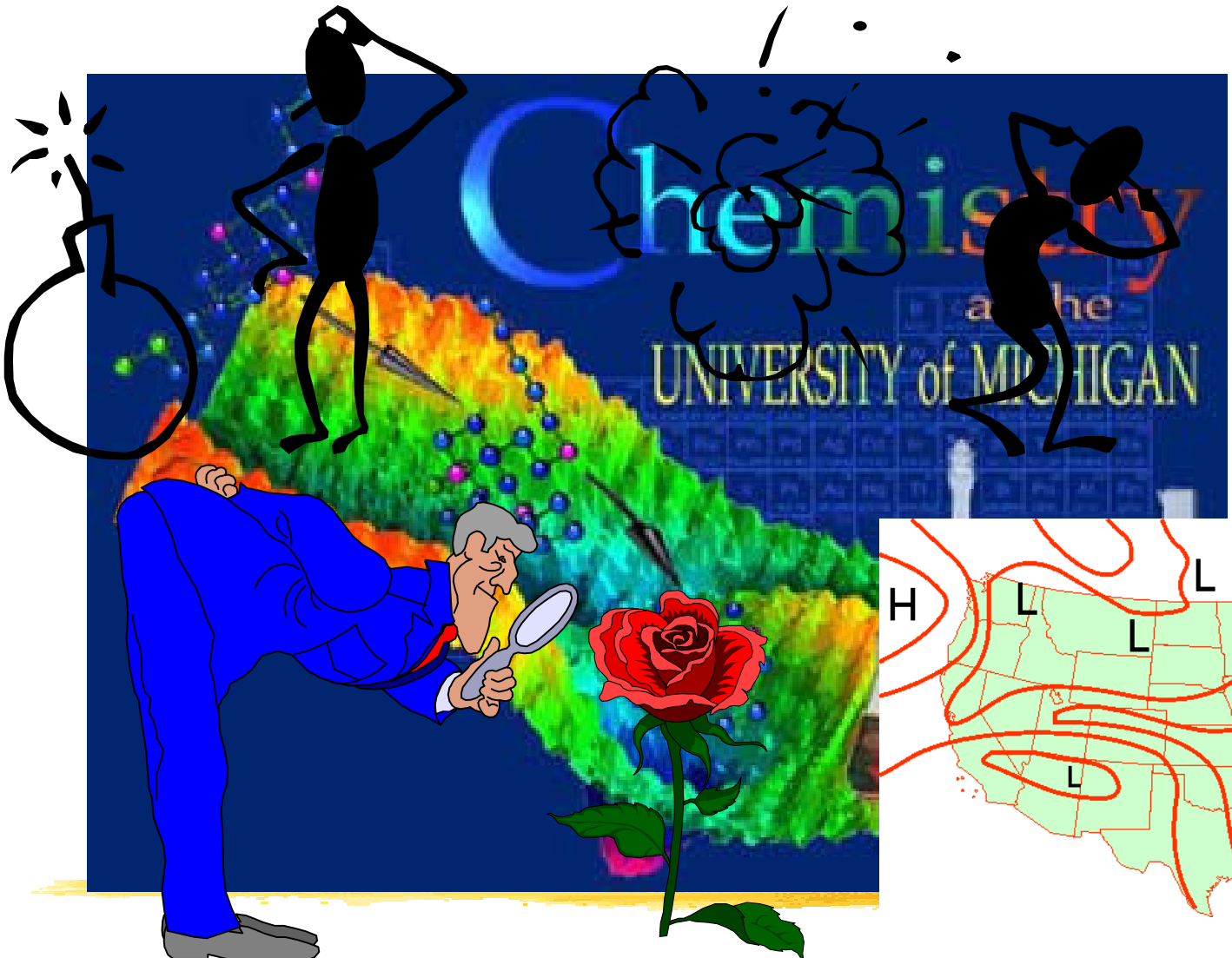
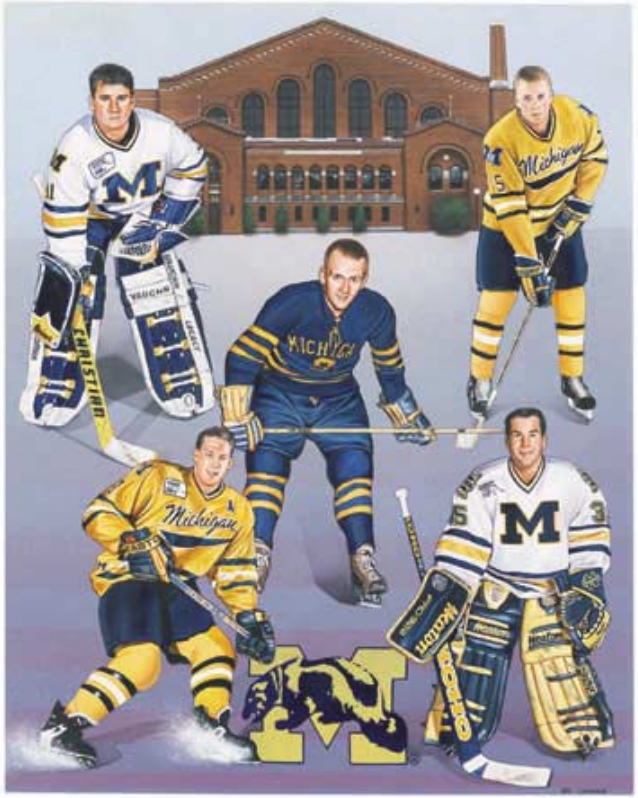
Chem 260: Chemical Principles

