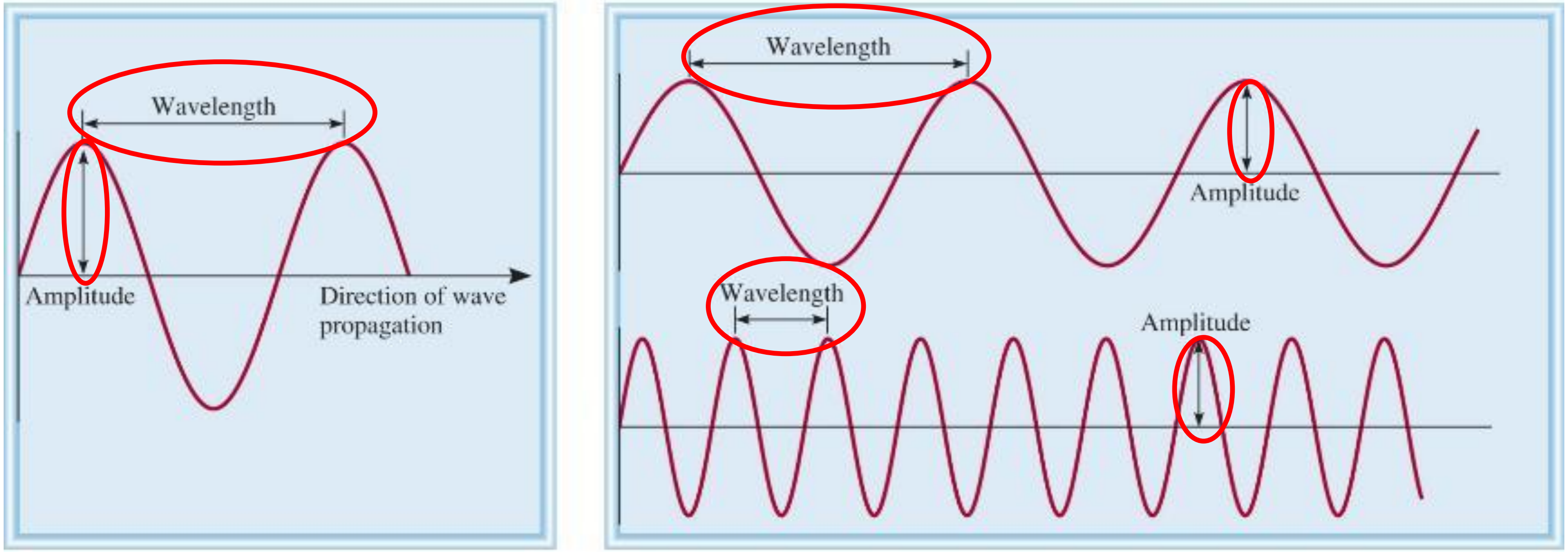
Properties of Waves



Wavelength (λ) is the distance between identical points on successive waves.

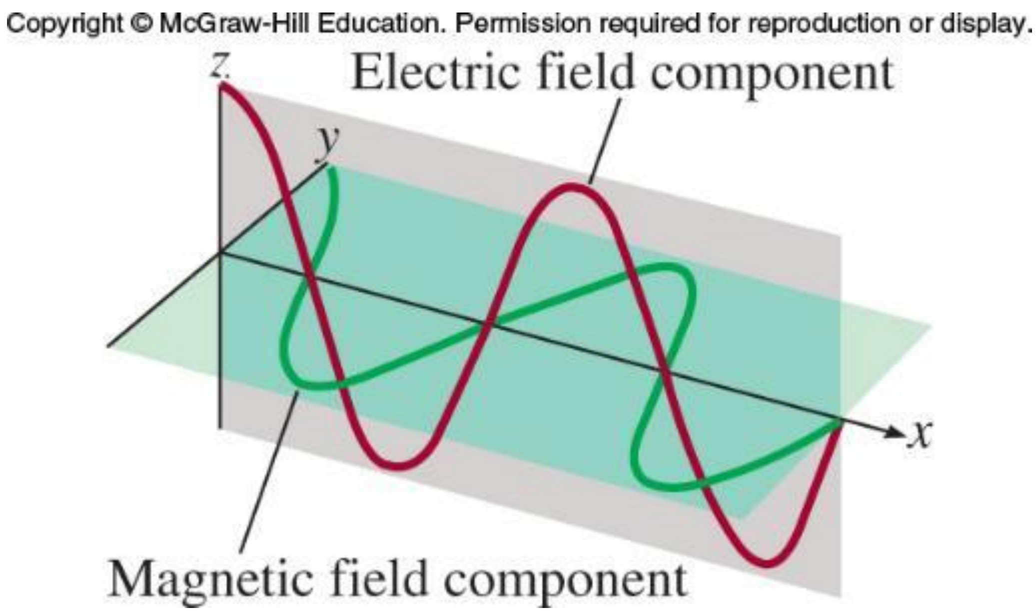
Amplitude is the vertical distance from the midline of a wave to the peak or trough.

