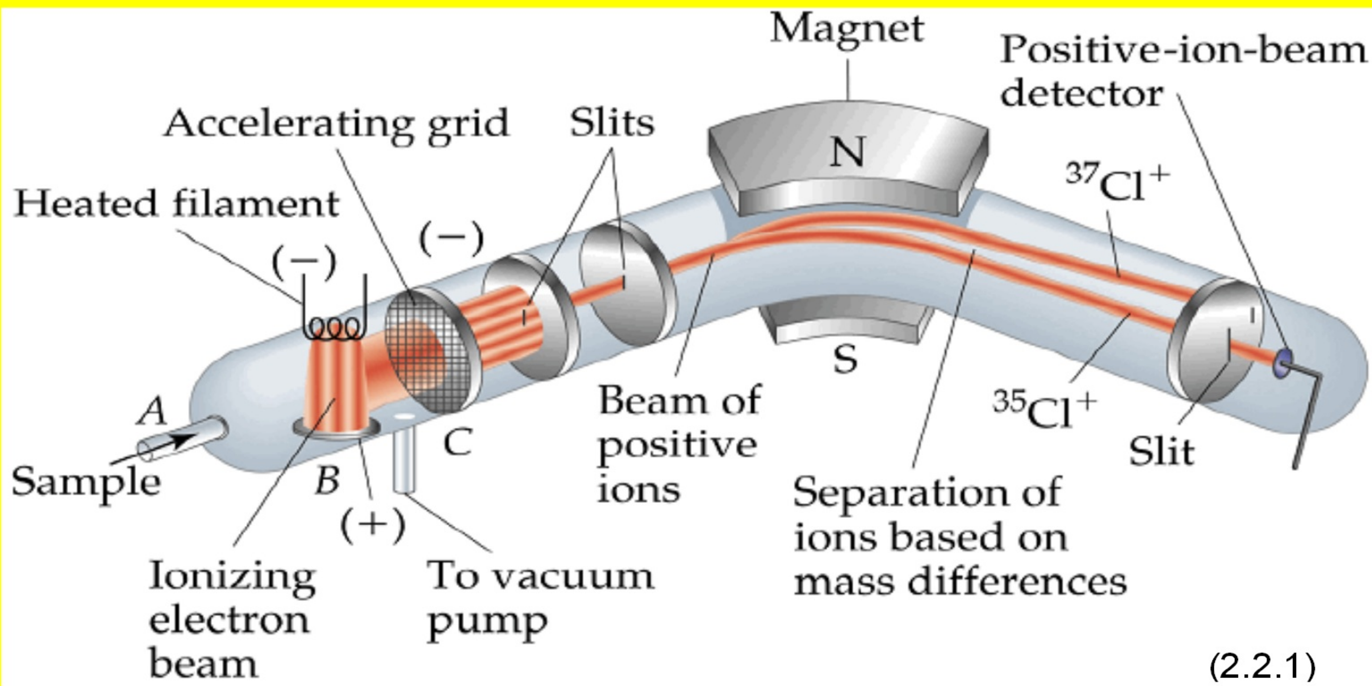
The Atomic Mass Scale

- ^{1}H weighs 1.6735×10^{-24} g and ^{16}O 2.6560×10^{-23} g.
- We define: mass of ^{12}C = exactly 12 amu.
- Using atomic mass units:

$$1 \text{ amu} = 1.66054 \times 10^{-24} \text{ g}$$

$$1 \text{ g} = 6.02214 \times 10^{23} \text{ amu}$$

Mass Spectrometer – An instrument used to separate a mixture of samples with different masses. It gives the mass and relative abundance of each sample. The MS can be used to calculate average atomic mass. (2.2.1)



(2.2.1)

Steps in the operation of the mass spectrometer:

