LAB 2

SPECTRA OF GASES AND SOLIDS

RUBRIC

ASTR 101 Spectra Rubric: /15 + /6 + /21 + /18 + /24 + /6 + /10(neatness) = /100

Grade Value	0	1	2	3	Weight
Objective & Introduction	Content missing	Basic content. Non-scientific jargon and wording. Difficult to understand sentences.	Acceptable content. Some attempt at scientific terminology. Sentences acceptable.	Excellent content. Proper use of jargon and scientific wording. Assumptions noted and justified.	5
Grade Value	0	1	2	3	Weight
Procedure	Content missing	Basic content. No special equipment described, minimal description of procedure, no discussion of measurement uncertainties.	Acceptable content. Special equipment noted, important points of procedure noted, basic discussion of measurement uncertainties.	Excellent content. Special equipment addressed and discussed, procedure detailed and informative, measurement uncertainties noted.	2
Grade Value	0	1	2	3	Weight
Observations, Tables & Graphs	Content missing	Basic content. Incomplete information. Tables missing title, or other details. Graphs missing titles, labels, and/or too small. Sketches lacking detail.	Acceptable content. Minor details missing from graphs, tables and sketches, but all major details present.	Excellent content. Tables and graphs complete. Observations thorough.	7
Grade Value	0	1	2	3	Weight
Answers	Content missing.	Basic content. Questions answered simplistically; answers show lack of insight. Results not clearly discussed. Units neglected. No link between objective and results.	Acceptable content. Questions mostly answered correctly. Results mentioned, with spotty units. Weak link provided between objective and results.	Excellent content. Questions answered in detail. Clear connection between objective and results. Units clearly included.	6
Grade Value	0	1	2	3	Weight
Discussion	Content missing.	Basic content. Lacking discussion about expectations, assumptions, and consistency. No discussion about broader context.	Acceptable content. Limited discussion of expectations, assumptions and consistency. Limited discussion of broader context.	Excellent content. Expectations, assumptions and consistency clearly and correctly addressed. Broader context discussed.	8
Grade Value	0	1	2	3	Weight
Conclusion & References	Content missing.	Basic content. Conclusion unclear or lacking insight. References limited or missing.	Acceptable content. Correct conclusion but limited. Some references included.	Excellent content. Conclusion correct and focused. Detailed references included.	2

LAB 2: SPECTRA OF GASES AND SOLIDS

LEARNING OBJECTIVES:

- Nature of light = electromagnetic radiation.
- Generation of a spectrum.
- Types of spectra (continuum, absorption and emission).
- Identification of an element by its spectrum.

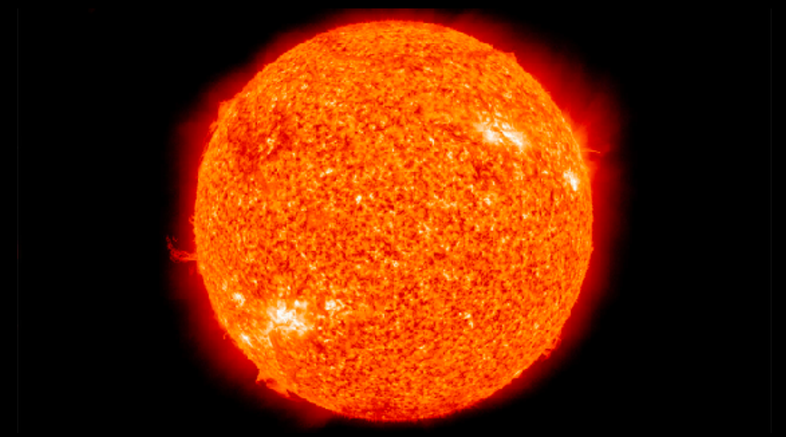
LIGHT = VISIBLE PART OF EM RADIATION

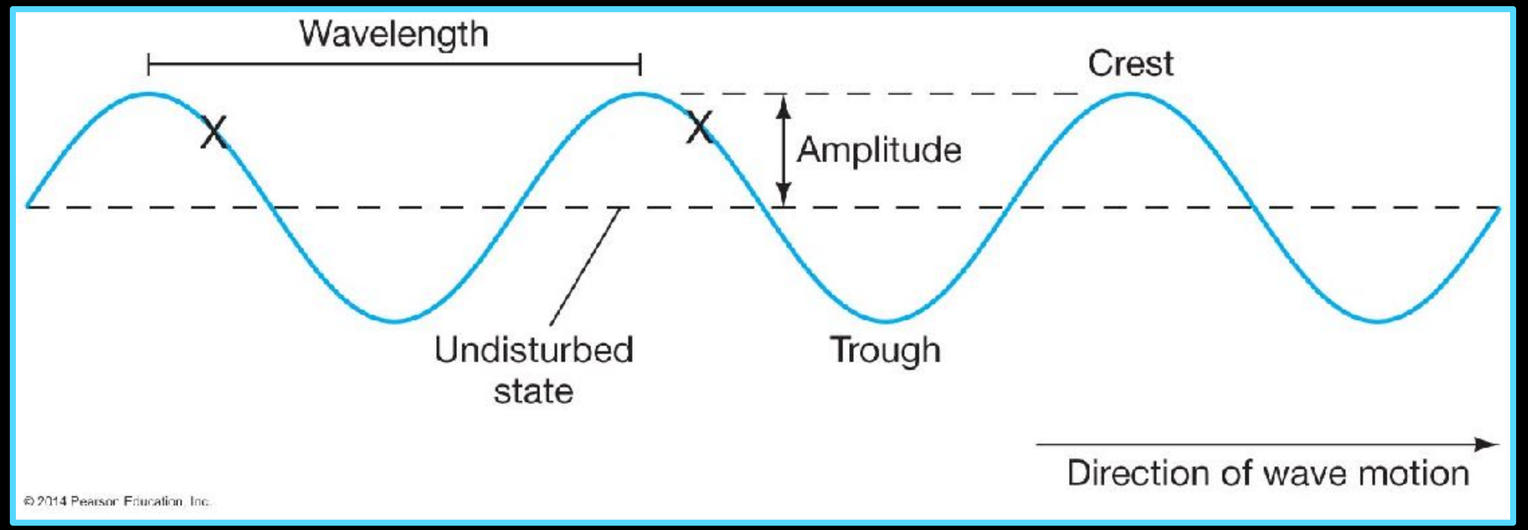
VERY SPECIAL NATURE OF LIGHT

Light = Particle (photon)

Light = Wave (electromagnetic radiation)

Light = Needs no medium (travels in vacuum)

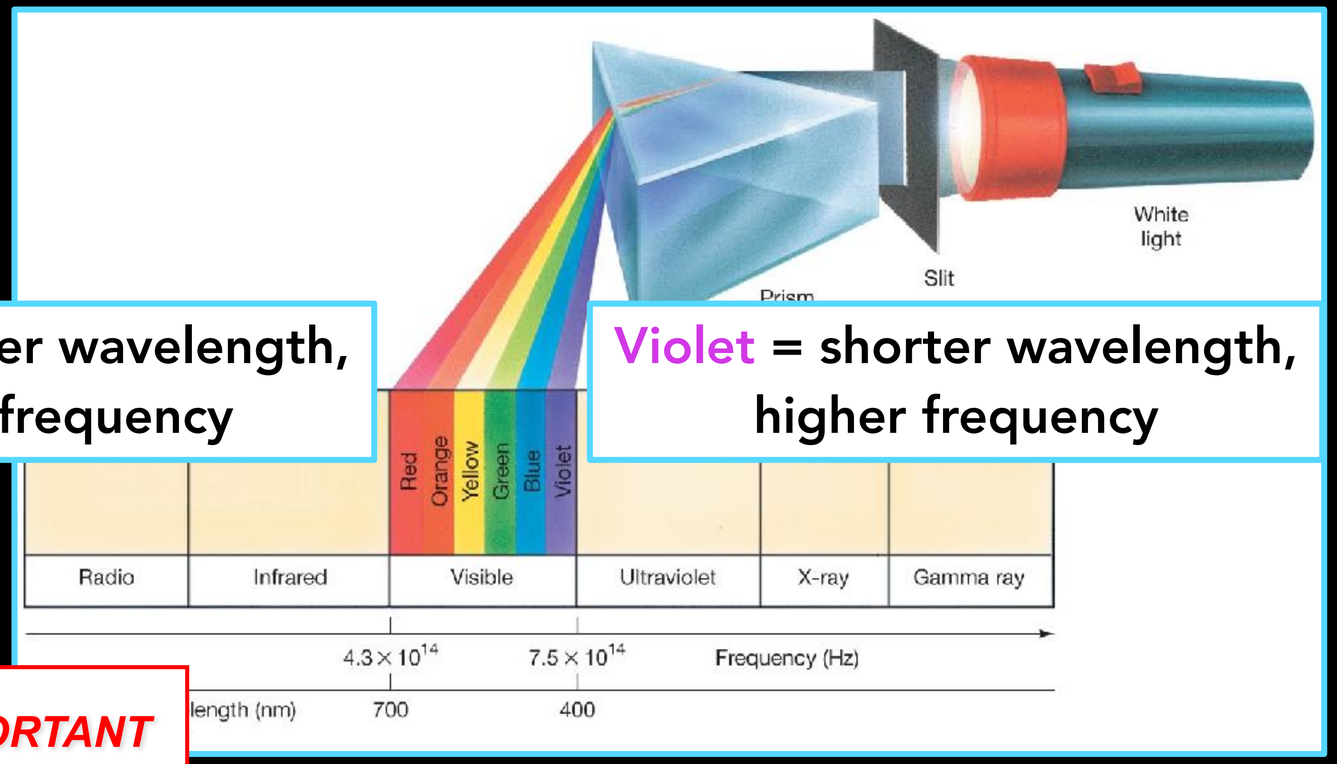




Properties of a wave:
Speed
Frequency
Wavelength

ELECTROMAGNETIC RADIATION

- White lights is composed of many colors (Rainbow)