Frequency (ν) is the number of waves that pass through a particular point in 1 second ($\text{Hz} = 1\ \text{cycle/s}$).

The speed (*u*) of the wave $= \lambda \times \nu$

Light as a Wave

Maxwell (1873), proposed that visible light consists of electromagnetic waves.



Electromagnetic radiation is the emission and transmission of energy in the form of electromagnetic waves.

Speed of light (c) in vacuum $= 3.00 \times 10^{8}$ m/s

All electromagnetic radiation:

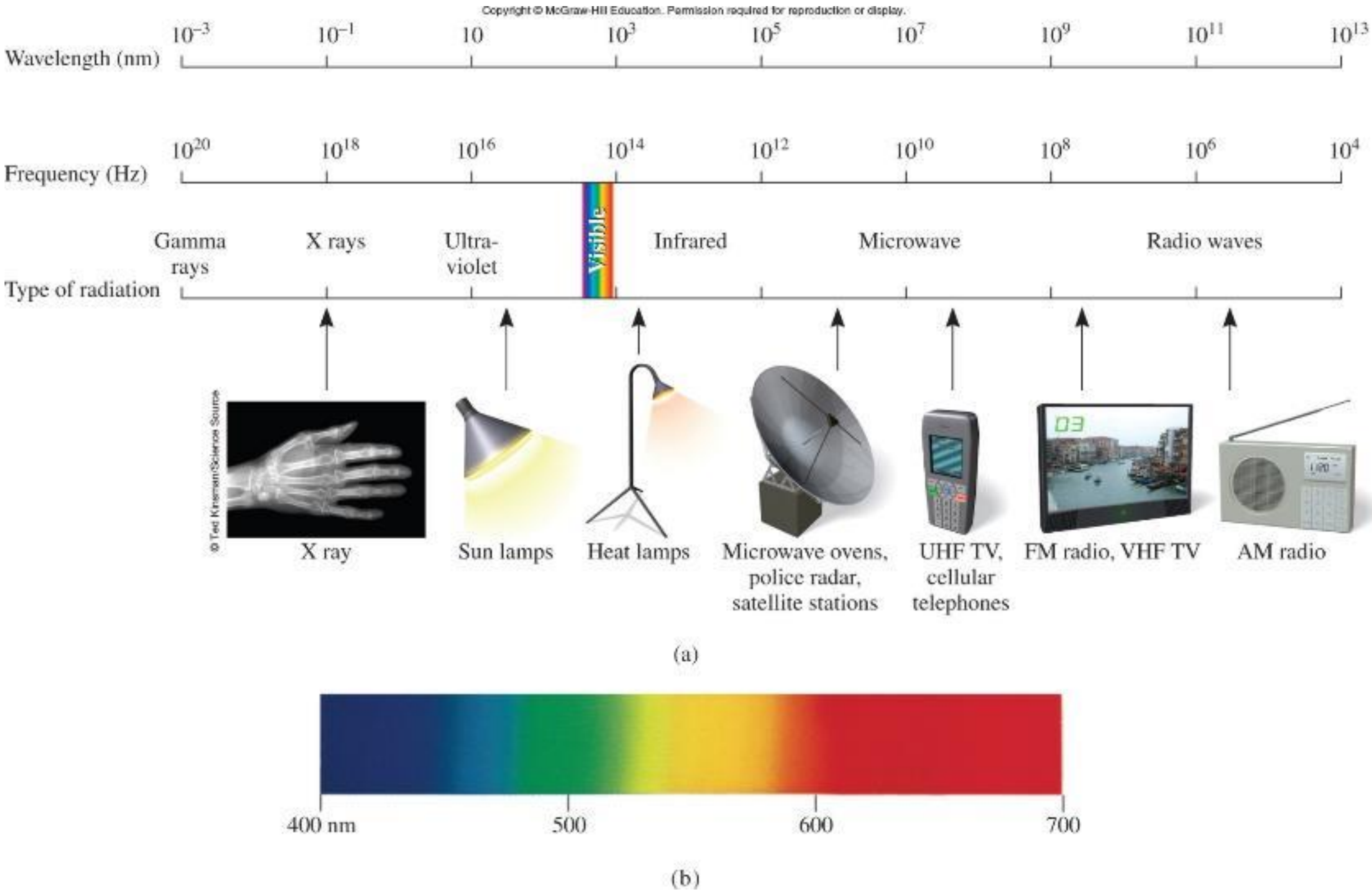
$$\lambda \times \mathrm{v} = c$$

Example 7.1

The wavelength of the green light from a traffic signal is centered at 522 nm (522×10^{-9} m). What is the frequency of this radiation?