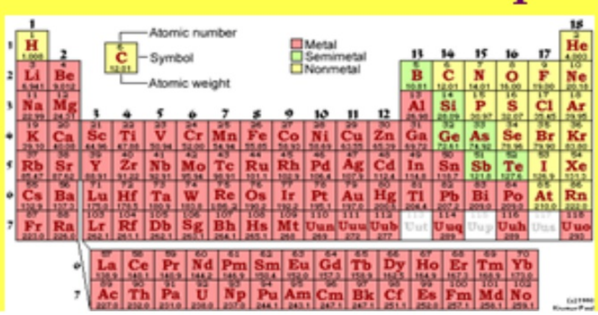
1. Vaporization – sample is turned to gas.
2. Ionization – beam of electrons causes sample to lose electrons (some bonds may be broken).
3. Acceleration – electric field causes positive ions to accelerate.
4. Deflection – magnetic field causes moving cations to be deflected (lightest deflected most)
5. Detection – a detector determines the amount of each sample (isotope) present.

Relative Atomic Masses (A_r) (2.2.2)

- Relative atomic mass: average masses of isotopes:
  – Naturally occurring C: 98.892 % ^{12}C + 1.108 % ^{13}C.
- Average mass (A_r) of C:

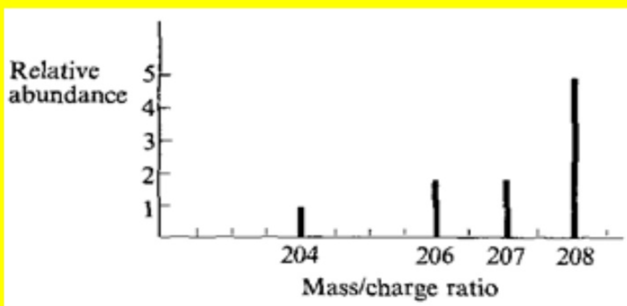
(0.98892)(12 amu) + (0.0108)(13.00335) = 12.011 amu.

- Relative atomic mass is also known as atomic weight (AW).
- Atomic weights are listed on the periodic table.



Example (2.2.2 and 2.2.3)

- Use the mass spectrum of lead below to calculate the relative atomic mass of lead.