Red = longer wavelength, lower frequency

Violet = shorter wavelength, higher frequency

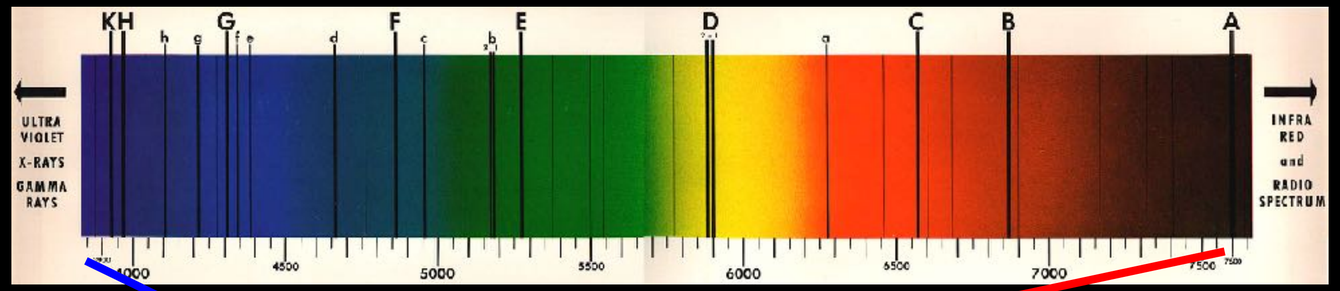
IMPORTANT

Speed of light = frequency x wavelength

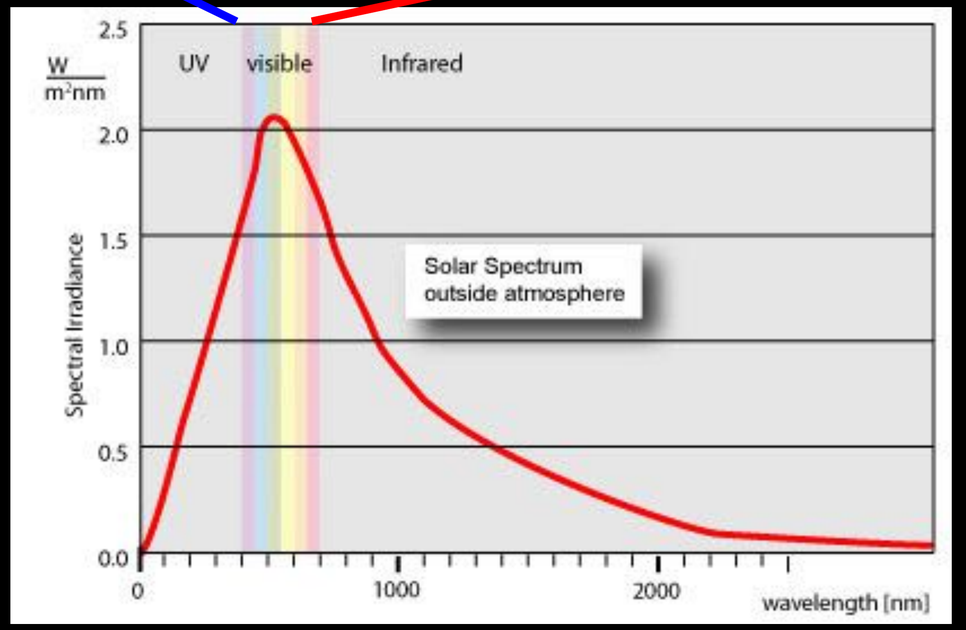
Speed of light = 300,000 km/s (Universal constant!)

SPECTROSCOPY = STUDY OF THE SPECTRA OF OBJECTS

Image of a spectrum



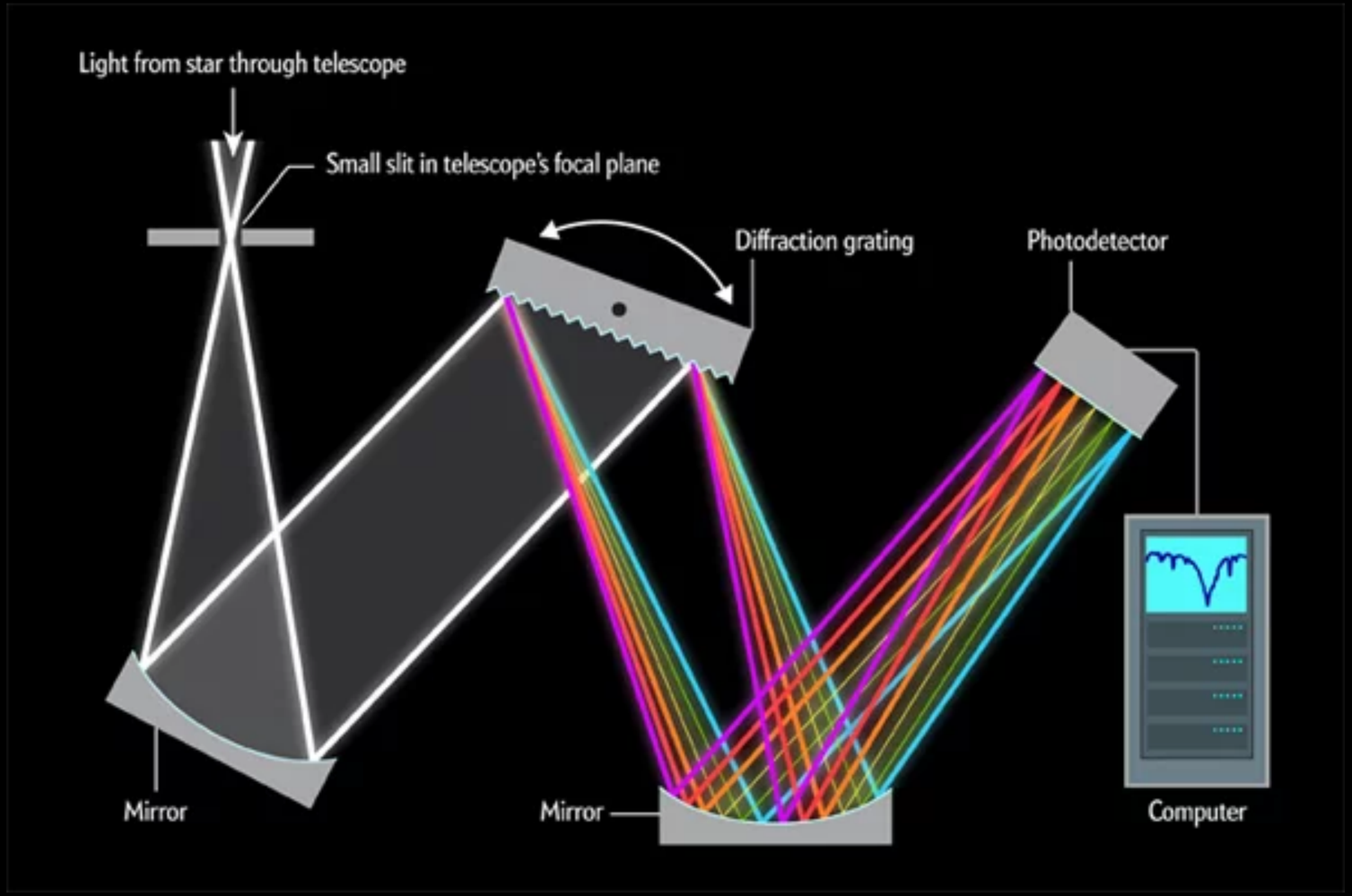
Measured Intensity vs. Wavelength



Most of Sun's energy is in green light!

SPECTRUM = DISPERSE LIGHT INTO MANY COLORS (AKA FREQUENCIES)

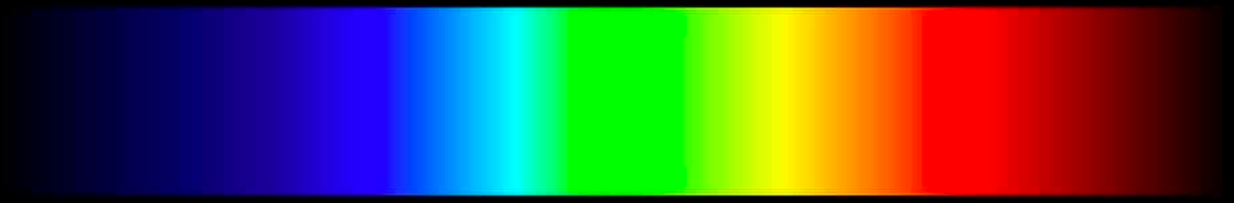
- Instrument = Spectrograph.
- Spectrograph measures the amount of energy (= intensity) at all frequencies.