$5.75 \times 10^{14}/\mathrm{s}$, or $5.75 \times 10^{14}\ \mathrm{Hz}$

Electromagnetic Spectrum



Mystery #1, "Heated Solids Problem" Solved by Planck in 1900

All objects emit electromagnetic radiation over a wide range of wavelengths.

Radiant energy emitted by an object at a certain temperature depends on its wavelength.

Energy (light) is emitted or absorbed in discrete units (quantum).

$$E = h \times \mathrm{v}$$

Planck's constant (*h*)

$$h = 6.63 \times 10^{-34}\ \mathrm{J \cdot s}$$

Mystery #2, “Photoelectric Effect” Solved by Einstein in 1905

Light has both:
1. wave nature
2. particle nature

Photon is a “particle” of light

$$h\nu = \mathrm{KE} + W$$

$$\mathrm{KE} = h\nu - W$$

Example 7.2

Calculate the energy (in joules) of

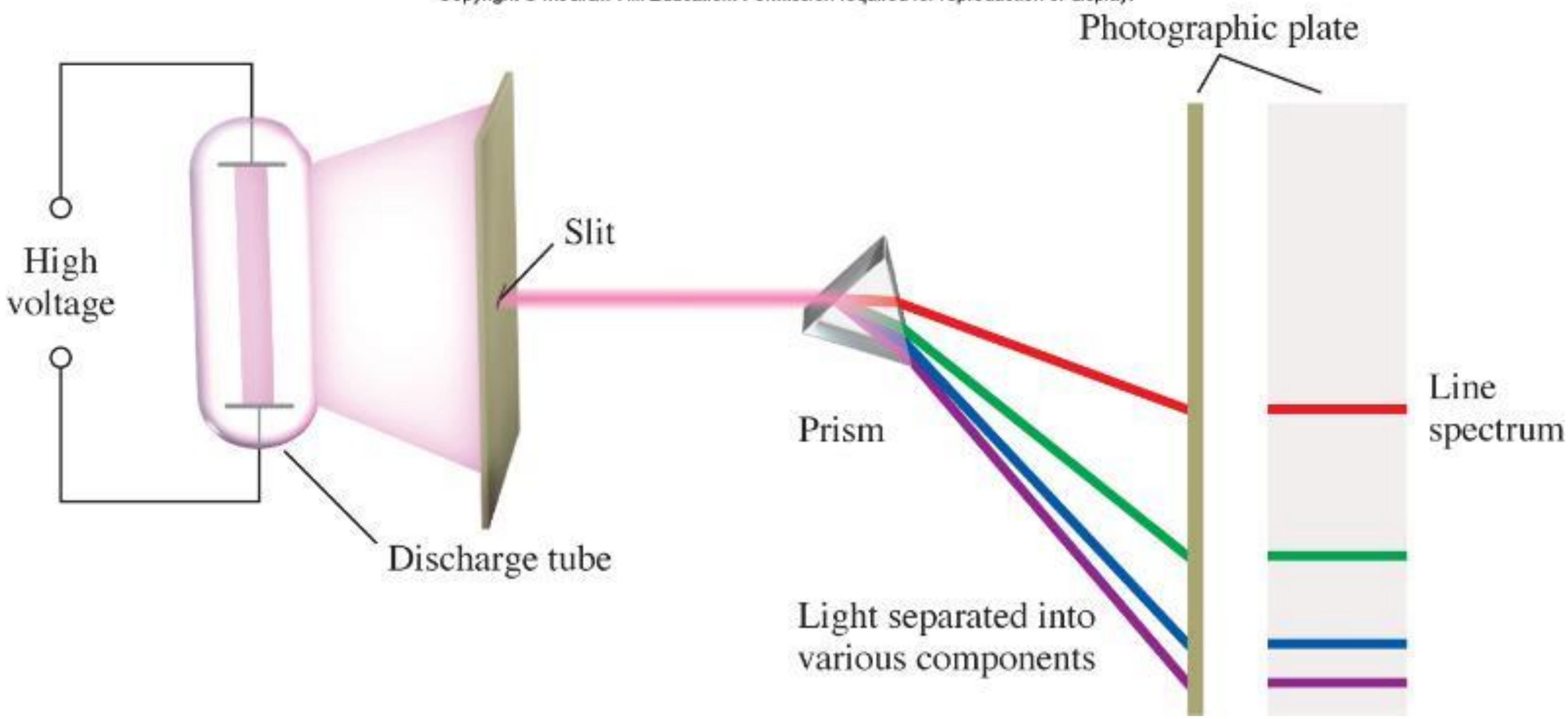
(a) a photon with a wavelength of 5.00×10^{-5} m (infrared region)