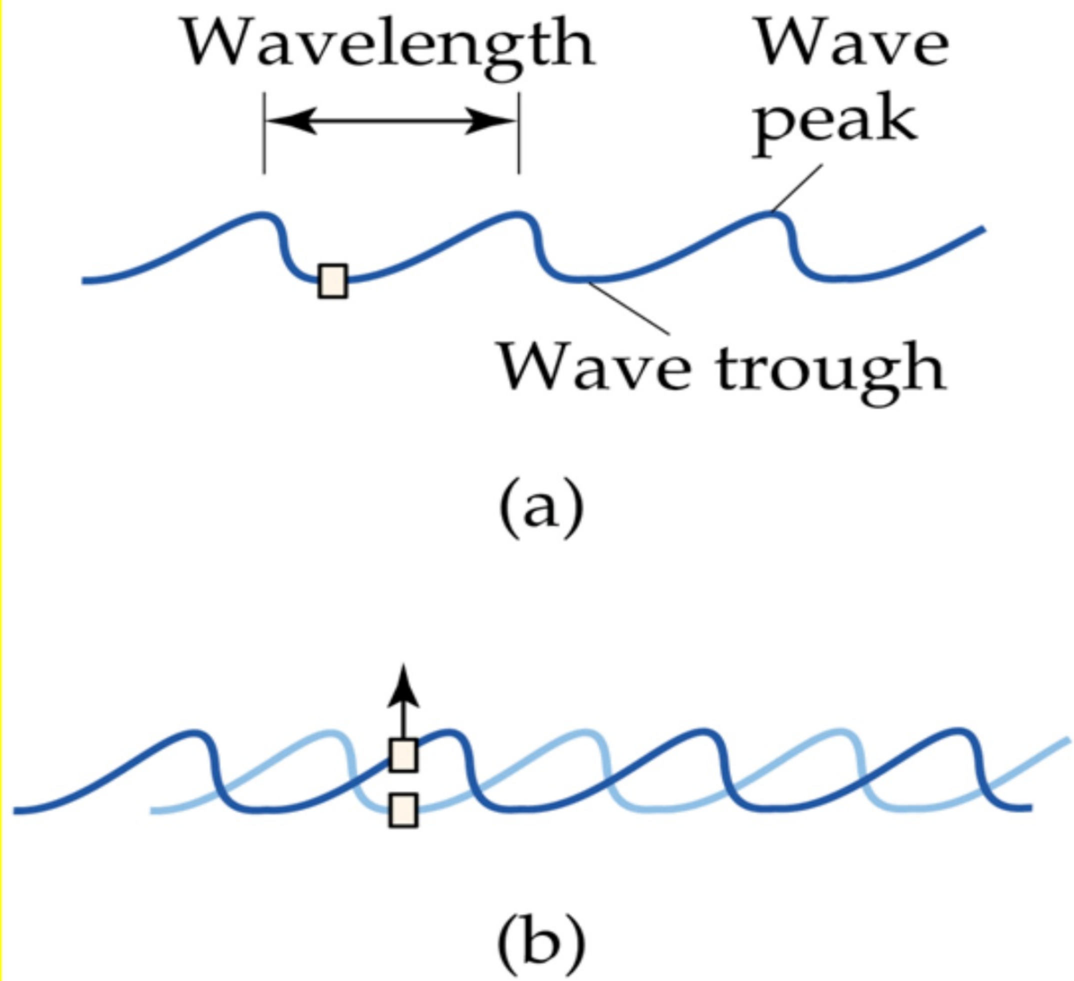


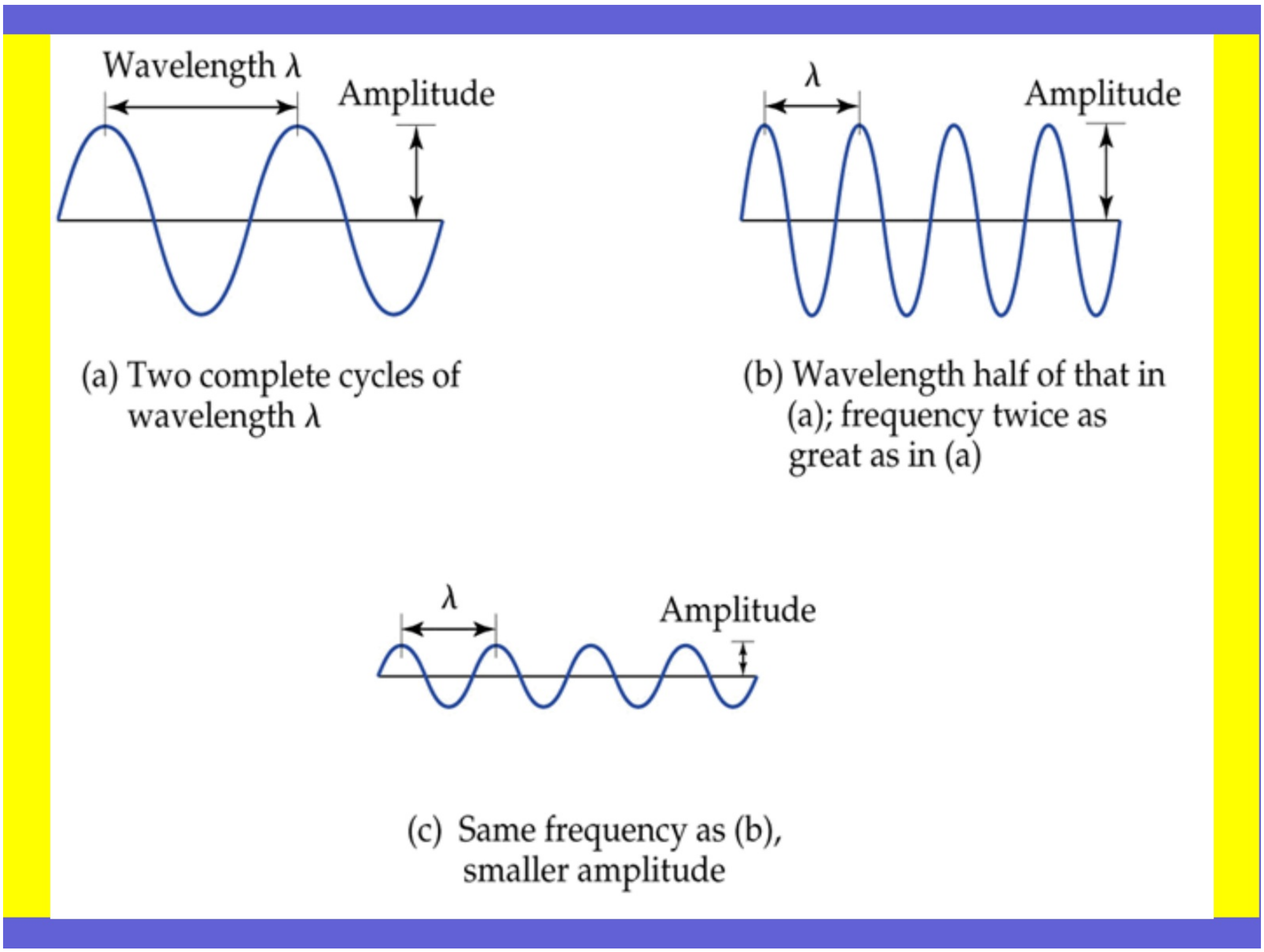
Light and Waves

- All waves have a characteristic wavelength, λ, and amplitude, A.
- The frequency, ν, of a wave is the number of cycles which pass a point in one second.
- The speed of a wave, v, is given by its frequency multiplied by its wavelength:
- For light, speed = c.

$$c = \nu\lambda$$

$\text{m}\cdot\text{s}^{-1}$ Hz (s^{-1}) m


Wavelength
Wave
peak
Wave trough
(a)
(b)



(a) Two complete cycles of wavelength λ

(b) Wavelength half of that in (a); frequency twice as great as in (a)

