How the Sun Works Unit

Week 2 – What's inside the sun?

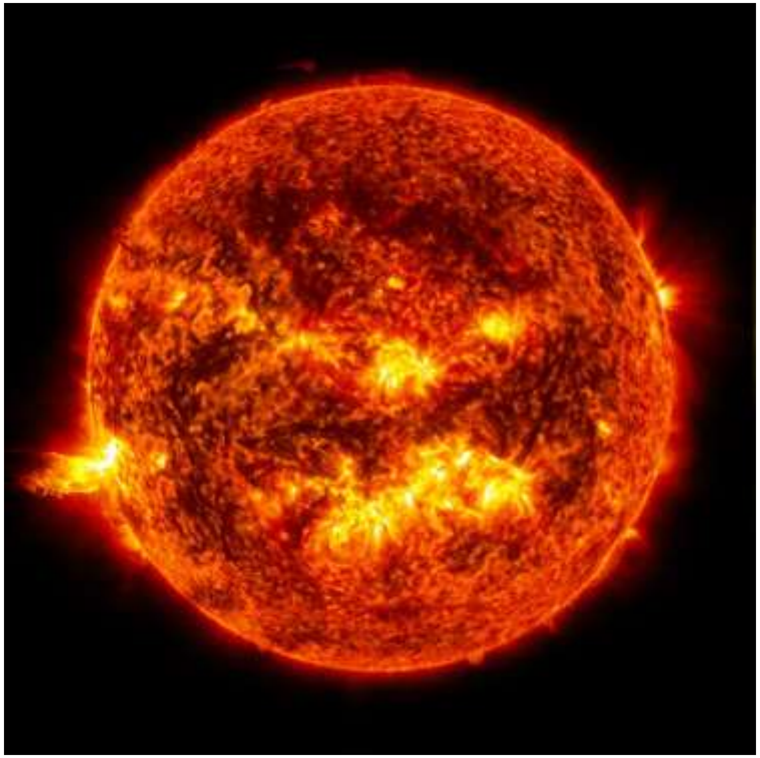
WATERFORD ASTRONOMY

1

Carbon TIME *Developed from Carbon TIME materials (carbontime.bscs.org). Used with permission.*

Sun Unit – W2 Driving Question

- **This week's driving question: What's inside the sun?**
  - How can we measure what is in the sun if we can't visit the sun?
  - What is sunlight?
  - Can the structure of the sun tell us anything about its function?



Studying the Sun

- **The sun is too far away and too intense to study directly.**
  - However, the earth is bombarded by light and other forms of radiation from the sun.
  - Most of our understanding of the sun as well as the rest of the universe emerged from the analysis of this radiation.

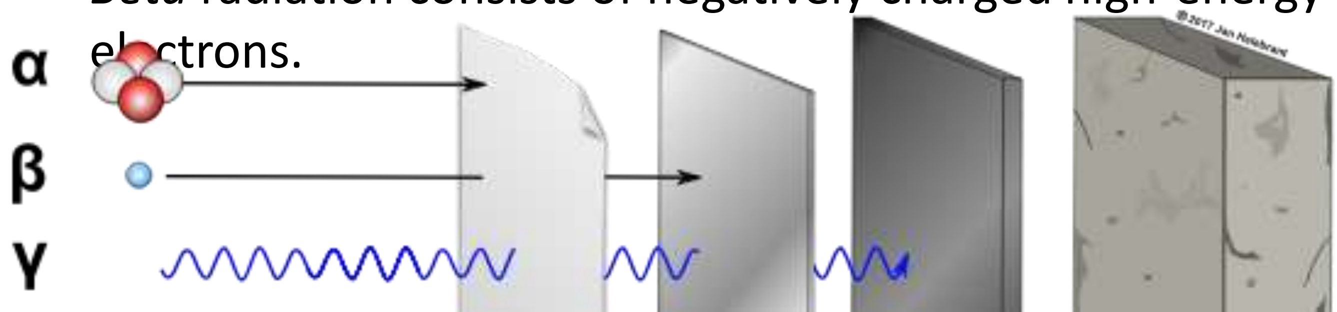
Radiation

– **<u>Radiation</u> is emitted energy (or *energy that moves*)** .