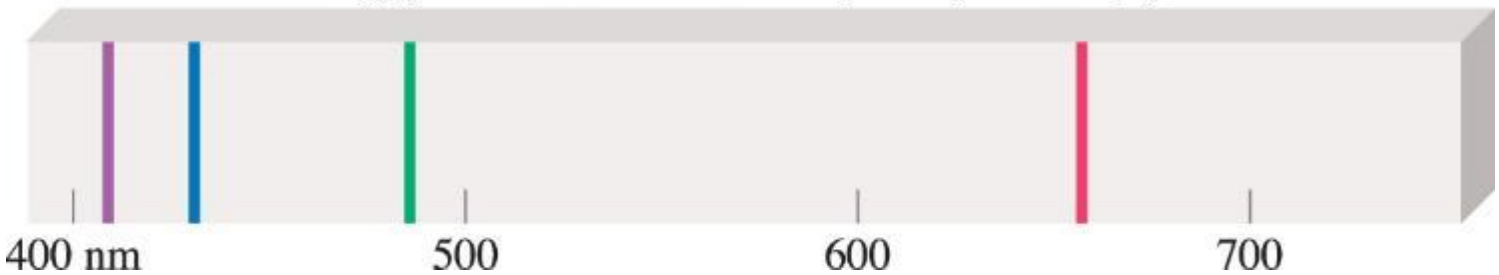
3.98×10^{-21} J

(b) a photon with a wavelength of 5.00×10^{-11} m (X ray region)