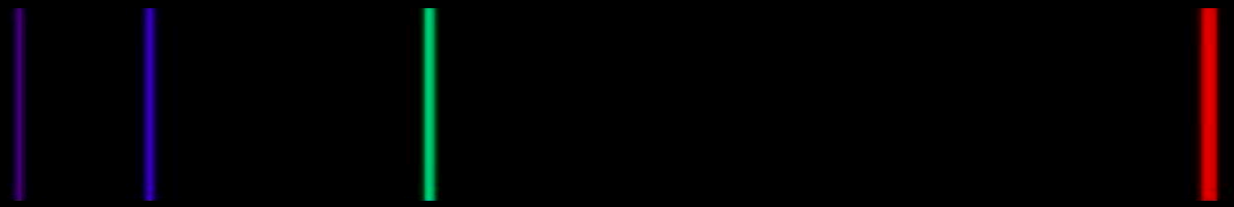


SPECTROSCOPY = STUDY OF THE SPECTRA OF OBJECTS

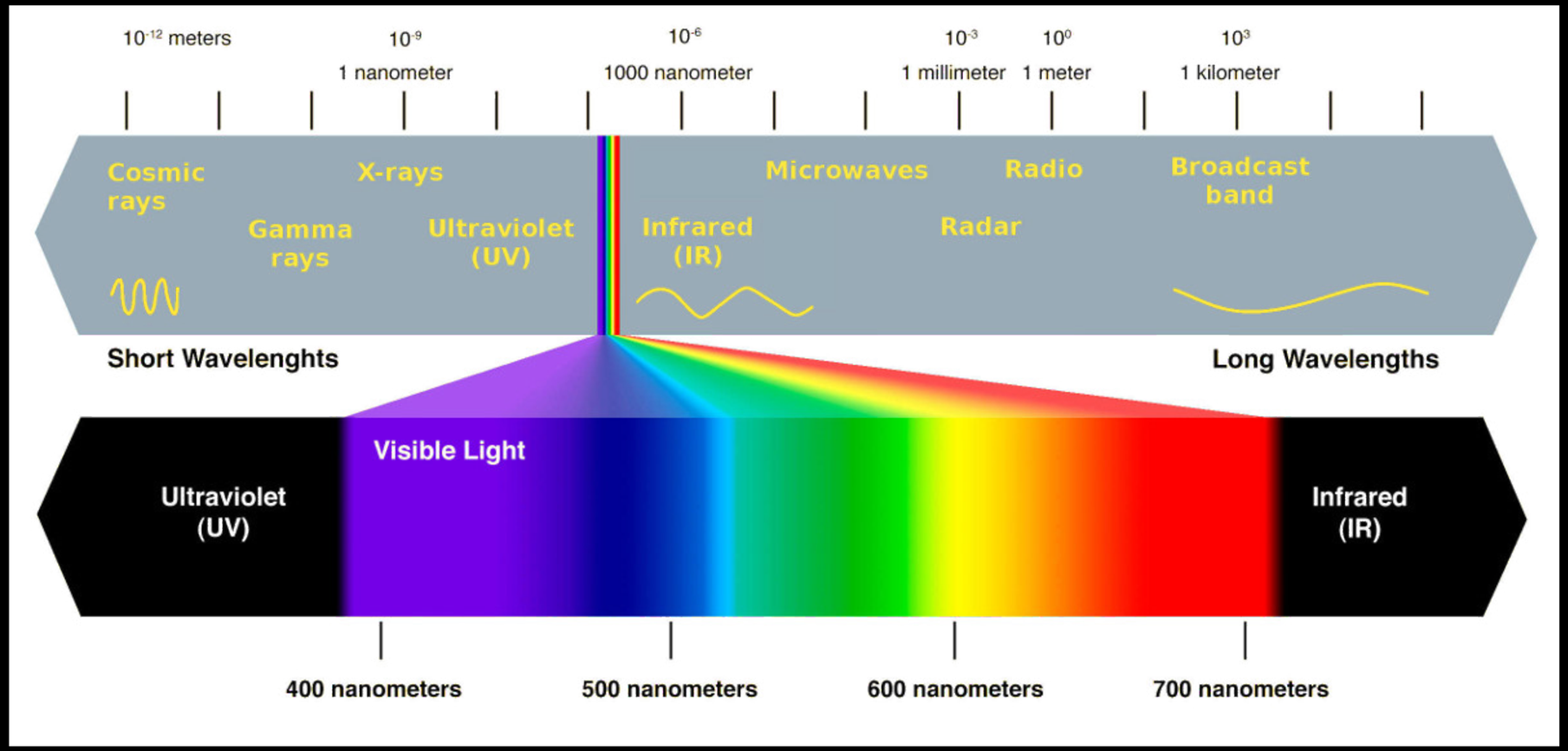
Three types of spectra:

- Continuous
- Emission
- Absorption





CONTINUUM SPECTRUM



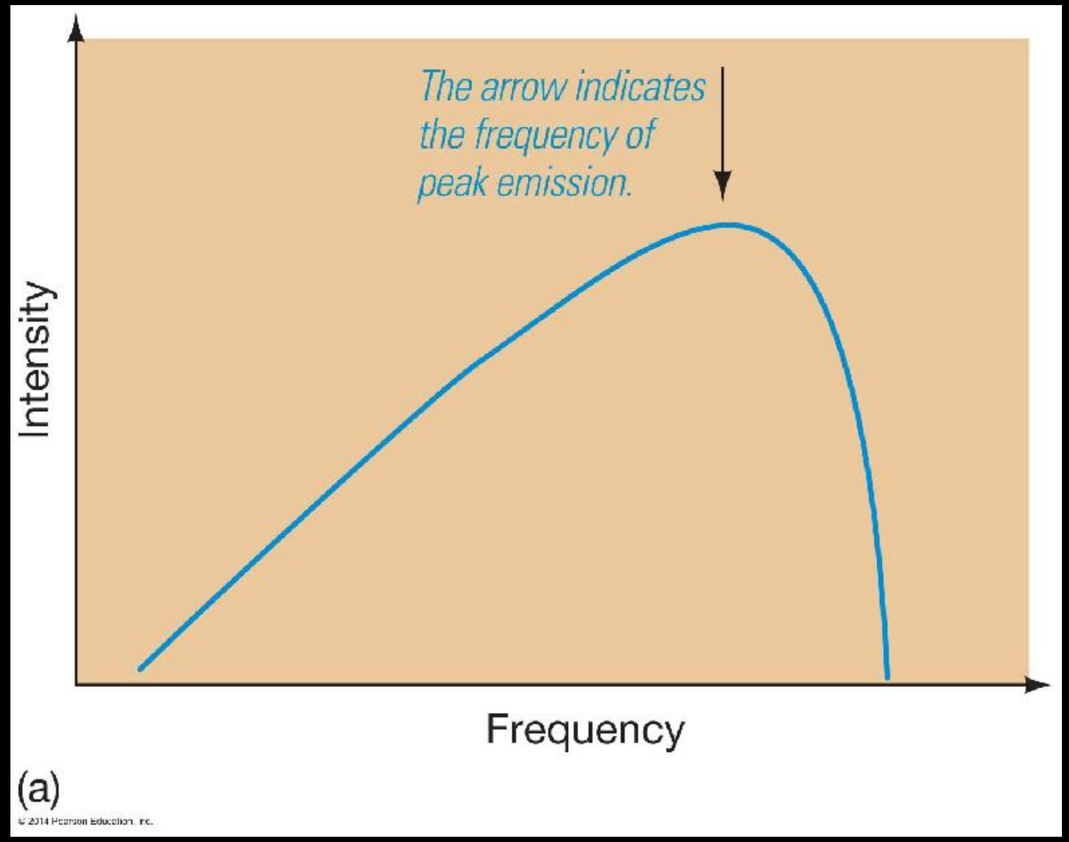
Continuum spectrum

Produced by a heated object, such as a star

All colors seen, though at varying intensities

CONTINUUM SPECTRUM = SMOOTH VARIATION IN INTENSITY OF ALL FREQUENCIES

The frequency of peak intensity is related to the temperature! (Wien's Law)

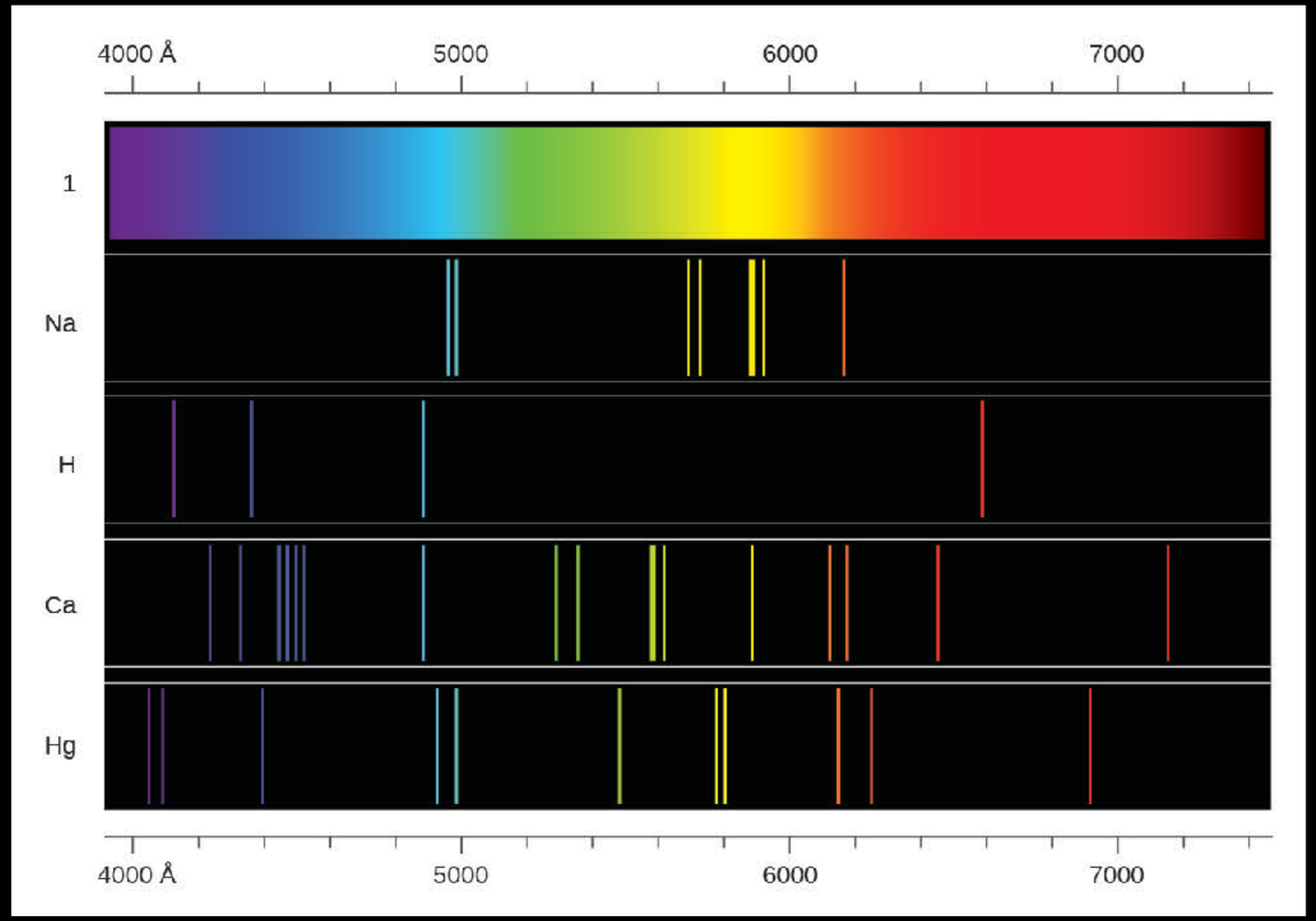


Blackbody as seen through a spectrograph

EMISSION SPECTRUM

Emission Line spectrum:

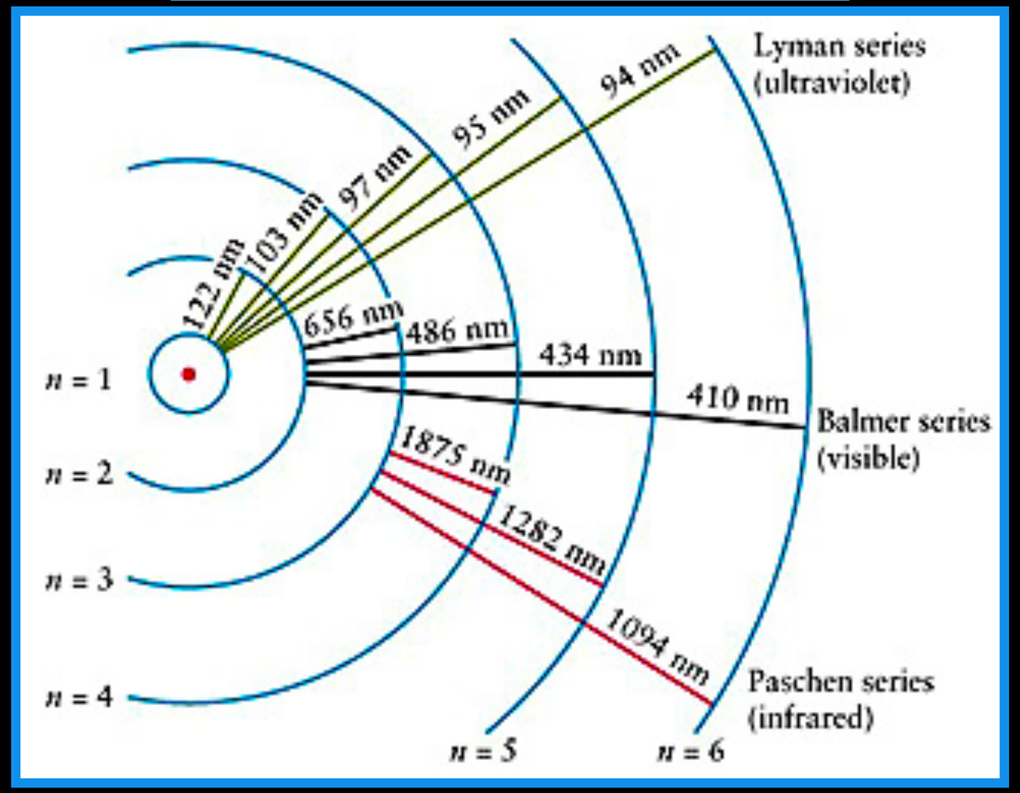
- Produced by a heated gas
- Only certain colors seen
- Each gas has its own unique spectrum



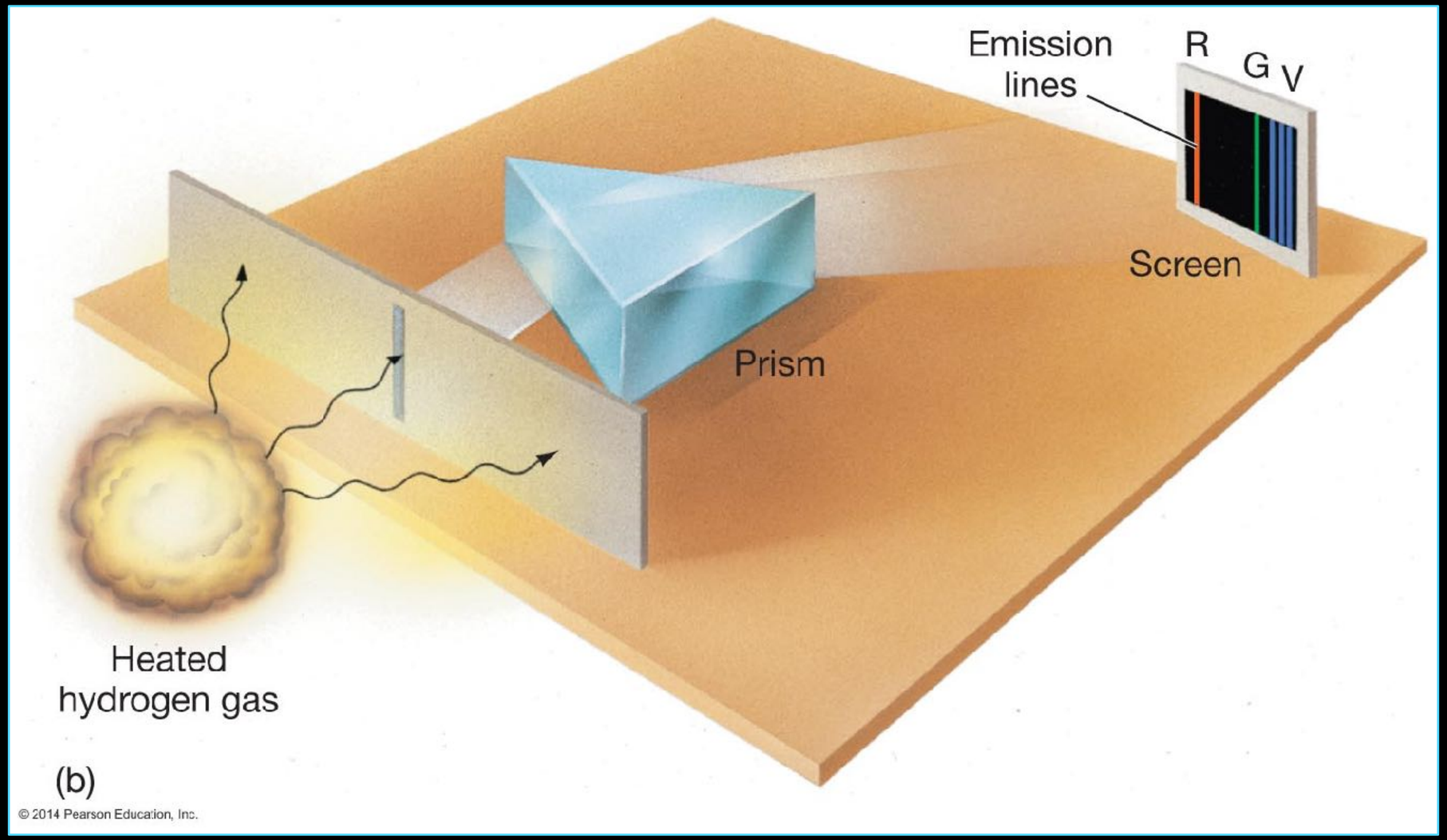
EMISSION LINE SPECTRUM = RADIATION FROM EXCITED (= HEATED) GAS

- Electron jumps from high energy level to low energy level
- Emits light of a certain frequency (color)
- For different atoms (elements) energy levels are fixed in nature
- So each element has a unique spectrum

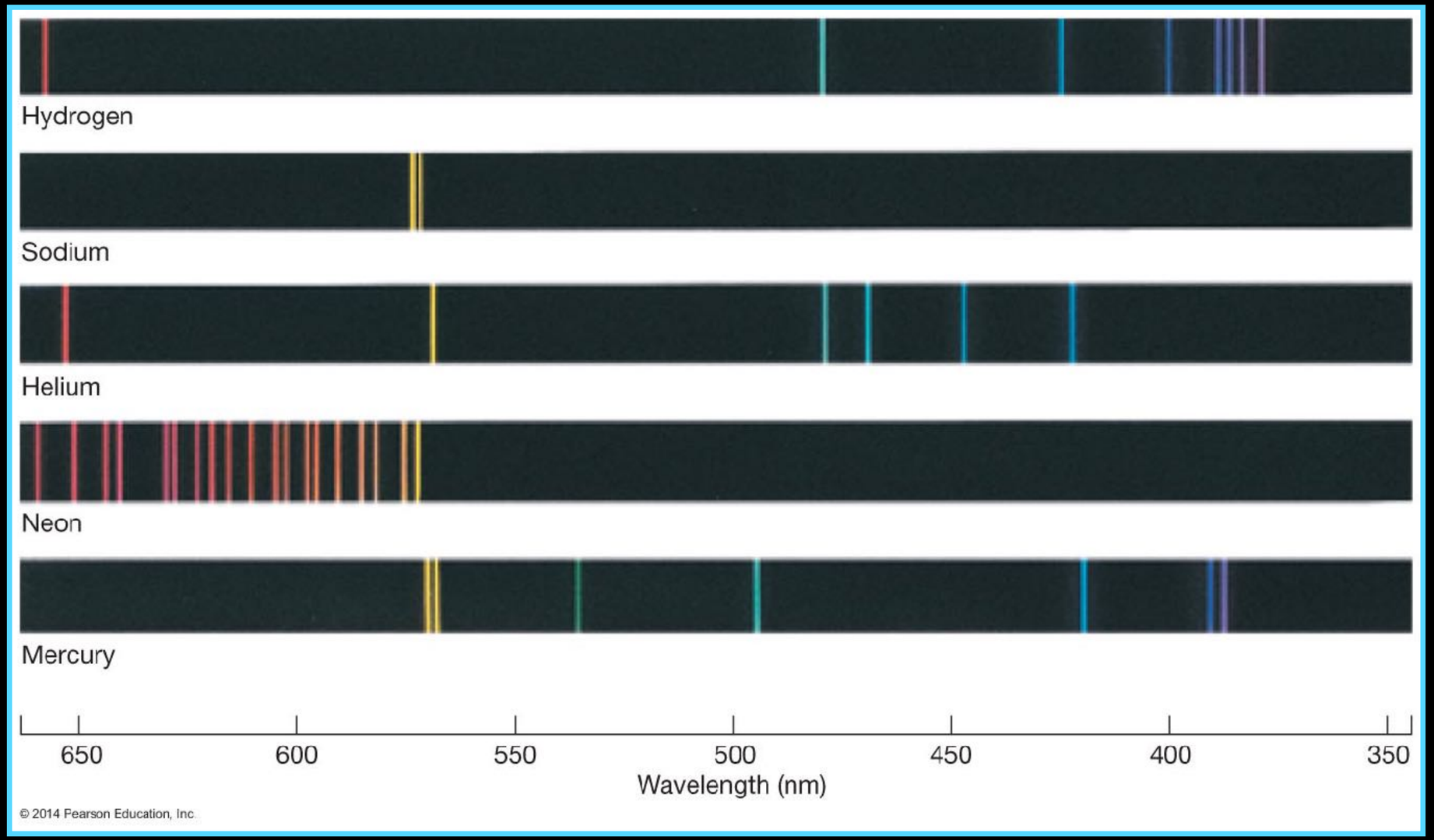
Some of the many energy states of Hydrogen atom