- Most often, the radiation we experience is <u>electromagnetic radiation</u> (or *gamma* radiation), which consists of moving waves of energy.
- Examples include light (<u>*photons*</u>), as well as X-rays and microwaves.
- The size of the wavelength determines the type of the EM radiation (e.g., radio waves have the shortest wavelengths; x-rays are among the longest).

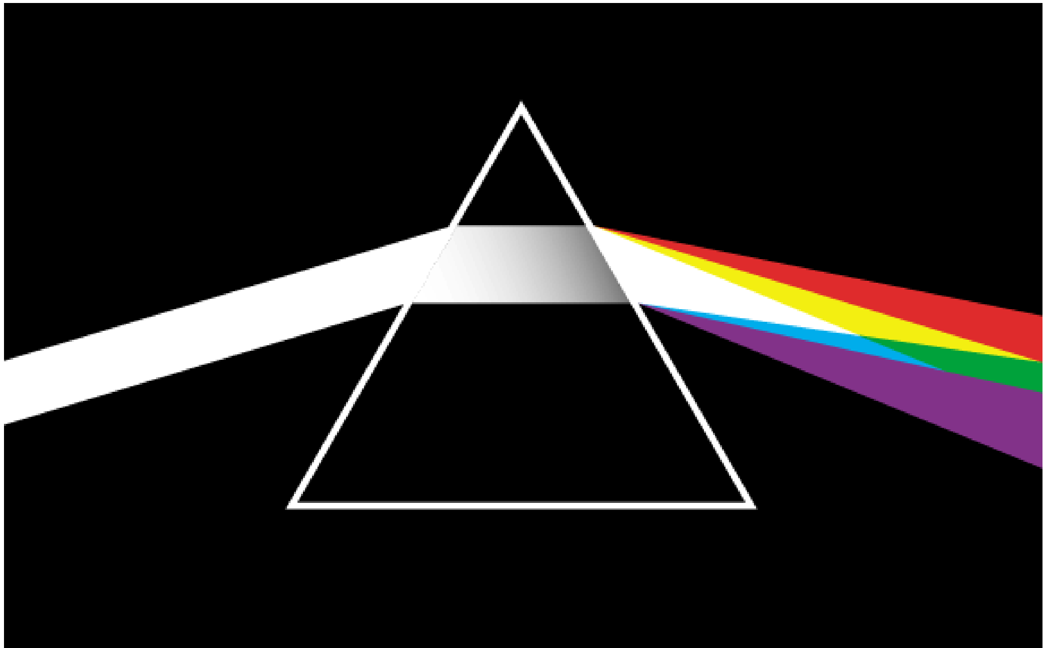
– **Radiation can also exist as moving subatomic particles**.

- *Alpha* radiation entails positively charged protons and neutrons
- *Beta* radiation consists of negatively charged high-energy electrons.