Nils G. Walter

What the h… are Chemical Principles ?



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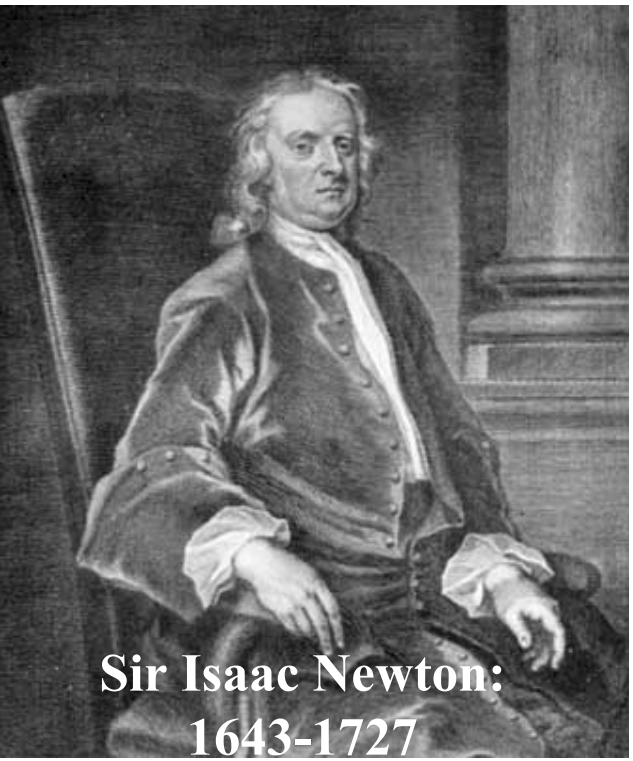
Chem 260: Chemical Principles

↓ better:

The Fundamental Physical Principles that Underlie Modern Chemistry and its Applications

Physics at the End of the 19th Century

Everything's clear!


Sir Isaac Newton:
1643-1727

Newton's ideas (published in his *Principia* in 1687) still dominate the physical sciences:

1. "All matter attracts all other matter with a force proportional to the product of their masses and inversely proportional to the square of their distance" (apples, planets)
2. A particle travels in a trajectory with precise position and momentum
3. Any type of motion can be excited to a state of arbitrary energy
4. Waves and particles are distinct concepts

Kinetic energy: $E_K = \frac{1}{2}mv^2$ **Potential energy:** $E_P = mgh$

Force: $F = ma$ **Work:** $w = -\int F(s)ds$

The Dramatic Failure of Classical Physics
Case 1: Black-Body Radiation

Electromagnetic radiation

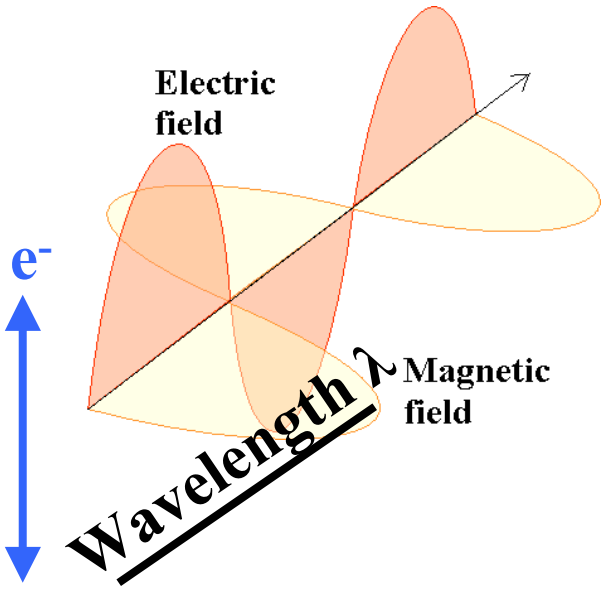


Table 2 *Colour, frequency, and wavelength of light*[†]

	Frequency/ (10^{14} Hz)	Wavelength/ nm	Energy of photon/(10^{-19} J)
X-rays and γ-rays	10^3 and above	3 and below	660 and above
Ultraviolet	10	300	6.6
Visible light			
Violet	7.1	420	4.7
Blue	6.4	470	4.2
Green	5.7	530	3.7
Yellow	5.2	580	3.4
Orange	4.8	620	3.2
Red	4.3	700	2.8
Infrared	3.0	1000	1.9
Microwaves and radiowaves	3×10^{-11} Hz and below	3×10^6 and above	2.0×10^{-22} J and below

[†] The values given are approximate but typical.