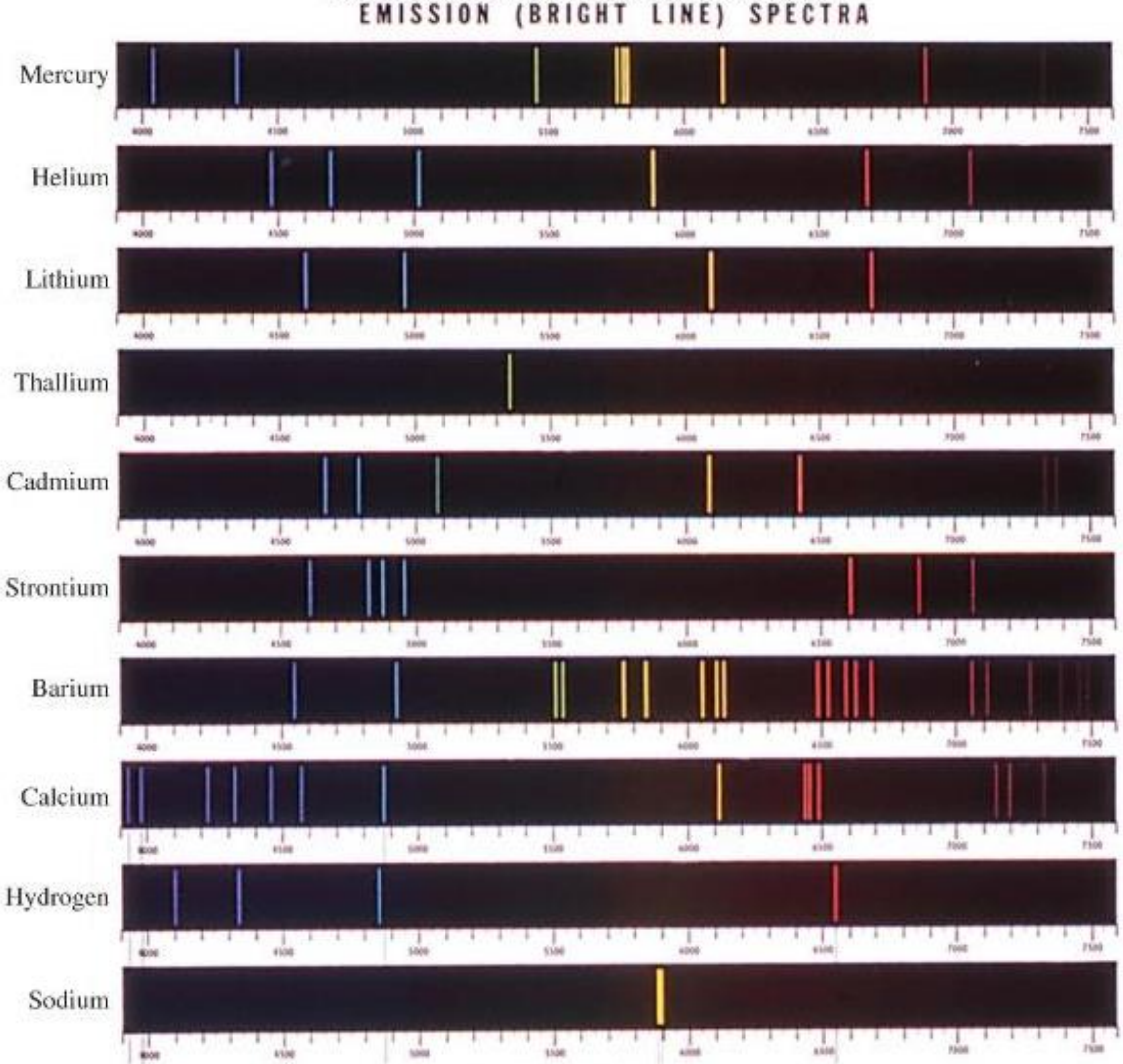
3.98×10^{-15} J

Line Emission Spectrum of Hydrogen Atoms





Emission Spectra of Some Elements



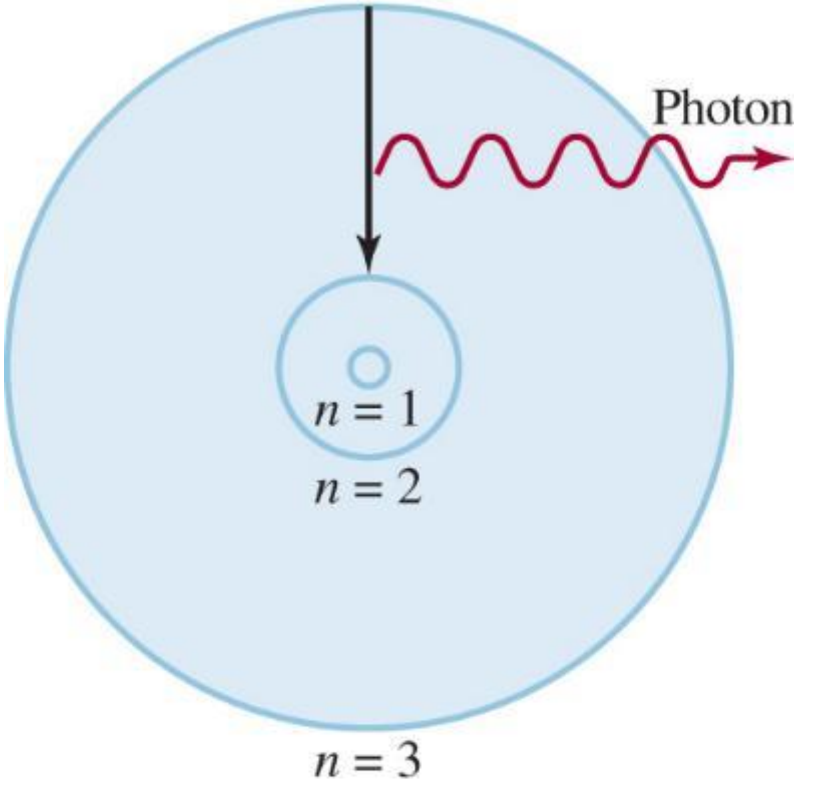
Courtesy of Wabash Instrument Corp.

Bohr's Model of the Atom (1913)

1. e^- can only have specific (quantized) energy values

2. light is emitted as e^- moves from one energy level to a lower energy level

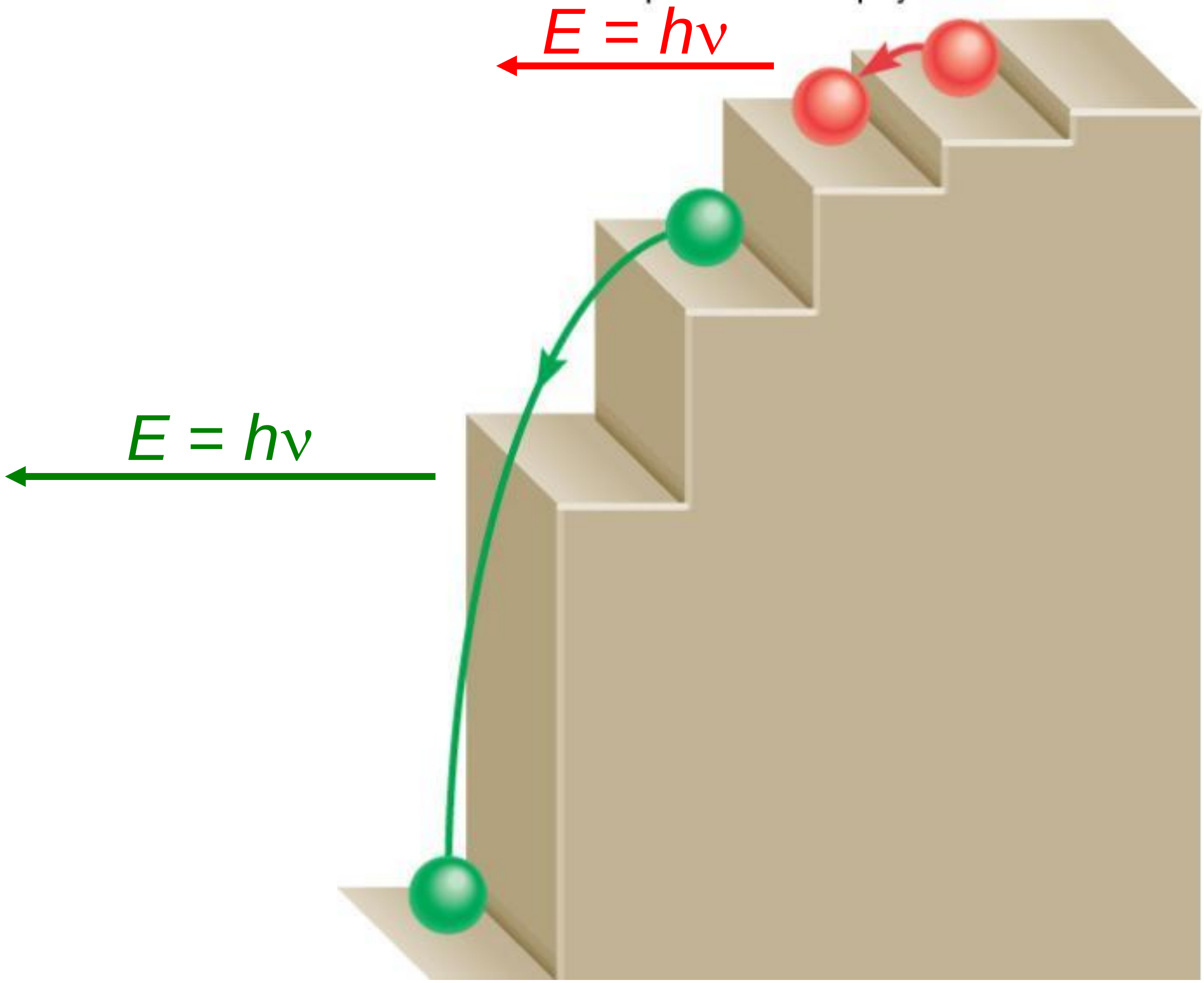
$$E_n = -R_H\left(\frac{1}{n^2}\right)$$



