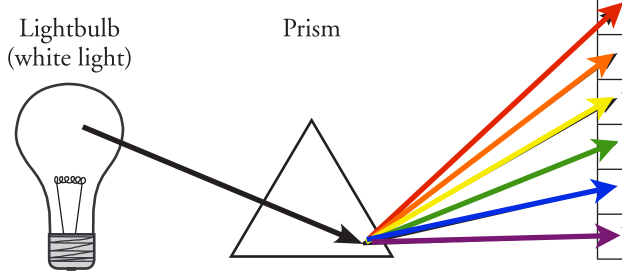
From fireworks to stars, the color of light is useful in learning about the inside of atoms. The emission of light by hydrogen and other atoms has played a key role in understanding the electronic structure of atoms. Trace materials, such as evidence from a crime scene, lead in paint or mercury in drinking water, can be identified by heating or burning the materials and examining the color(s) of light given off by an element when "excited" by the introduction of energy from an outside source, resulting in the emission of a bright-line spectra.

White Light



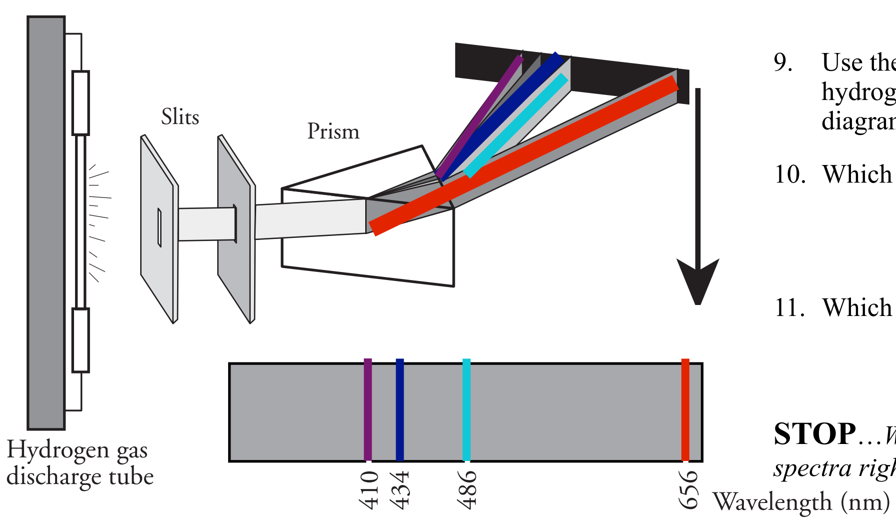
Color	Photon Energy ($\times 10^{-21}$) (J)	Wavelength Range (nm)	Speed (m/s)
Reds	269–318	625–740	3.00×10^8
Oranges	318–337	590–625	3.00×10^8
Yellows	337–352	565–590	3.00×10^8
Greens	352–382	520–565	3.00×10^8
Blues	382–452	440–520	3.00×10^8
Violets	452–523	380–440	3.00×10^8

1. Trace the arrows in the diagram above and shade in the table with the appropriate colored pencils.
2. What happens to white light when it passes through a prism? splits into all the colored wavelengths
3. Why are the color labels in the table above plural (i.e., "Reds" rather than "Red")?

   Red is a wide range of wavelengths
4. Do all colors of light travel at the same speed? Yes, at 300,000,000 meters per second
5. Do all colors of light have the same energy? If no, which colors have the highest energy and the least energy, respectively?

   No, purple has the highest energy, red has the lowest energy.
6. Which color corresponds to the longest wavelengths? red
7. Which color corresponds to the shortest wavelengths? purple
8. Write a sentence that describes the relationship between wavelength and energy of light.

   The energy and wavelength are inversely proportional.



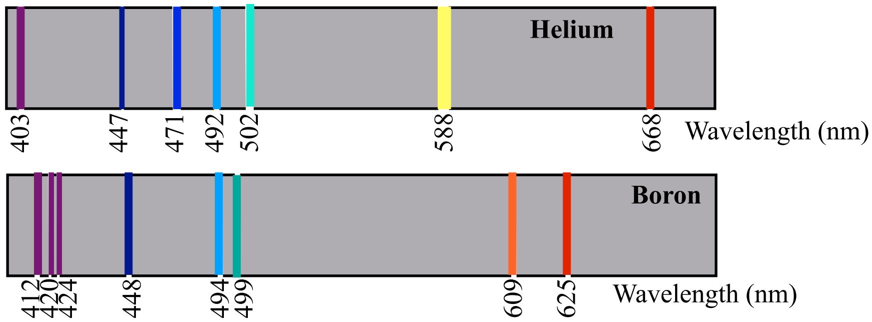
9. Use the appropriate colored pencils to color the hydrogen emission spectral lines as shown in the diagram.
10. Which color of light has the most energy?

    purple
11. Which color of light has the least energy?

    red

STOP…*We will look at an actual hydrogen emission spectra right now.*

12. The spectral lines shown below are for helium and boron and were produced using the same method as the hydrogen shown on the previous page. Use the appropriate colored pencils to color the emission spectral lines.