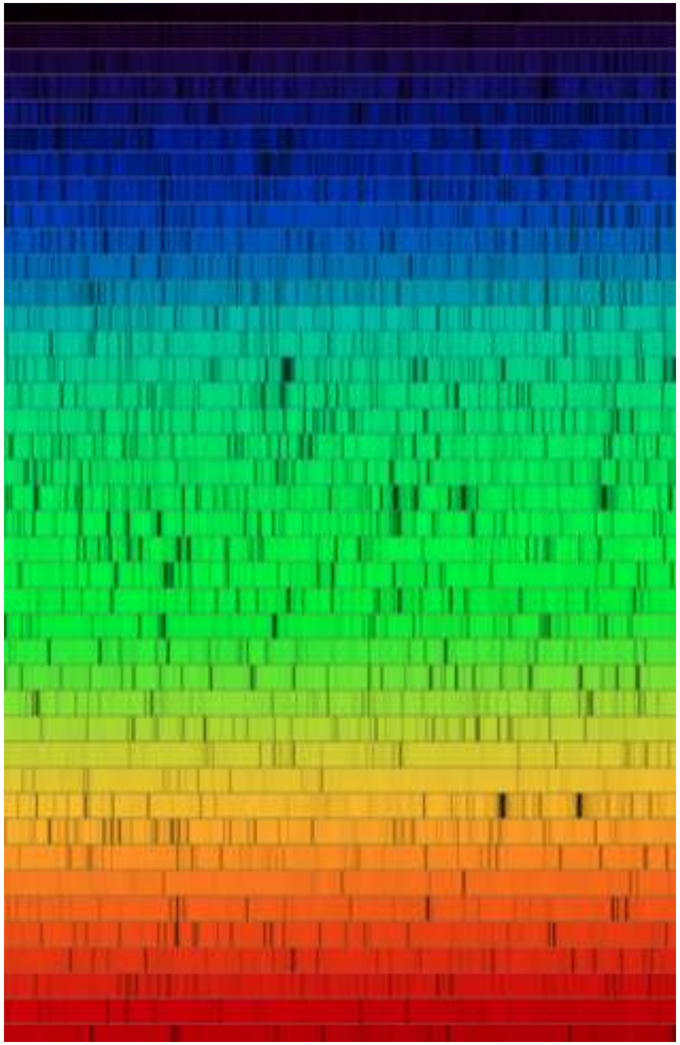
Spectroscopy

- **<u>Spectroscopy</u> is the study of diffracted light.**
  - Diffraction is the 'bending' of light around an object.
  - For example, Isaac Newton was the first to demonstrate that when white light passes through a prism, it is *dispersed* into a full color spectrum.



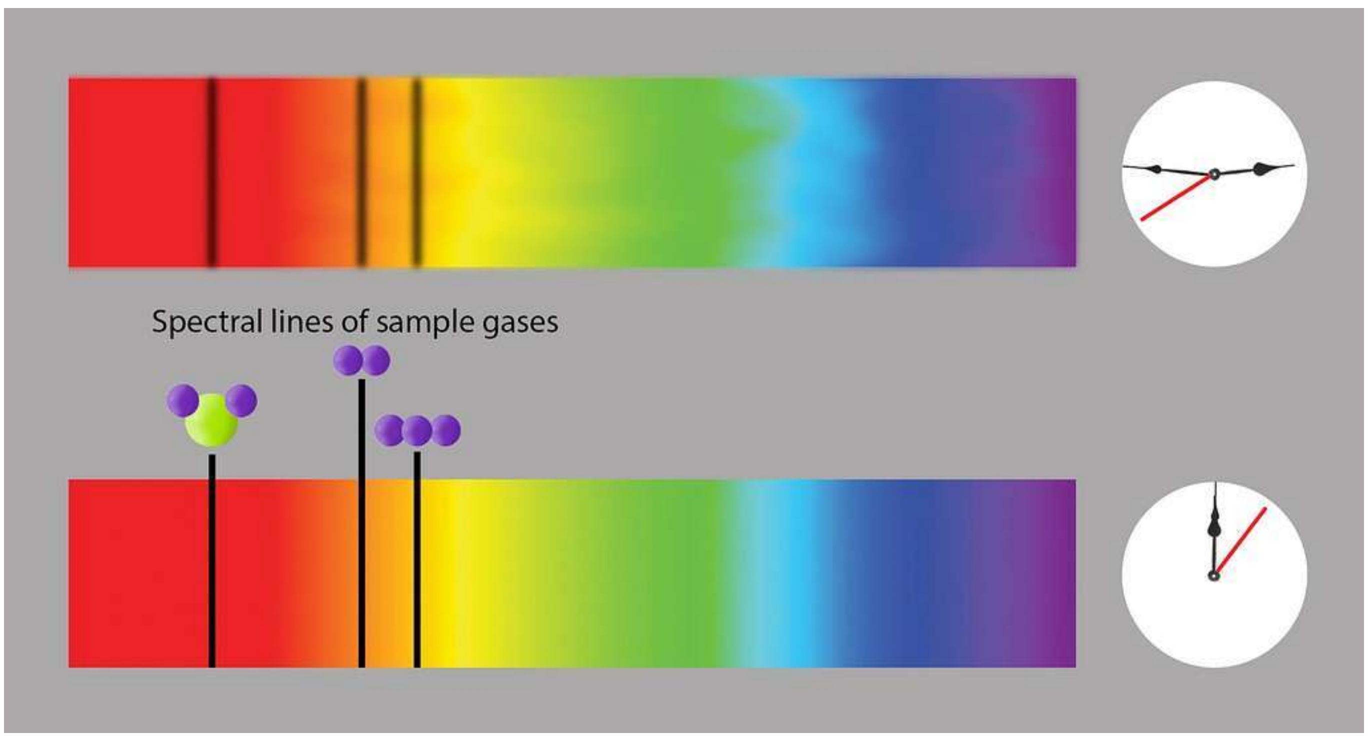
“Gaps” in the light

- **As scientists began to develop more accurate and precise prisms, they noticed “gaps” in the light.**
  - Instead of uniform bands of light, dark bands sometimes appeared between colors (the spectral signature).
  - When light moves through clear containers of different gases, each gas has a unique banding pattern.