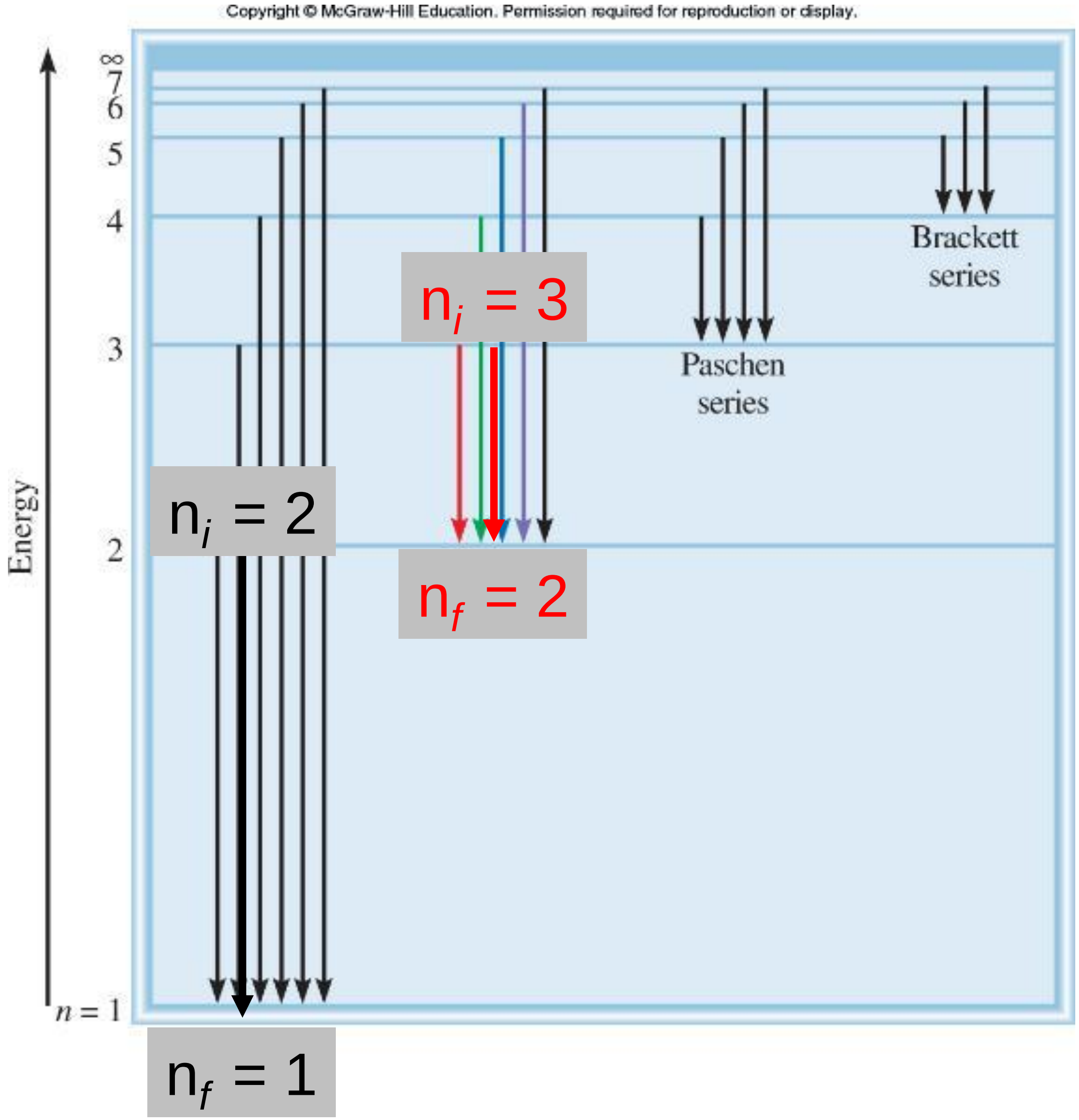
n (principal quantum number) $= 1,2,3,\ldots$