13. "The spectral lines for atoms are like fingerprints for humans." What does this statement mean, and how do the emission spectra for hydrogen, helium, and boron support this statement?

   Spectral lines are unique to each element, like fingerprints are unique to each human. Hydrogen, helium, and boron's emission spectra are all unique.

Circle the appropriate word to complete each statement in Questions 15–18.

14. Electrons and protons *attract* / *repel* each other.

15. As an electron gets closer to the nucleus the *attraction* / *repulsion* to the nucleus gets *stronger* / *weaker*.

16. For an electron to move from an energy level close to the nucleus to an energy level far from the nucleus the electron would need to *absorb* / *lose* energy.

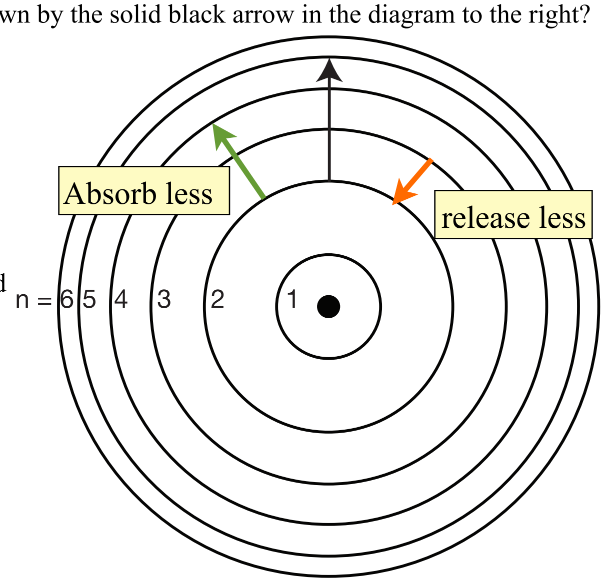
17. For an electron to move from an energy level far from the nucleus into an energy level closeer to the nucleus the electron would to *absorb* / *lose* energy.

STOP and read this before proceeding….and check in with the teacher before moving on to #19

Niels Bohr (of the quarter Bohr diagram in the corner of the whiteboard) modified Rutherford's Nuclear Atom model to explain how light interacted with the electrons in an atom to produce spectral lines. His model included electrons orbiting the nucleus at specific energy levels. Electrons absorb energy from various sources, such as heat, light, or electricity, and the electrons move from lower energy levels (*ground state*) to higher energy levels (*excited states*). Energy is released as electrons return to their lower energy levels. In the hydrogen atom, **visible** light is released whenever electrons transition back to to the second energy level.

18. Is energy *absorbed* or *released* for the electron transition shown by the solid black arrow in the diagram to the right? Explain how you know.

   Energy is absorbed. Moving an electron away from the positive proton that is holding it, would require an input of energy.



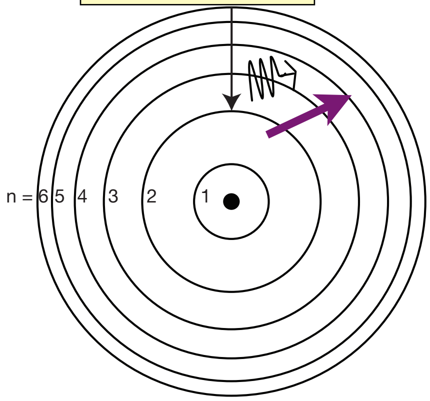
19. Sketch in a green arrow that would represent an electron transitioning in the same direction as the black arrow, but would be a transition of less of energy.

20. Sketch in a red arrow that would represent an electron transitioning in the opposite direction as the black arrow, and would be a transition of less of energy.

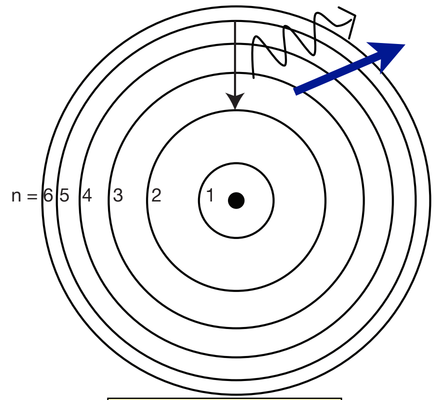
Each of the diagrams below represents a transition in the hydrogen atom that causes one of the colored spectral lines as represented at the bottom of page 1.

21. Identify the diagram below that depicts a hydrogen atom with an electron moving from energy level 3 to energy level 2. Label that diagram with "n=3 to n=2," list the appropriate wavelength, and color the wavy line with the correct color as on the bottom of page 1 to represent the appropriate corresponding color of light emitted. Complete each of the following statements by circling the appropriate word(s).
    - (a) This 3 to 2 electron transition *absorbs* / ***releases*** energy.
    - (b) This electron moves from a *lower* / ***higher*** energy state to a ***lower*** / *higher* energy state.
    - (c) Light is *absorbed* / ***released*** in the 3 to 2 electron transition.