(c) Same frequency as (b), smaller amplitude

Examples

•

1 Calculate the wavelength of light with a frequency of 1.89×10^{18} Hz.

2 Calculate the frequency of light with a wavelength of 585 nm.

Examples

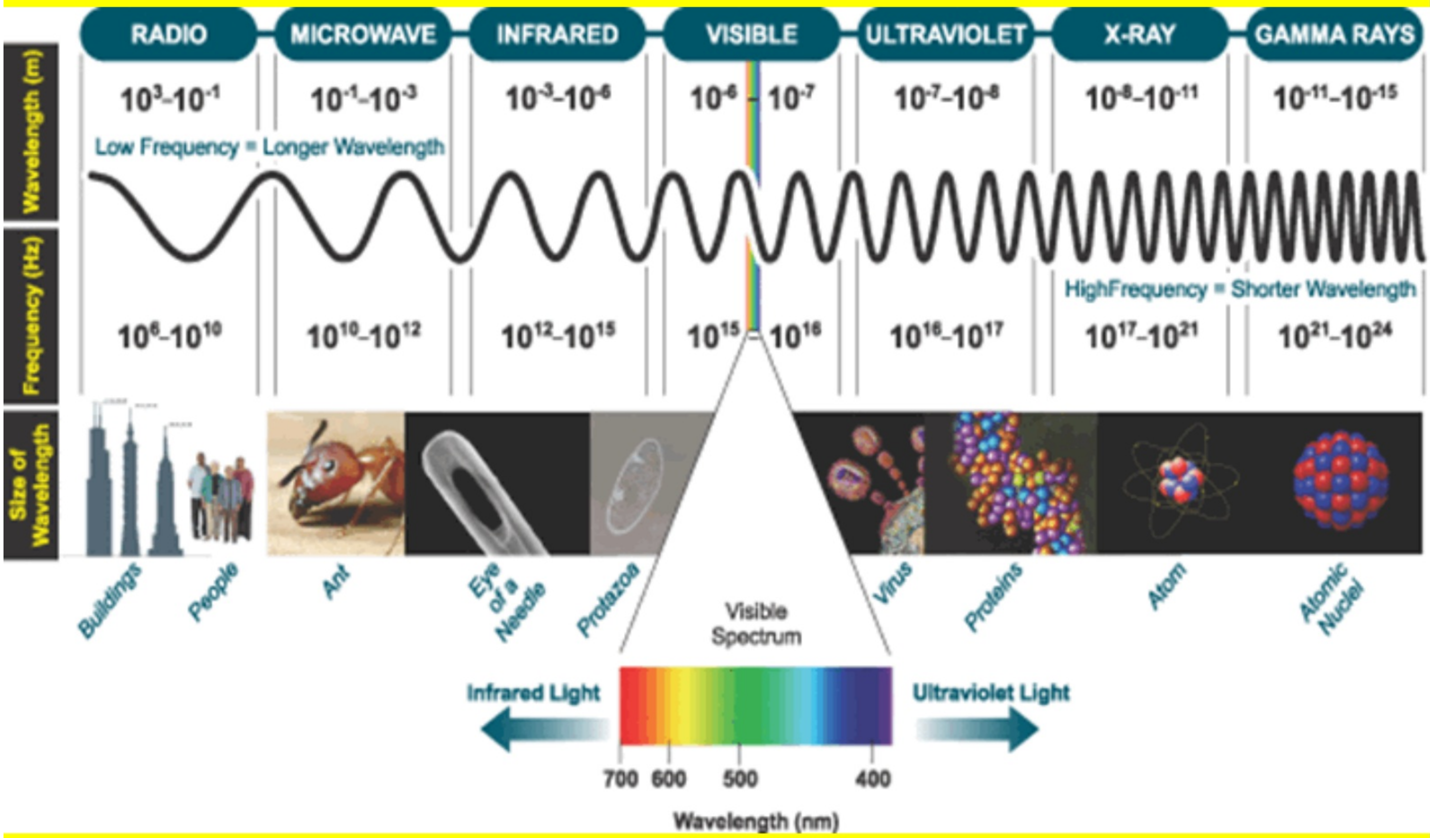
-

1 Calculate the wavelength of light with a frequency of 1.89×10^{18} Hz.

1.59×10^{-10} m

2 Calculate the frequency of light with a wavelength of 585 nm.

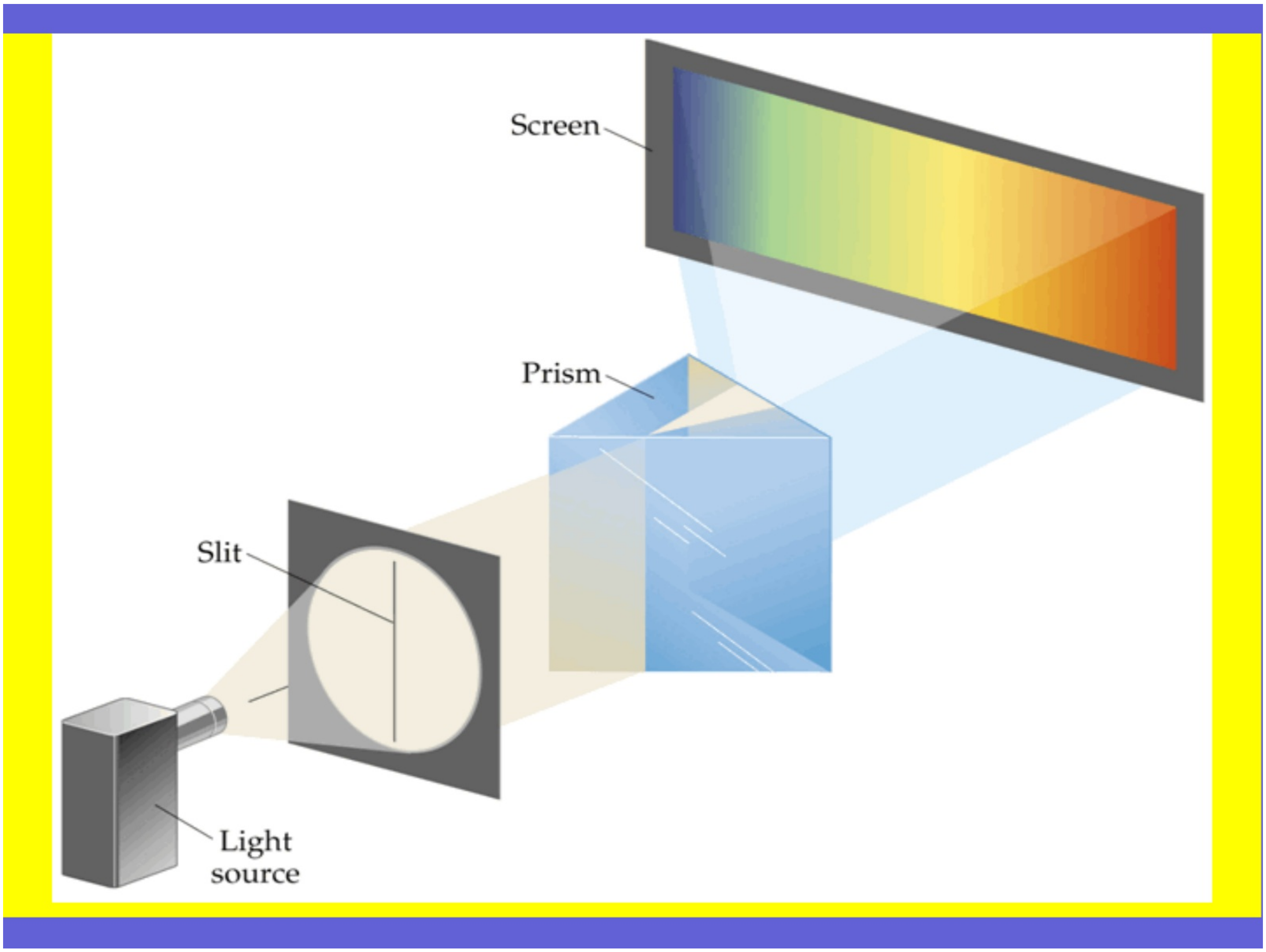
5.12×10^{14} s^{-1} or Hz


RADIO
MICROWAVE
INFRARED
VISIBLE
ULTRAVIOLET
X-RAY
GAMMA RAYS
Wavelength (m)
10^{3}–10^{-1}
10^{-1}–10^{-3}
10^{-3}–10^{-6}
10^{-6} – 10^{-7}
10^{-7}–10^{-8}
10^{-8}–10^{-11}
10^{-11}–10^{-15}
Low Frequency = Longer Wavelength
Frequency (Hz)
HighFrequency = Shorter Wavelength
10^{6}–10^{10}
10^{10}–10^{12}
10^{12}–10^{15}
10^{15} – 10^{16}
10^{16}–10^{17}
10^{17}–10^{21}
10^{21}–10^{24}
Size of Wavelength
Buildings
People
Ant
Eye of a Needle
Protozoa
Virus
Proteins
Atom
Atomic Nuclei
Visible Spectrum
Infrared Light
Ultraviolet Light
700
600
500
400
Wavelength (nm)