EMISSION LINE SPECTRUM = RADIATION FROM EXCITED (= HEATED) GAS

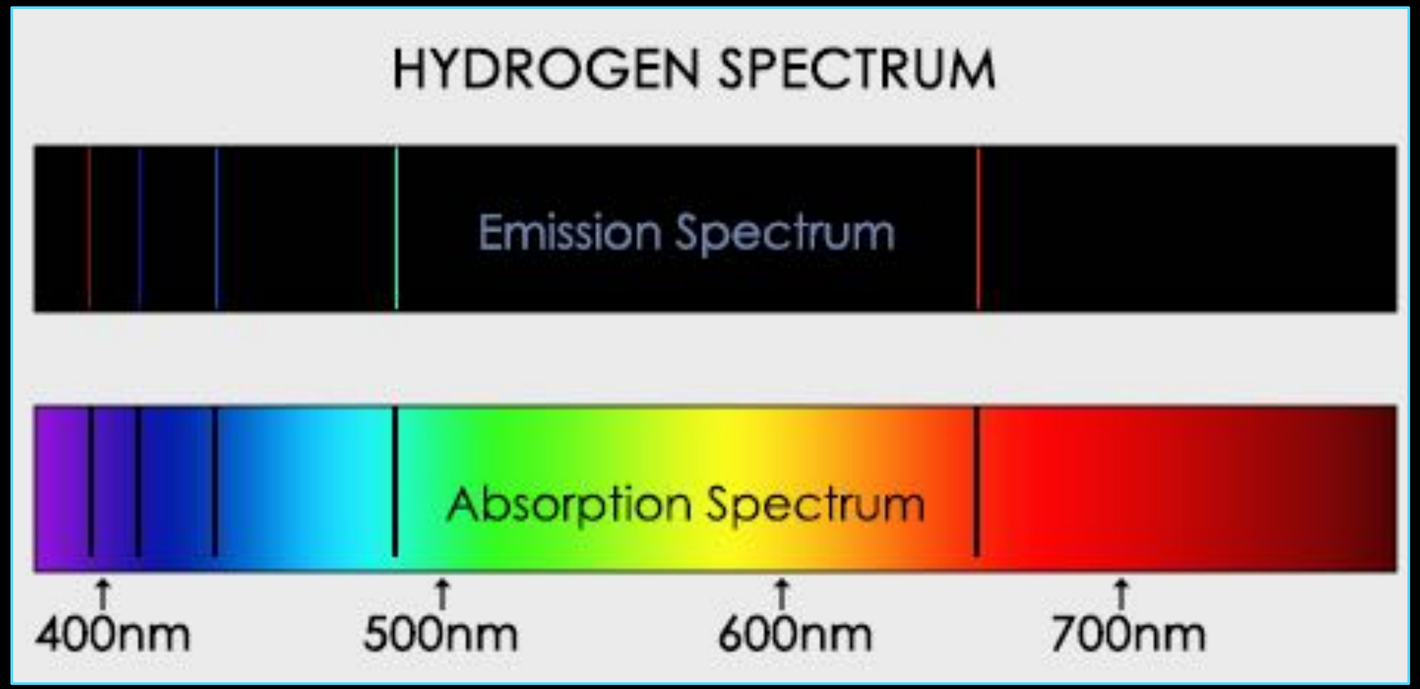


EMISSION LINE SPECTRUM = EVERY ELEMENT HAS UNIQUE SIGNATURE



ABSORPTION SPECTRUM

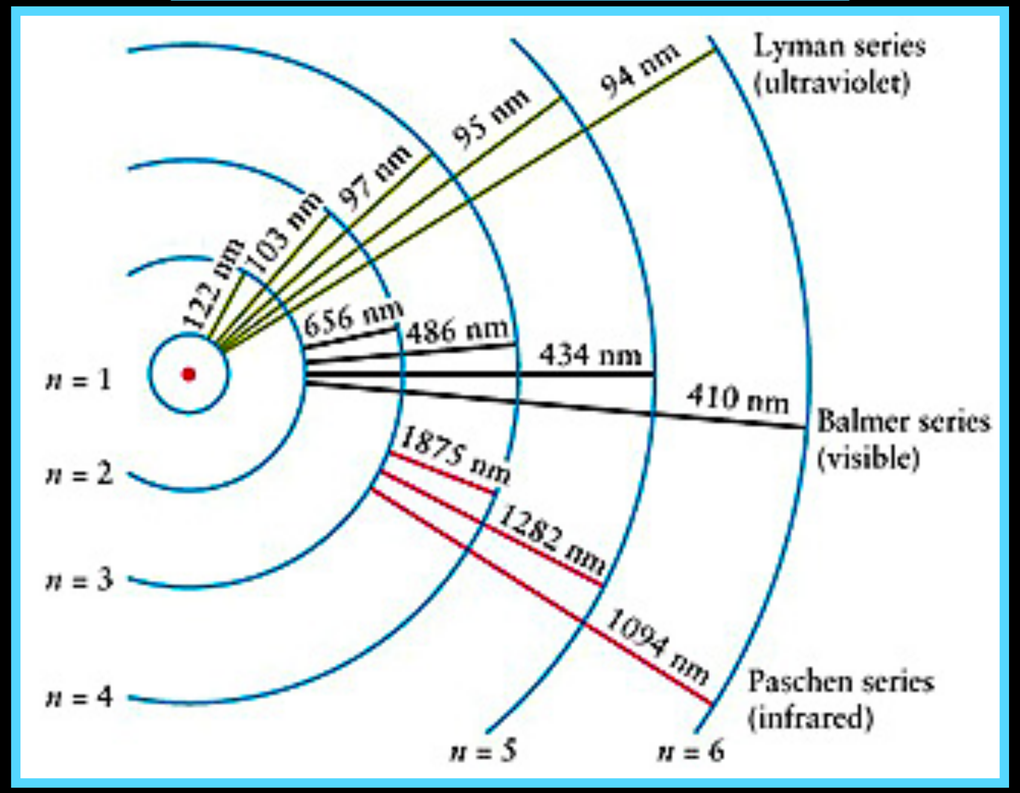
- Produced by a cold gas
- Certain colors are absent
- Each gas has its own unique spectrum
- Is the negative of the emission spectrum