What has this to do with a black body (capable to emit and absorb all ν)?

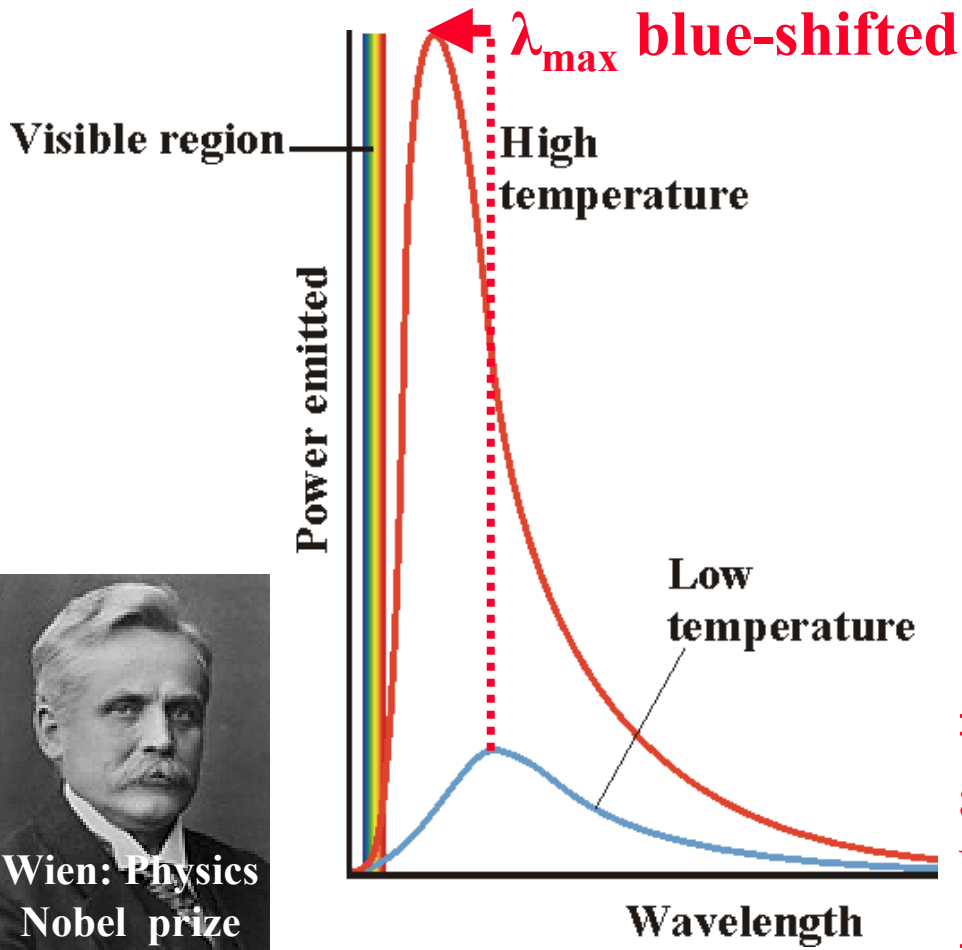
Speed of light

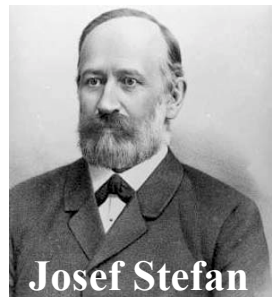
$$\lambda = \frac{c}{\nu} = \frac{1}{\tilde{\nu}}$$

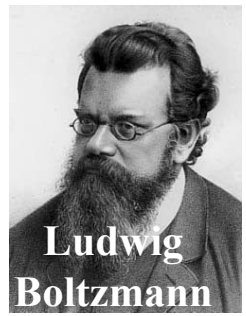
Wavenumber

Properties of Black-Body Radiation

Power density of a black body:




Josef Stefan


Ludwig Boltzmann

Emittance = total power emitted

$\Rightarrow$ Stefan-Boltzmann law:

$$M = aT^4; a = 56.7\,nW\,m^{-2}\,K^{-4}$$

Wien: Physics Nobel prize 1911

$\Rightarrow$ The higher the temperature of a lamp wire, the more power will be emitted as light!

$\Rightarrow$ Halogen lamps!

Wien's displacement law: $T\lambda_{max} = 2.9\,mm\,K$

$\Rightarrow$ Surface temperature of the sun w/ $\lambda_{max} \approx 490$ nm!