Line Spectra and the Bohr Model

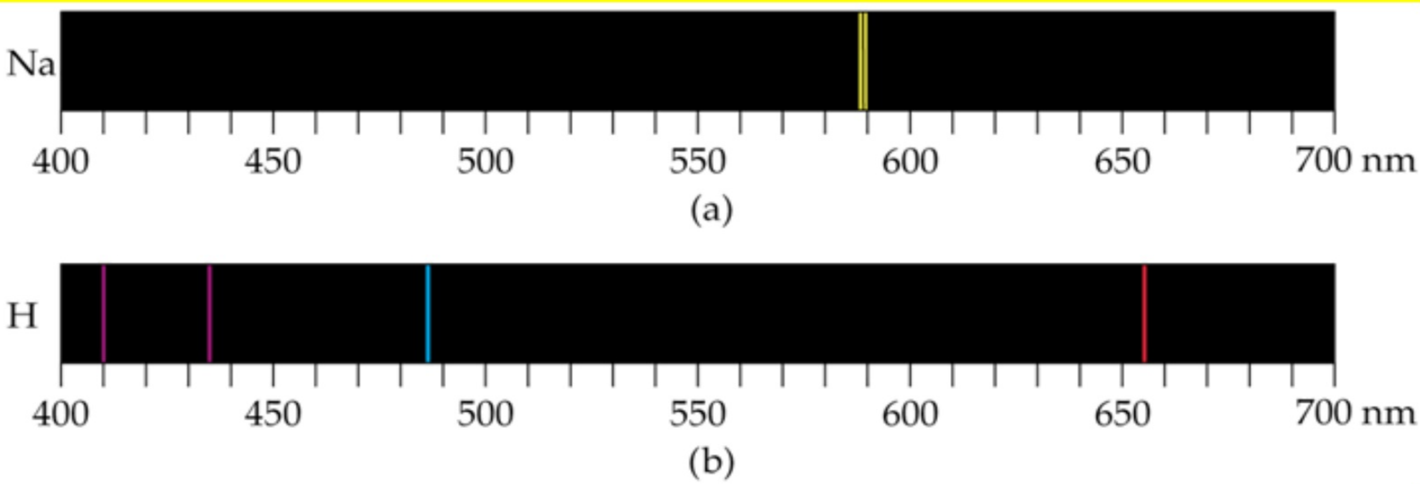
Line Spectra

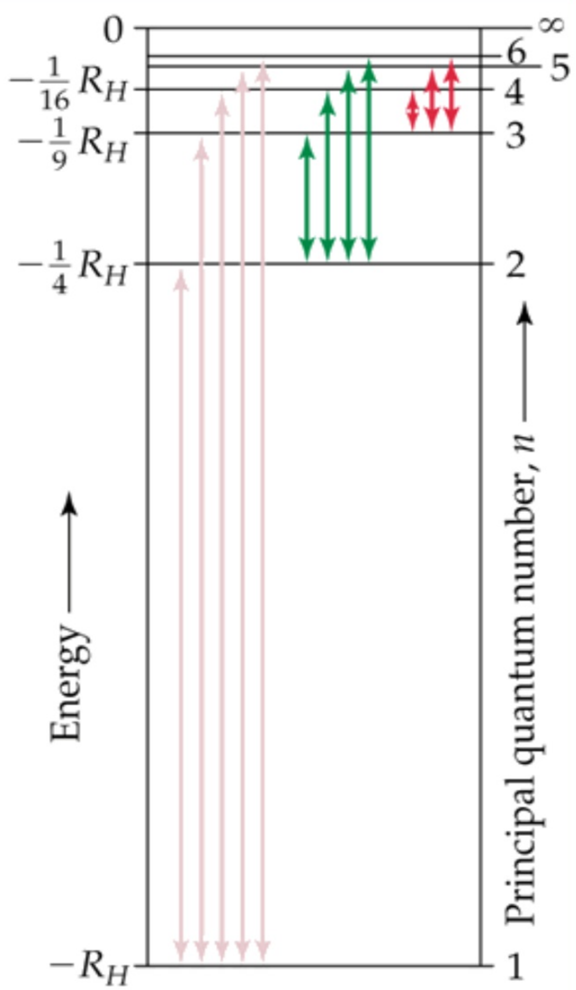
- Radiation composed of only one wavelength is called monochromatic.
- Radiation that spans a whole array of different wavelengths is called continuous.
- White light can be separated into a continuous spectrum of colors.
- Note that there are no dark spots on the continuous spectrum that would correspond to different lines.


Screen
Prism
Slit
Light
source

Bohr Model

- Colors from excited gases arise because electrons move between energy states in the atom.





0
$-\frac{1}{16}R_H$
$-\frac{1}{9}R_H$
$-\frac{1}{4}R_H$
$-R_H$
Energy
∞
6
5
4
3
2
1
Principal quantum number, n

Bohr Model

Types of Spectra

- **Emission Spectrum** – a set of colored lines produced by "downward" transitions between energy levels.
- produced when electrons are excited (by electricity or flame) and then return to lower energy levels.
- **Absorption Spectrum** – a continuous spectrum with "dark lines" missing. It is produced by "upward" transitions between energy levels.
- produced when white light (or IR, UV, other) is shown through a sample. Specific colors are absorbed.
-

The two spectra are "complimentary." The lines and colors involved are exactly the same.