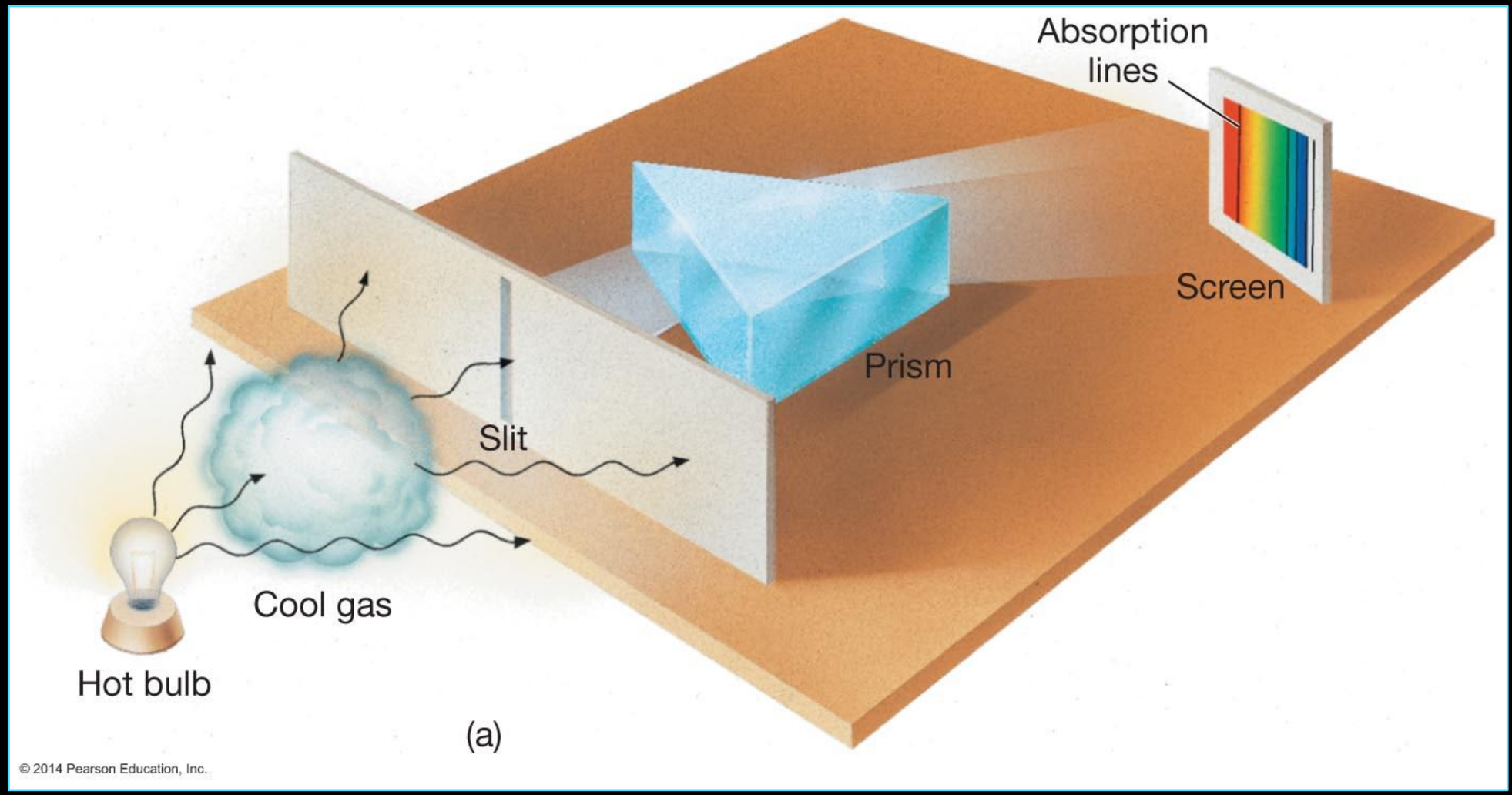
ABSORPTION LINE SPECTRUM = LIGHT ABSORBED BY COOL GAS

- Electron jumps from low energy level to high energy level
- Absorbs light of a certain frequency (color)
- For different atoms (elements) energy levels are fixed in nature
- So each element has a unique absorption spectrum

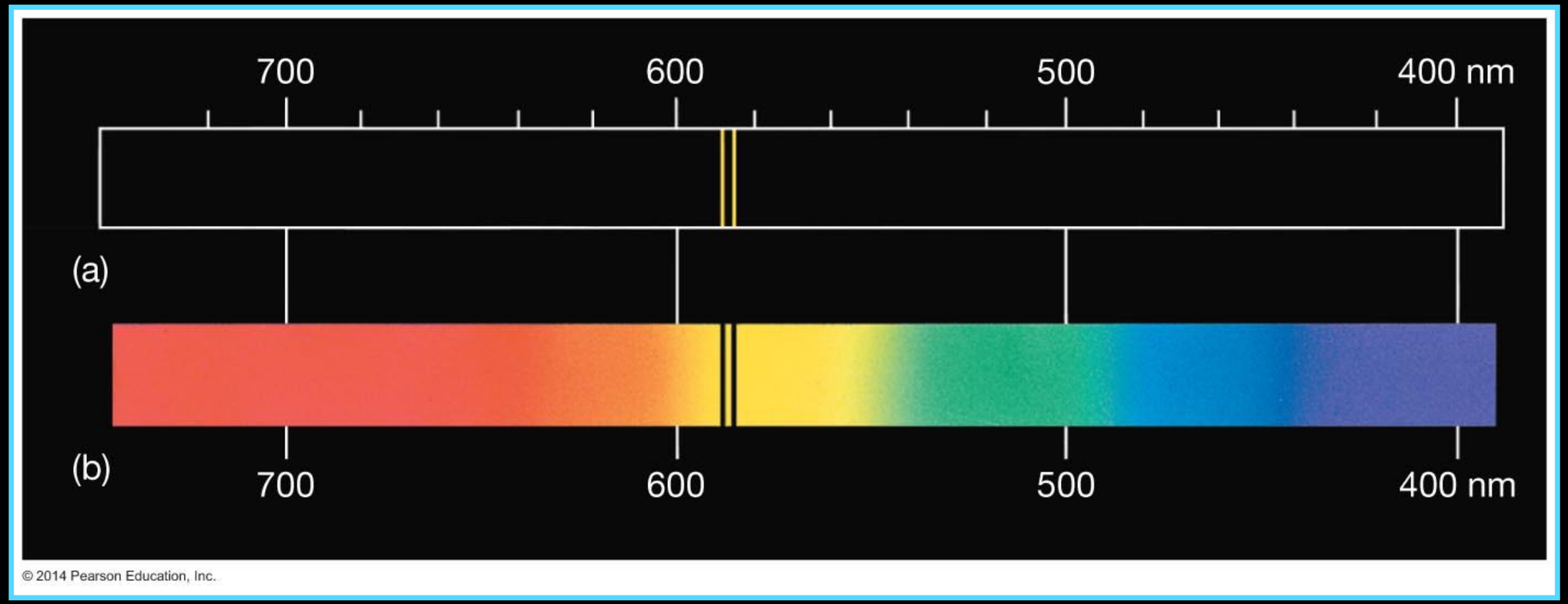
Some of the many energy states of Hydrogen atom



ABSORPTION LINE SPECTRUM = LIGHT ABSORBED BY COOL GAS

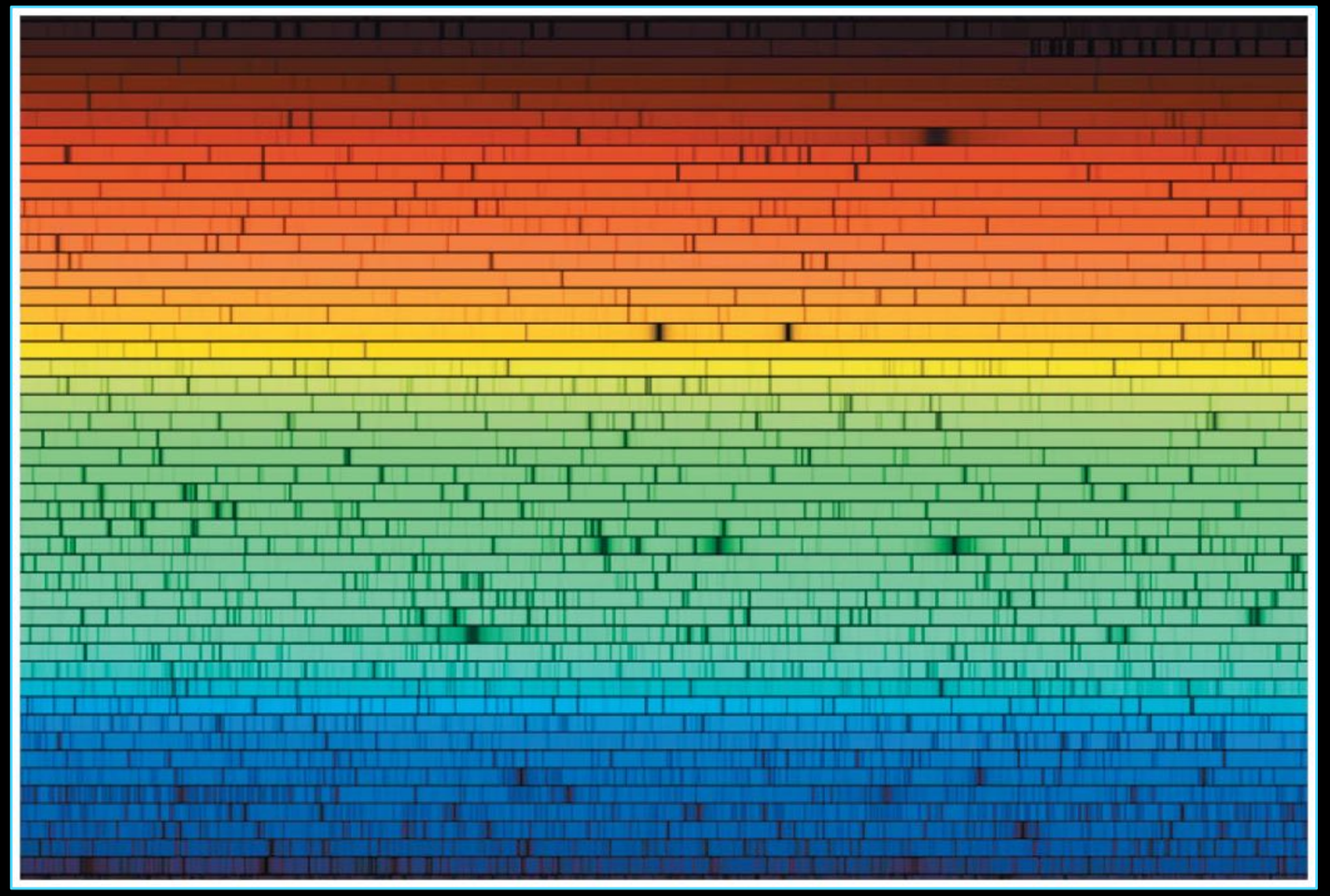


EX: SPECTRUM OF SODIUM



THE SOLAR SPECTRUM SHOWS HUNDREDS OF ABSORPTION LINES!