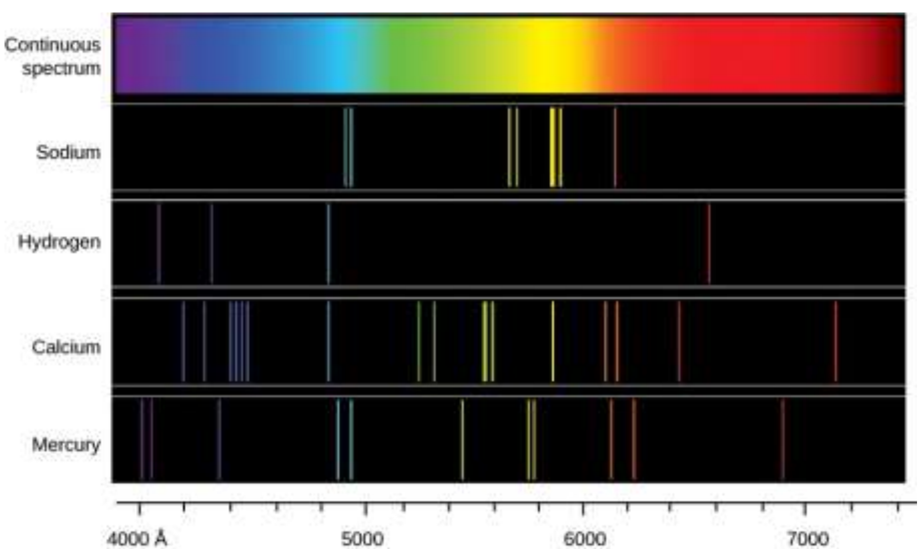
Spectral Signatures

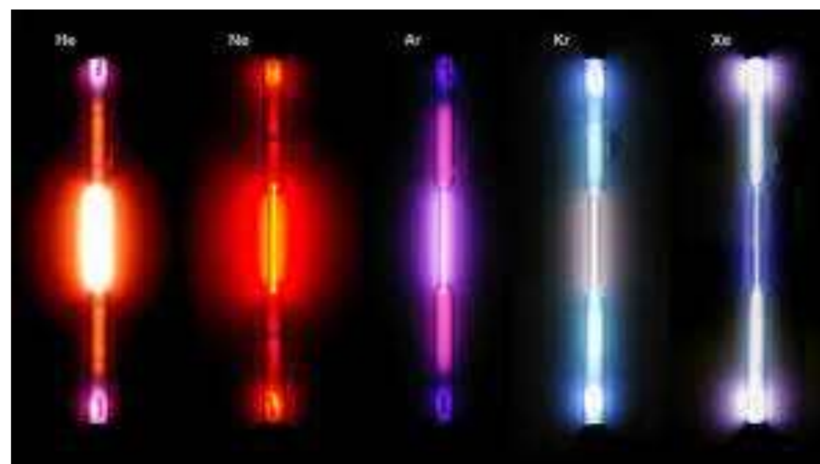
- **Scientists soon realized that each gas had a particular pattern of "gaps" associated with it.**
  - When light passed through a gas, it "lost" light in predictable places that were specific to each kind of gas.



Glowing Gases

- **Similarly, scientists observed that if gases were heated, they "glowed" with particular colors**.
  - These were the same colors that were missing from the gaps when light was shown through the gases.
  - Heated gases only emitted light at certain specific wavelengths of light (i.e., in specific colors).

