Incandescent Light Bulbs

Question:

An incandescent light bulb contains some gas with the filament. How would removing the gas affect the bulb's energy efficiency?

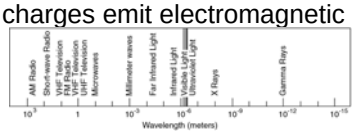
- Make it more efficient
- Make it less efficient
- No change

Observations About Incandescent Light Bulbs

- Light bulbs glow yellow-white
- They get very hot during operation
- You can feel heat radiating from them
- They burn out
- They come in many wattages
- They come in many specialized types

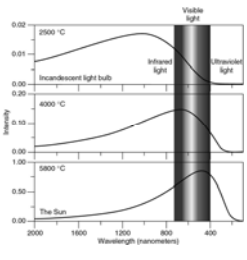
Thermal Radiation

- All materials contain electric charges
- Thermal energy makes charges accelerate
- Accelerating charges emit electromagnetic waves
- All materials emit electro-magnetic waves (thermal radiation)



Black Body Spectrum

- The spectrum and intensity of electromagnetic waves from a black body depend only on its temperature



Incandescent Bulbs

- Features:
  - Tungsten filament yields light
  - Electric wires deliver power
  - Glass bulb protects filament
  - Inert gas fill prolongs life

Operation Issues, Part 1

- Filament temperature
  - Determines color temperature and efficiency
  - Higher temperature yields higher efficiency
  - Higher temperature shortens filament life
- Filament heating
  - Heats due to power lost by an electric current
  - Requires thinner filament at higher voltages

Operation Issues, Part 2

- Filament reactivity
  - Tungsten is reactive
  - Tungsten needs protection from oxygen in air
- Filament sublimation
  - At high temperatures, tungsten atoms sublime
- Non-reactive gas limits sublimation
  - Gas bounces tungsten atoms back to filament
  - Gas leads to convective heat loss

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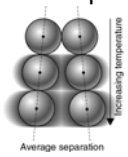
Sealing Issues

- Atoms vibrate with thermal energy
- Average separation increases with temp
- Solids expand when heated
- Some materials expand more than others when heated
- To avoid stress and fracture, glass and wires must expand equally

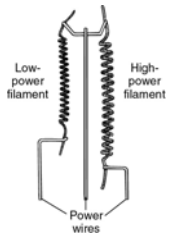


Halogen Bulbs

- Features:
  - Bromine/Iodine/Oxygen gas added to bulb
  - Bulb has small, high temperature envelope
- Produces a filament recycling process

Three-Way Bulbs

- Two separate filaments
  - One low-power filament
  - One high-power filament
- Three light levels
  - Low-power filament only
  - High-power filament only
  - Both filaments together



Specialized Bulbs

- Clear vs. Soft white bulbs
- Long life (high voltage) bulbs
- Rough service bulbs
- Energy-saver bulbs
- Krypton bulbs
- Heat bulbs
- Photoflood bulbs

Summary About Incandescent Light Bulbs

- Light Bulbs emit visible thermal radiation
- Most of their thermal radiation is not visible
- They fail when the filament sublimes away
- The glass envelope keeps oxygen out
- The inert gas fill lengthens the filament life