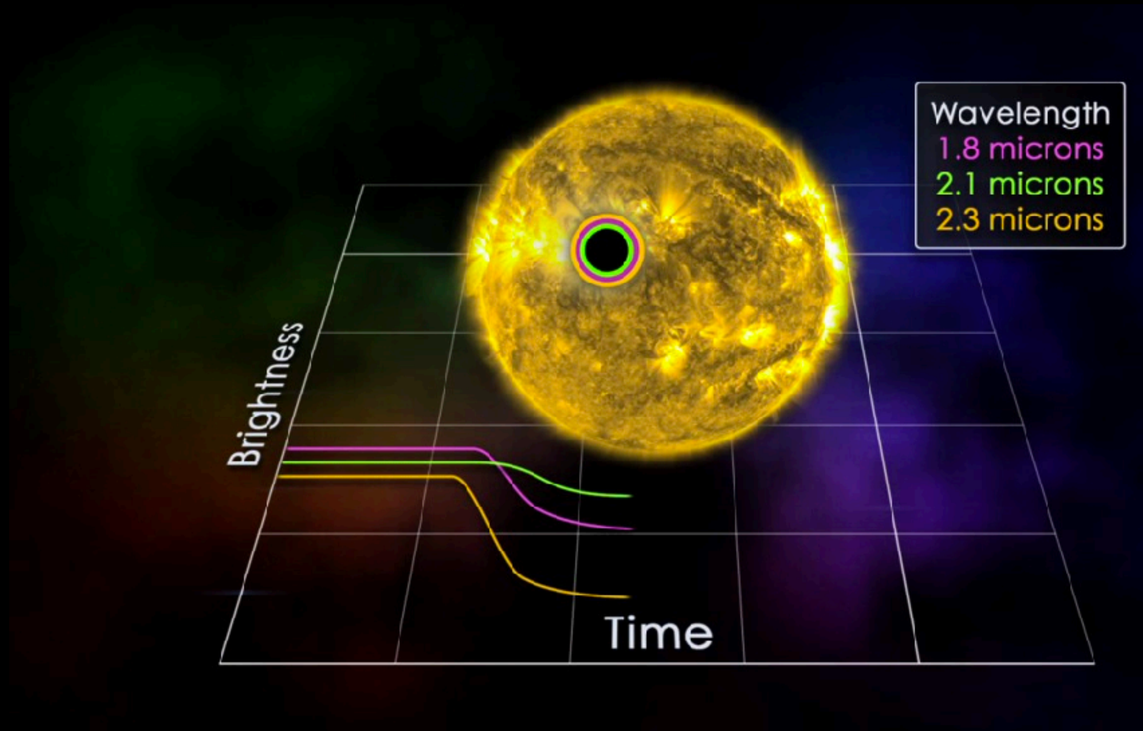
By comparing the frequencies (= wavelengths) of missing lines with spectra of gases in the lab, we can determine the chemistry of the Sun!!



IMPORTANCE OF SPECTROSCOPY

- Spectra can tell us chemical composition of a number of astronomical objects! Stars, molecular clouds (Birth place of stars), nebulas, galaxies, etc.
- More recently we have been able to get spectra of exoplanet atmospheres! Two ways to do this:

1. **Direct Imaging:** Directly imaging an exoplanet.
2. **Transit Spectroscopy:** Measuring the change in the apparent radius of an exoplanet through transits, as a function of wavelength.

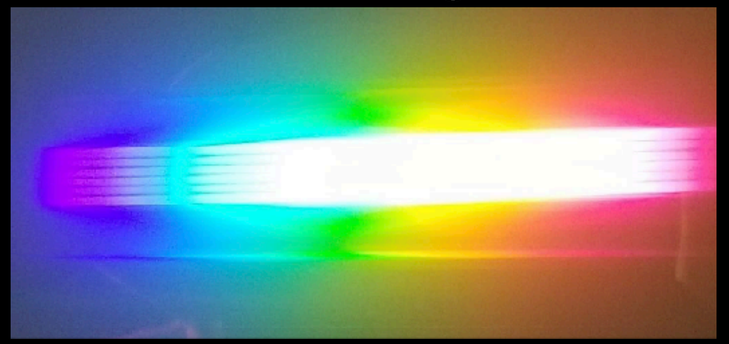


LAB 2: PART 1

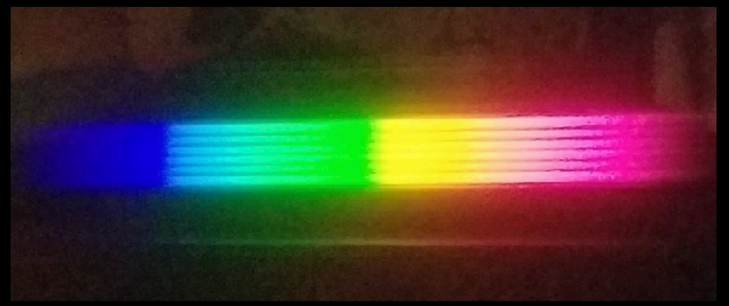
Visual observation and sketching of different types of spectra:

- Incandescent light bulb
- Fluorescent light bulb

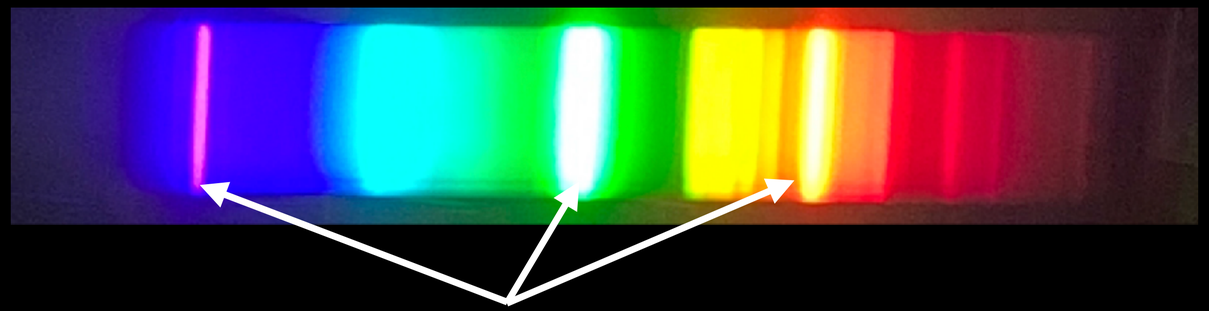
Incandescent High Power



Incandescent Low Power

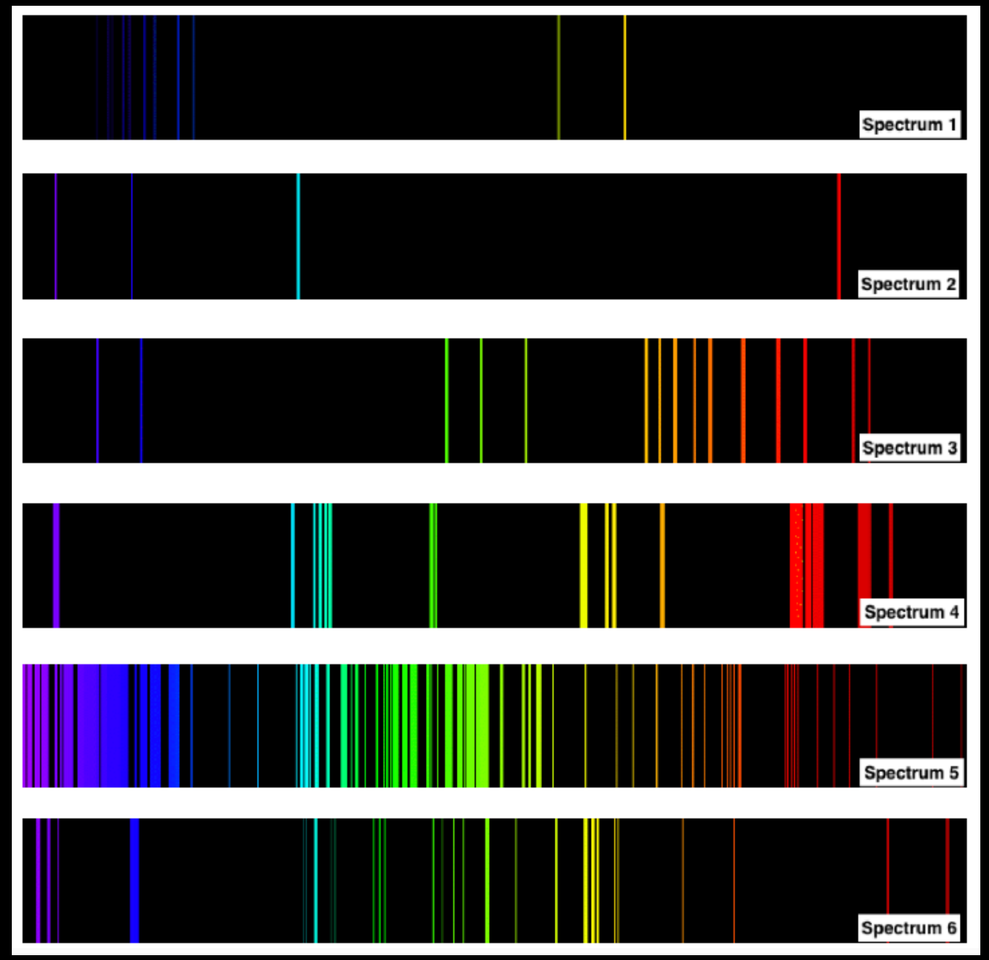


Fluorescent



PART 1 CONT.

- Observe and describe emission spectra of different elements/molecules.