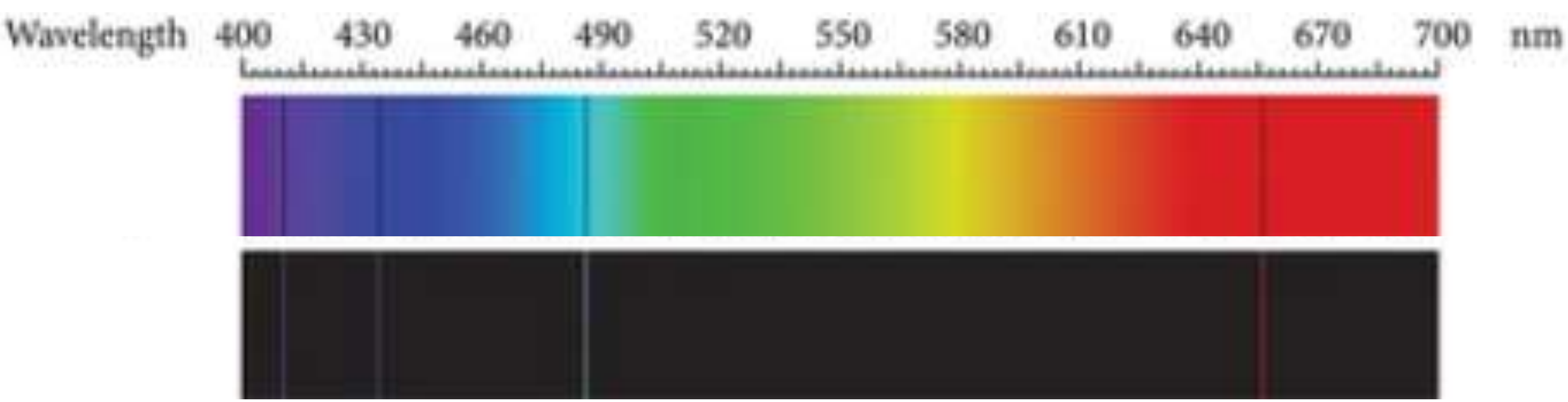




Source: https://courses.lumenlearning.com/astronomy/chapter/spectroscopy-in-astronomy/

Absorption vs. Emission Lines

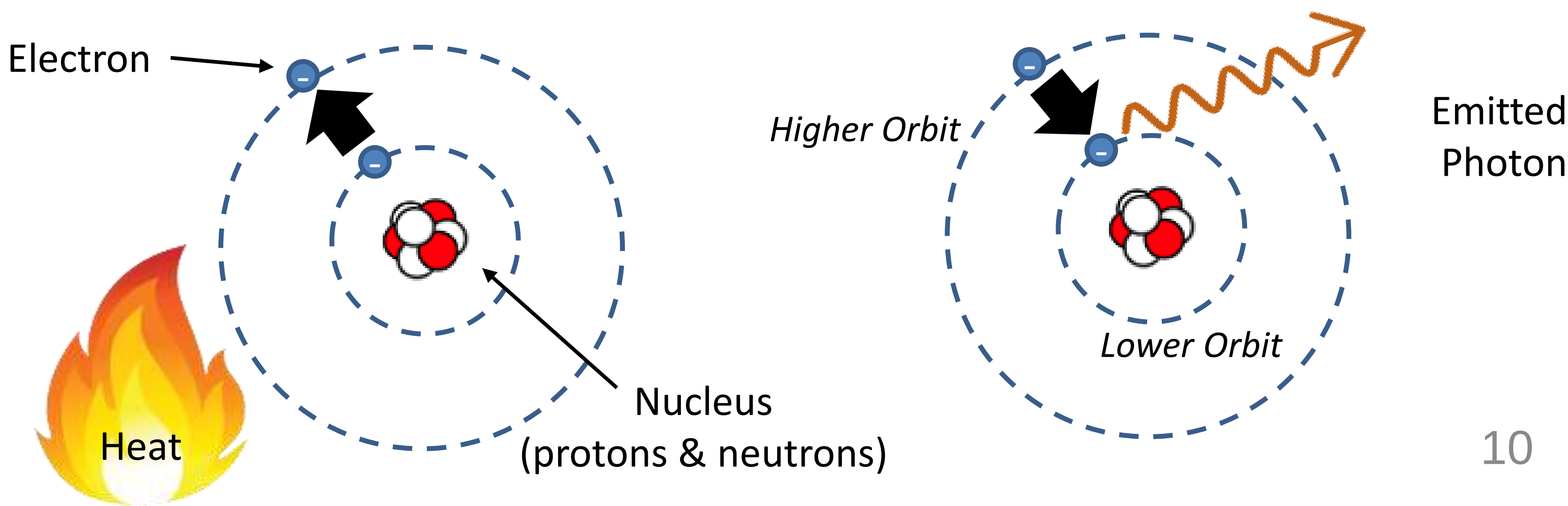
- **If light passes through a gas (*such as hydrogen, shown below*), it is absorbed at specific wavelengths.**
  - This can be observed as <u>absorption lines</u>, or 'gaps' in light.
- **If a gas is heated, it only releases light in specific wavelengths.**
  - These appear as <u>emission lines</u> or individual bands of light at specific wavelengths.
- **The gaps in absorption lines match up with the wavelengths of light produced in emission lines**.