R_H (Rydberg constant) $= 2.18 \times 10^{-18}$ J

Quantized Energy



Energy Transitions of the Hydrogen Atom



$$E_{\text{photon}} = \Delta E = E_{\text{f}} - E_{\text{i}}$$

$$\Delta E = h\nu$$

Electrons changing falling to lower shell creates a photon of corresponding energy

Schrodinger Wave Equation

quantum numbers: (n, l, m_l, m_s)

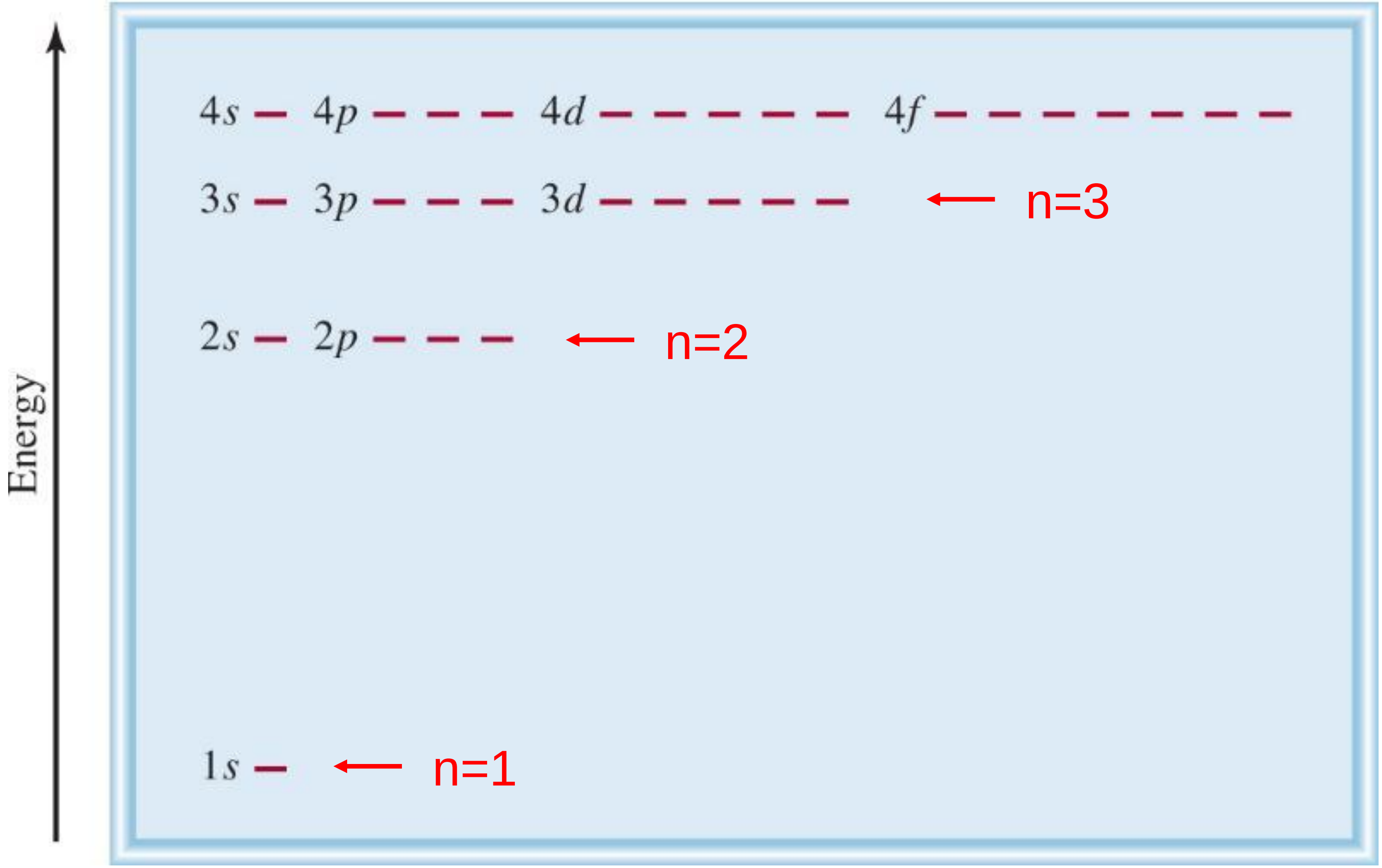
Shell – electrons with the same value of *n*