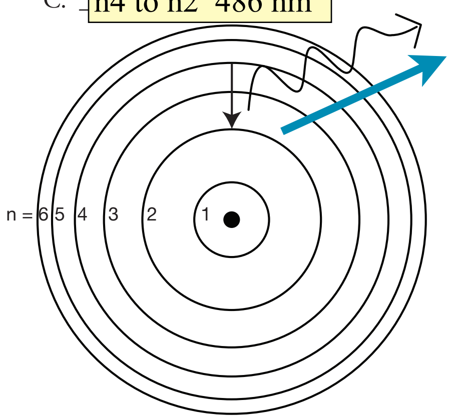
A. n6 to n2 410 nm



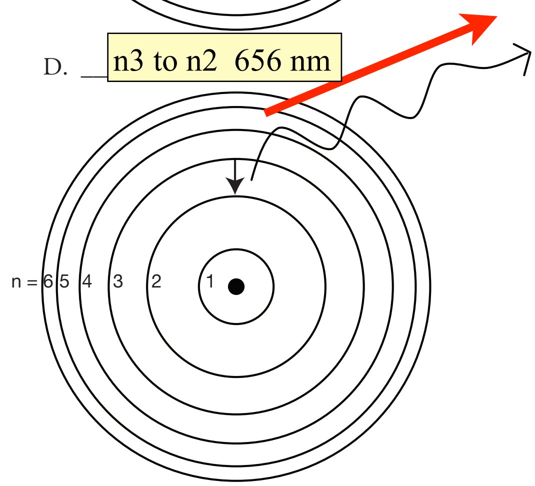
B. n5 to n2 434 nm



C. n4 to n2 486 nm



D. n3 to n2 656 nm



22. Label the remaining drawings above with the electron transitions that are occurring (n=? to n=?), the wavelengths, and the color the the wavy line to represent the corresponding color of light emitted.

23. Consider the electron transitions in the diagram above.
    - (a) Which of the electron transitions shown involves the most energy? How do you know?

      Diagram A, n6 to n2 The transition is the greatest movement.

    - (b) A *single* atom of hydrogen can NOT produce all four hydrogen spectral lines simultaneously. Suggest why not?

      A single atom of hydrogen has only one electron, thus could only do one transition at a time.

    - (c) Given that statement in (b) is true, how is it that we could see **all four** colors from our hydrogen gas discharge tube simultaneously?

      There are LOTs of hydrogen atoms in the tube all making various transitions simultaneously.

24. The hydrogen spectral emission lines shown on the previous pages represent the wavelengths of light that are in the **visible** range and can be "seen" by the naked eye. However, many other wavelengths can be detected with special equipment. All four of the visible light transitions were to the second energy level, but electron transitions within hydrogen that cause energy emssions that are not visible are transitions to energy levels other than level 2. Because of the proximity of energy level 1 to the positively (and oppositely) charged nucleus, all transitions to the first energy level are the **highest** energy.

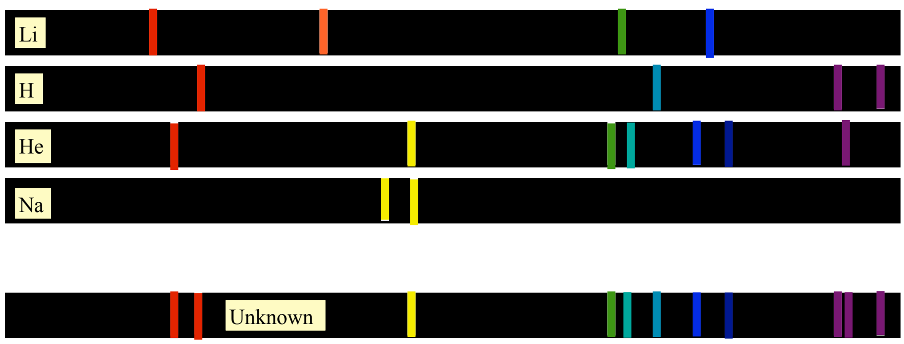
(a) Movement of a hydrogen elect any higher than 3rd nergy level t 3rd or higher energy level might be a transition that involves light with a wavelength in the infrared (IR) range (1000–706 nm). Justify your choice of energy levels?

These are transitions of LOW energy since the transitions are further from the nucleus.

(b) Movement of a hydrogen electron from ___any___ level to ___first___ energy level might be a transition that involves light with a wavelength in the ultraviolet (UV) range (10–400 nm). Justify your choice of energy level?

Transitions to first energy level put the electron closest to the nucleus where the attraction is the greatest.

25. Below are four diagrams for the bright line spectra of four elements and then the spectrum of a mixture of gases. Look to the white board and use your colored pencils to shade in the correct colors on the emission spectra shown below.



(a) Is the high-energy end of the emission spectra shown below at the *left* or *right* side?

(b) What do you notice about the way the emission spectra above were drawn on this page compared to the hydrogen and boron emission spectra shown on page 1 & 2?

This is backwards to the way the spectra are drawn on page 1 & 2

(c) Which element(s) are NOT present in the Unknown? How can you tell?

NO Na since there is only 1 yellow line and NO Li present since there is no orange line

(d) Which element(s) ARE in the Unknown? How can you tell??

H and He are present since the lines of both elements are shown