Source: www.shutterstock.com

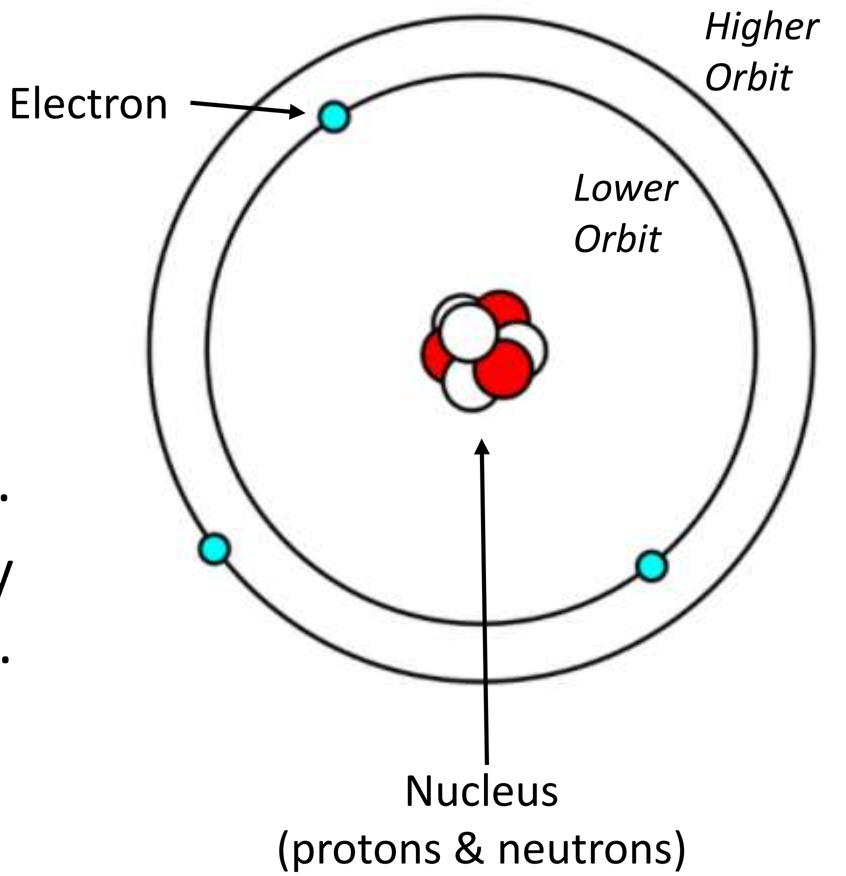
Spectral Signatures

- **Each element produces a unique <u>spectral signature</u> (color pattern) because of its subatomic properties**.
  - When an electron absorbs energy (such as heat), it moves to a higher orbit around the atom's nucleus.
  - When the electron moves back to a lower orbit, it releases this energy as specific wavelengths of light (*photon*).