Subshell – electrons with the same values of *n* **and** *l*

Orbital – electrons with the same values of *n, l*, **and** m_l

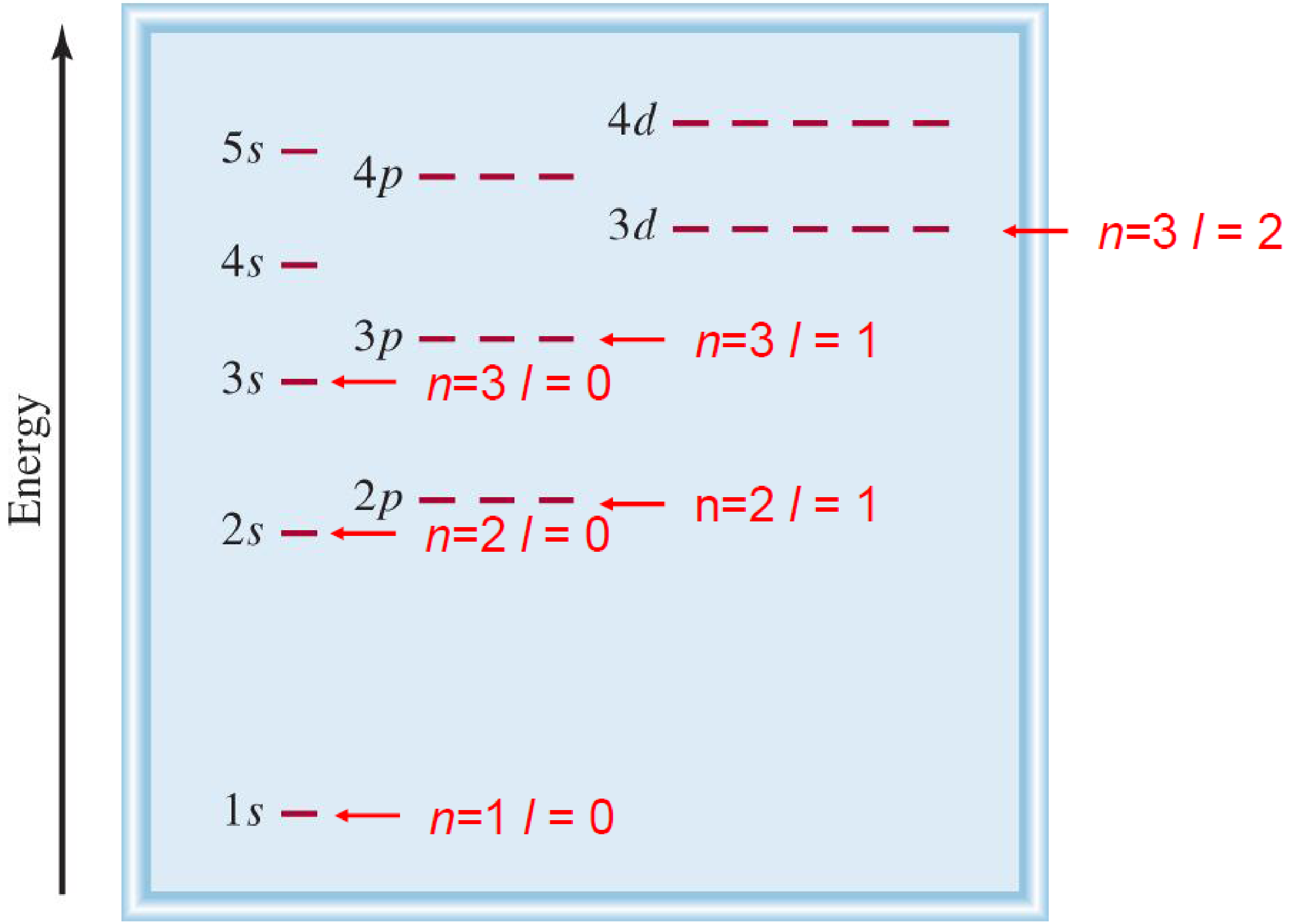
Energy of orbitals in a ***single*** electron atom

Energy only depends on principal quantum number ***n***



Energy of orbitals in a ***multi***-electron atom

Energy depends on ***n*** and ***l***



Outermost subshell being filled with electrons