Combustion Class 2

Radiation, Thermo

Outline

	Date	Class #		Comb. Lecture	Problem Due
Nov	11	19 √	Concepts, Candle, Fireplace, Premixed, Diffusion	1	
	13	20	Heats of Formation, Heats of Reaction, Heat Capacities, Enthalpies	2	#1
	18	21	Stoichiometry, Equilibrium Constants	3	#2,#3
	20	22	Adiabatic Flame Temperature, Multi-Component Equilibrium, NASA-Lewis Code	4	#4
	27		BYU Friday, **NO Class**		
	29		**Thanksgiving**		
Dec	2	25	Heterogeneous Combustion	5	#5
	4	26	NO_X Mechanisms, Soot	6	#6
	9	27	Flame Speeds, Turbulence, Explosions	7	#7
	11	28	Review	8	#8

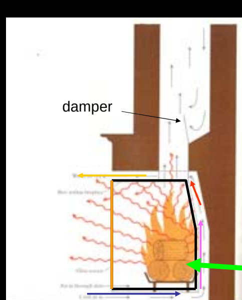
Progress

- ✓ Diffusion Flames
- ✓ Premixed Flames
- Homogeneous Combustion
- Heterogeneous Combustion
- Deflagration
- Detonation
- Stoichiometric
- Equivalence Ratio
- Extinction
- Flammability Limits
- Heat of Vaporization
- Heat of Combustion
- High Heating Value
- Chemical Equilibrium
- Dissociation
- Heats of formation & reaction
- ✓ Underventilated flames
- ✓ Overventilated flames
- Adiabatic Flame Temperature
- ✓ Soot
- Blackbody Radiation
- Thermal NOx
- Turbulence
- Ignition
- Flame Speed
- Flashback

Progress (cont.)

- ✓ How does a candle work?
- How does a fireplace work?
- Regimes of heterogeneous combustion
- Sources of NOx
- Single particle vs. cloud combustion
- As rec'd, dry, and daf bases for coal
- Turbulence effects
- Swirl
- Use of NASA-Lewis code
- Elementary step reaction sequences vs. global mechanisms

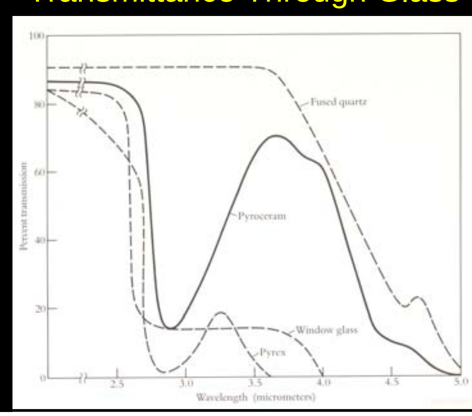
Modern Fireplace



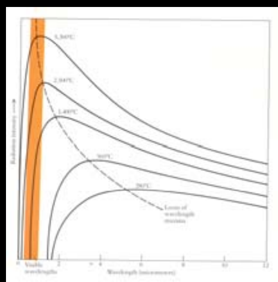
- Fire contained in insert
- Quartz glass transmits radiation from fire
- Room air circulates around insert (fan?)
- Combustion air from outside vent

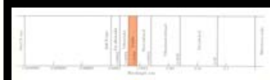
Figure from Fire, by J. W. Lyons (1985)

Transmittance Through Glass



Radiation





Planck's Law

$$e_{b\lambda} = \frac{2\pi C_1}{\lambda^5\left(e^{C_2/\lambda T} - 1\right)}$$

$$e_b = \int_0^\infty e_{b\lambda}\, d\lambda = \sigma T^4$$

Solar Radiation

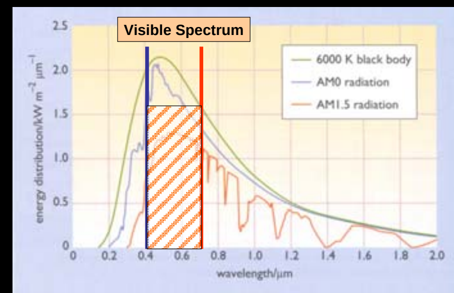
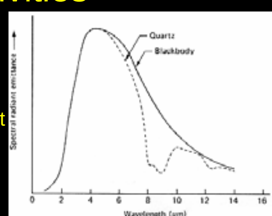
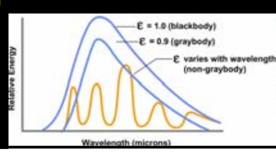


Figure 3.8 The spectral power distributions of solar radiation corresponding to Air Mass 0 and Air Mass 1.5. Also shown is the theoretical spectral power distribution that would be expected, in space, if the sun were a perfect radiator (a 'black body') at 6000 °C

Emissivities

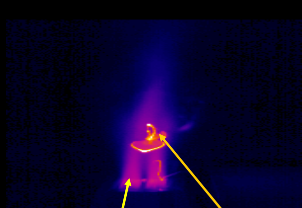
- Ratio of actual emission to blackbody emission
  - Emissivities range from 0 to 1
- May be wavelength dependent
  - Spectral emissivity (spectral means wavelength dependent)
- If emissivity is constant with wavelength, the source is termed a greybody rather than a blackbody

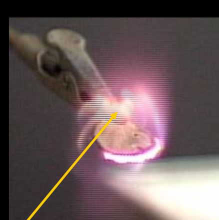




IR Camera Demo

Infrared and Visible Images of a BurningLeaf



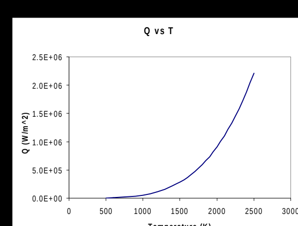


CO_2 and H_2O emission visible In infrared region

Soot emission not visible in infrared

Example 1. Compute heat loss due to radiation from a surface of temperature T when the surrounding surfaces are at 300 K.

$Q = \sigma (T^4 - 300^4)$



Example 2: At what wavelength is the peak emission from a blackbody radiating at a temperature of 1000 K?

$$\lambda_{\max} = \frac{C_3}{T}$$

$$\lambda_{\max} = \frac{C_3}{T} = \frac{2897.8\,\mu m - K}{1000\,K} = 2.9\,\mu m$$

Example 3. Plot the blackbody emission curve versus wavelength for several temperatures. Show where the visible light spectrum occurs.

$$e_{b\lambda} = \frac{2\pi C_1}{\lambda^5\left(e^{C_2/\lambda T} - 1\right)}\, W\, m^{-2}\ \mu m^{-1}$$