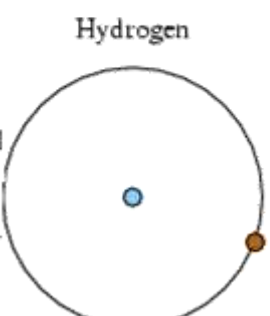
Reminder: Parts of the Atom

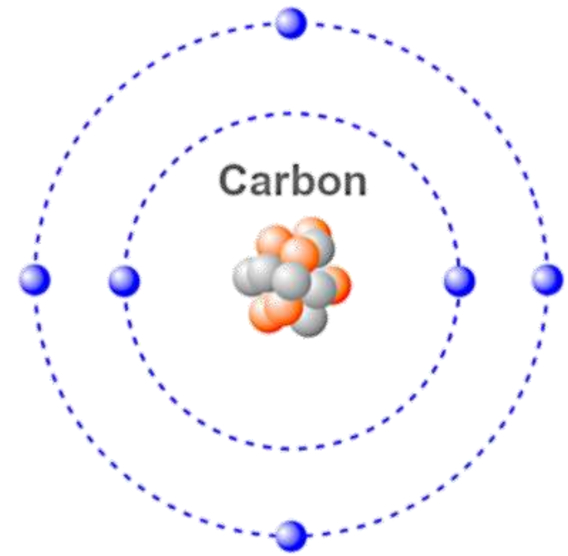
- **<u>Protons</u> – positively charged particles in the nucleus**.
  - The number of protons determines the element.
- **<u>Neutrons</u> – neutral particles in the nucleus**.
- **<u>Electrons</u> – negatively charged particles that orbit the nucleus**.
  - Electrons that absorb energy can move to a higher orbital.
  - When electrons drop to a lower orbital, they emit energy as a photon of light.



Why are there differences?

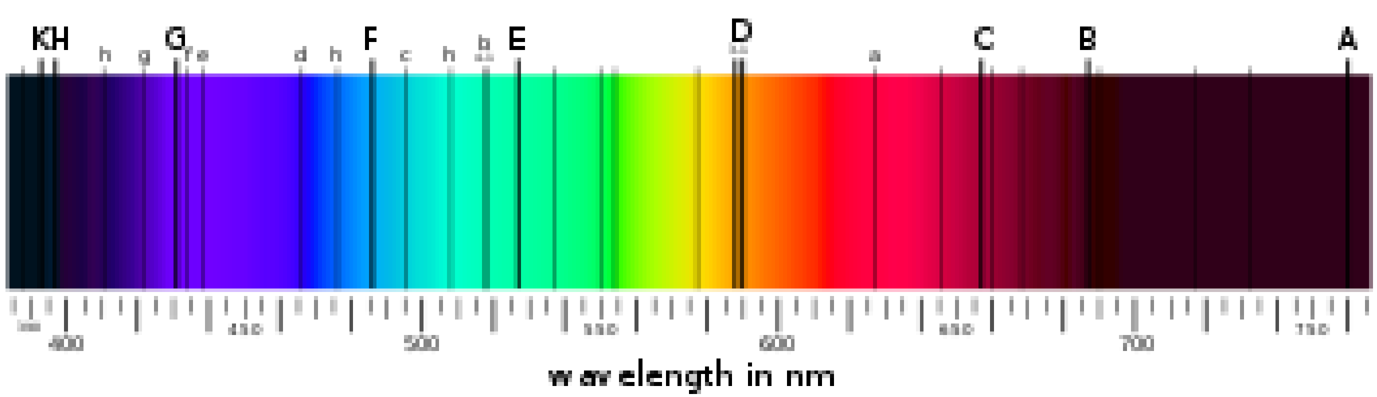
- **Each element has a specific number of protons in its nucleus**.
  - To be electrically neutral, an element needs to have equal numbers of positive protons and negative neutrons.
  - Elements with greater numbers of protons can support more orbiting electrons, resulting in increasingly complex spectra.
- **For example, a hydrogen atom only has one proton and one neutron. As a result, hydrogen has a simple spectra.**
  - However, a carbon atom has six protons and (usually) six electrons →
  - This can result in a wide variety of transitions between orbital levels among these electrons.





Interpreting Spectral Bands

- **The light emitted by an object (such as a star) will create a unique spectral signature based on the elements it contains.**
  - The banding pattern, and the intensity of each pattern indicates the atomic components of the source of light.
  - Spectral analysis of our solar system's sun indicates that it is roughly 70% hydrogen, 28% helium, and 2% carbon, nitrogen, oxygen, and other trace elements.



Revisions to W2 Driving Question

- **Can we now improve our answers to our driving questions?**
- **What's inside the sun?**
  - How can we measure what is in the sun if we can't visit the sun?
  - What is sunlight?
  - Can the structure of the sun tell us anything about its function?