PART 2-4

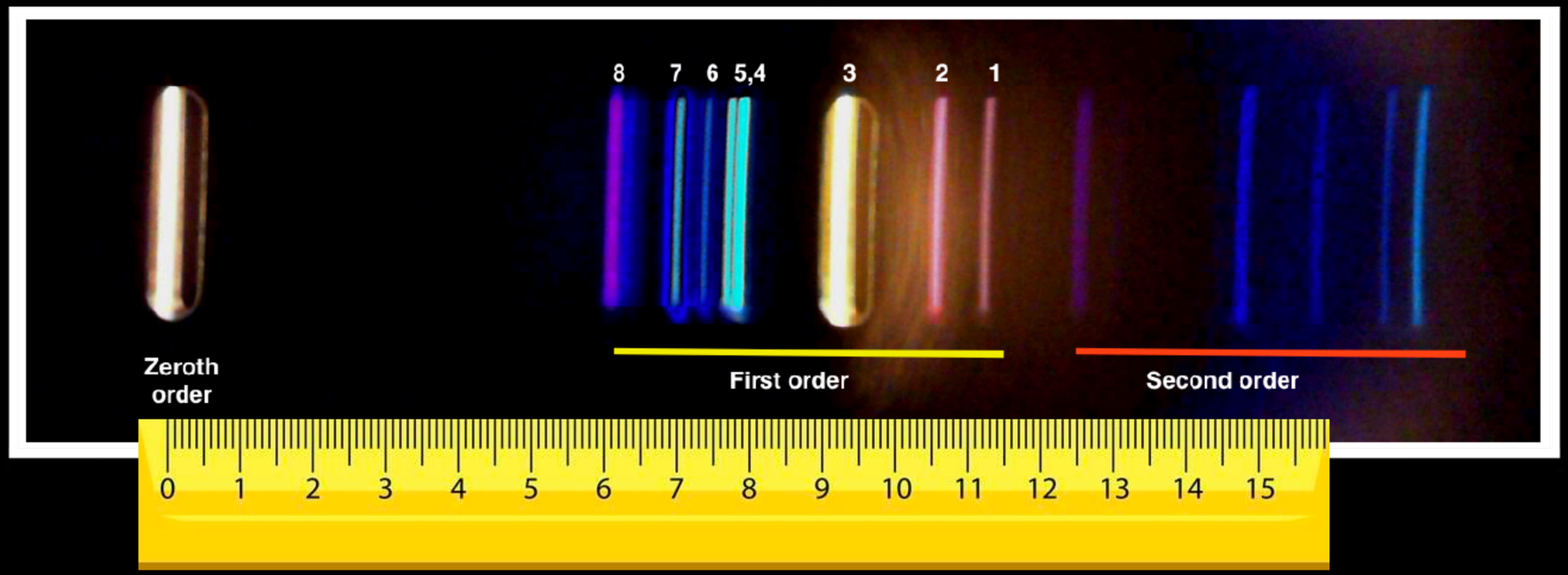
Measuring the wavelengths of the helium and hydrogen spectra:

- When obtaining a spectrum of a celestial object from a spectrograph, what we measure is flux vs. pixel.

- To convert pixels to real units (such as Ångstroms), we need to compare our spectrum with the spectrum of an element/molecule that is well measured using the same instrument.

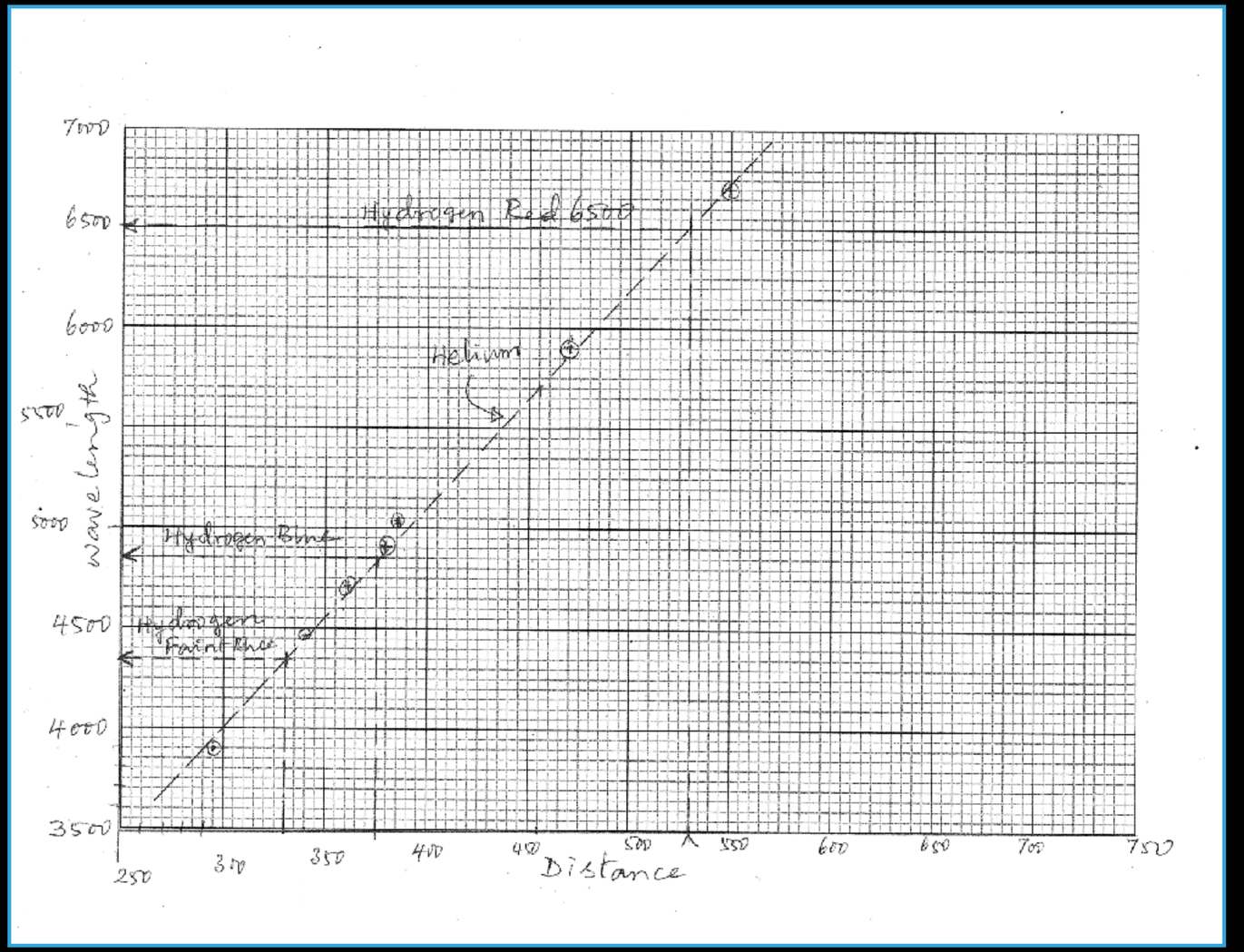
PART 2:

- Use the program *Cheese* to measure the distance of the Helium emission lines from the Zeroth order in pixels.



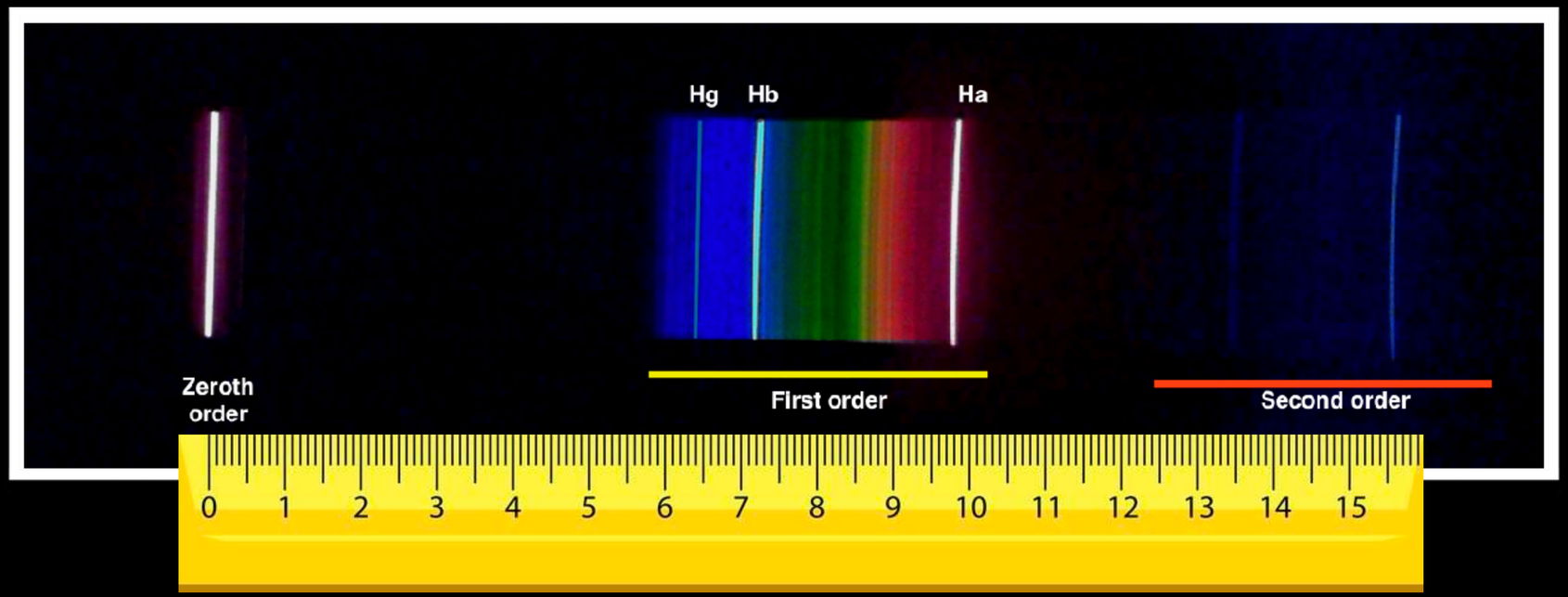
PART 3

- Create a graph of Helium line wavelengths in Å vs. measured values of each emission line in pixels.
- Create a line of best fit.



PART 4

- Repeat distance measurements, this time with Hydrogen spectrum.
- Make sure not to move camera in between measuring the Helium and Hydrogen spectrums.



PART 4 CONT.

- Use graph to extrapolate and find wavelengths for each hydrogen emission line.