the energy of an electron in a hydrogen atom corresponding to energy levels n = 1 → n = 4.

Name	Energy Level	Energy (J)
1	n = 1	
2	n = 2	
3	n = 3	
4	n = 4	

Show a sample calculation:

Now determine the changes in energy when an electron transitions from one energy level to another. The difference in energy, can be calculated by subtracting the final energy from the initial energy, $\Delta E = E_f = E_i$.

Energy Level	1 (final)	2 (final)	3 (final)	4 (final)
1 (initial)				
2 (initial)				
3 (initial)				
4 (initial)				

Show a sample calculation:

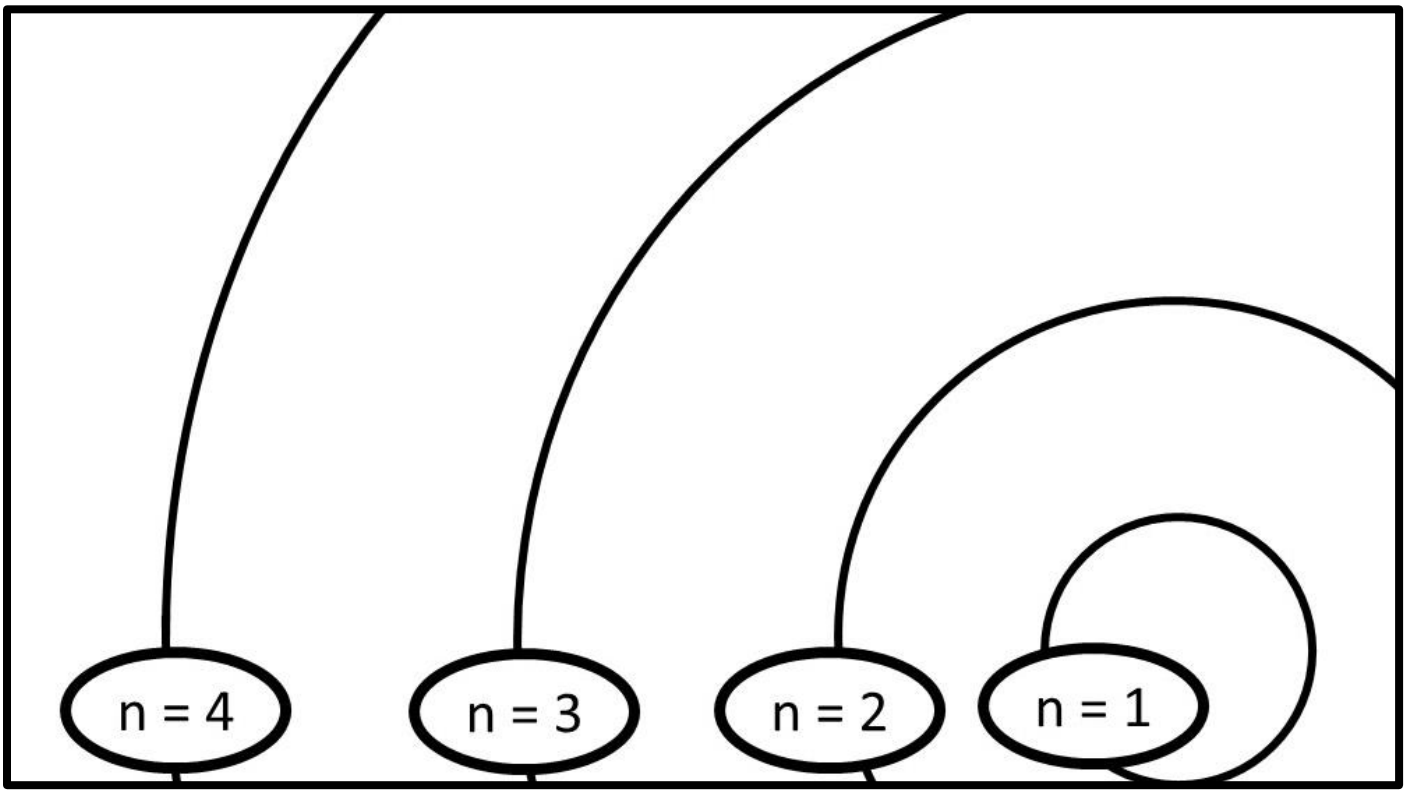
Note the sign of ΔE. Is this positive or negative? What does this mean about the light that is related to this transition?

_____
_____
_____
_____

What trend is observed between energy level transition and the amount of energy released? Is the difference between energy levels the same (i.e. is the difference between n = 1 and n = 2, the same as the difference between n = 2 and n = 3)?

_____
_____
_____
_____

Fill in the following diagram using arrows to show the transitions and label these arrows with the energies calculated in the previous table.



The energy of a photon, E, is related to the frequency of a photon by: $E = h\nu$

where E is energy

h is Planck's constant 6.626×10^{-34} Js

ν is the frequency of the photon emitted.

Prediction:

Rank the positive energies from lowest frequency to highest frequency (before calculating values):

_____<_____<_____<_____<_____<_____

lowest frequency highest frequency

What transitions do these correspond to?

_____ _____ _____ _____ _____ _____

Calculate the frequencies for the transitions (s^{-1}).

Energy Level	1 (final)	2 (final)	3 (final)	4 (final)
1 (initial)				
2 (initial)				
3 (initial)				
4 (initial)				

Show a sample calculation:

Evaluation

Were your predictions correct? If not, why?

_____
_____
_____
_____

What is the relationship between photon energy and frequency?

_____
_____
_____
_____

What trend is observed between energy level transitions and energy released?

_____
_____
_____
_____

What trend is observed between energy level transitions and frequency?

_____
_____
_____
_____

Frequency is related to wavelength by the equation: $c = \nu\lambda$,

where c is the speed of light (3.00×10^8 m/s)

ν is frequency

λ is wavelength

Prediction

Rank the positive energies from shortest wavelength to longest wavelength (before calculating values):

_____<_____<_____<_____<_____<_____

shortest wavelength longest wavelength

What transitions do these correspond to?

_____ _____ _____ _____ _____ _____

Calculate the wavelengths associated with these transitions (nm).

Energy Level	1 (final)	2 (final)	3 (final)	4 (final)
1 (initial)				
2 (initial)				
3 (initial)				
4 (initial)				

Show a sample calculation:

Evaluation

Were your predictions correct? If not, why?

_____
_____
_____
_____

What is the relationship between photon energy and wavelength?

_____
_____
_____
_____

What trend is observed between energy level transitions and wavelength?

_____
_____
_____
_____

Were any of the calculated wavelengths the same? What does this mean?

_____
_____
_____
_____

Concept Application

The sun is primarily comprised of hydrogen, but it emits white light due to the closeness of atoms in the sun. In the early 1800s Joseph von Fraunhofer observed that several parts of the spectrum were missing from the sun, and one of these missing parts was measured at a wavelength 656.3 nm. Why is this line missing from the solar spectrum, despite being made of mostly hydrogen?

_____
_____
_____
_____
_____
_____
_____
_____
_____