Topic 3: Incandescence vs. Luminescence

Light: Light is a source of energy. Light results from changes that occur in atoms when they absorb energy (excited state). Different types of light are distinguished by their different sources of energy. The two main forms of light are:

1. Incandescence (hot light)
2. Luminescence (cold light)

Incandescence: energy used to produce light comes from heat

Examples: the sun, candle flame

Incandescent light bulb

- electric current passes through a filament (wire)
- Electrons of the current collide with one another and with atoms of the filament
- Filament is negated and atoms are excited
- Atoms emit a stream of light with a wide range of energies
- The combination of all the resulting colors is white

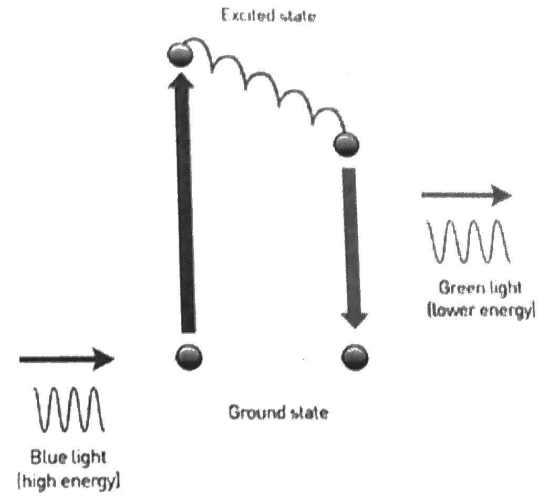
Luminescence: energy used to produce light comes from something besides heat

Type of Luminescence	Where the energy comes from	Detailed Explanation	Example
Fluorescence	light	Wavelengths of light are absorbed by a substance and then luminescence is immediately emitted by the substance at a longer wavelength. Luminescence is emitted only when stimulated by radiant energy. Luminescence ceases when radiant energy is removed.	black light posters
Phosphorescence	light	Wavelengths of light are absorbed by a substance and then luminescence is emitted slowly by the substance, at a lower intensity and for a longer duration. Luminescence emitted by the substance persists after the radiant energy has been removed.	glow in the dark paint
Chemiluminescence	chemical reaction	Luminescence is generated by the release of energy, as a result of the chemicals combining	glow sticks
Bioluminescence	living organism	A form of chemiluminescence in which the chemicals are produced by living organisms	fire flies

Topic 4: Fluorescence

Fluorescence:

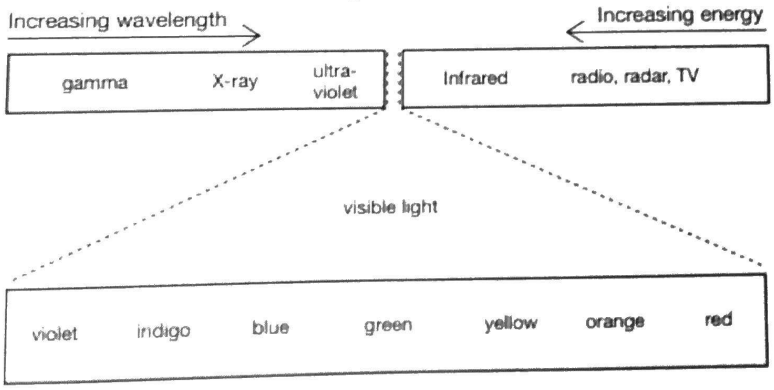
- When a material is electronically excited by absorbing high energy light and subsequently emits lower energy light



Where do we see fluorescence?

- fluorescent lights
- black lights
- labels in microscopy
- money, IDs, clothes

Electromagnetic Spectrum



Topic 5: Wien's Law

Wien's Law: tells us that objects of different temperatures emit light at different wavelengths

- Hotter objects emit most of their radiation at shorter wavelengths
  - Appear more blue
- Cooler objects emit most of their radiation at longer wavelengths
  - Appear more red

$$\lambda_{max} \approx \frac{W}{T}$$

W = 3×10^{-3} mK

T = absolute temperature (Kelvin)

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

Examples

1. The Sun

The sun is yellow-ish (λ = 500 nm = 5×10^{-7} m), what temperature is the surface of the sun?

$$T = \frac{3 \times 10^{-3}}{5 \times 10^{-7}} = 6000\,K$$

2. A stove

A stove is red-ish (λ = 700 nm = 7×10^{-7} m), what temperature is the stove?

$$T = \frac{3 \times 10^{-3}}{7 \times 10^{-7}} = 4286\,K$$

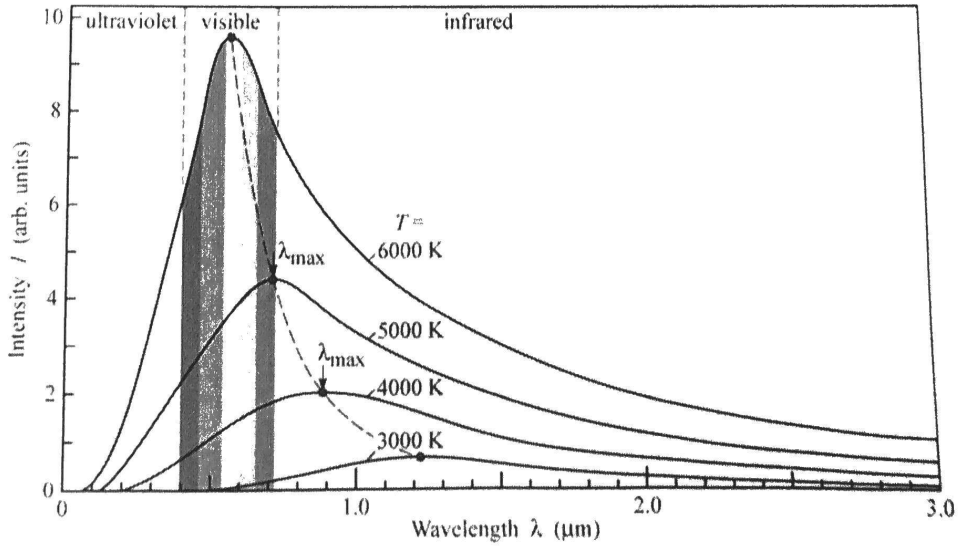
3. You!

Human body temperature is 37°C = 310 K, what wavelength do you glow at?

$$\lambda = \frac{3 \times 10^{-3}}{310} = 9.7 \times 10^{-6}\,m$$

Blackbody Radiation

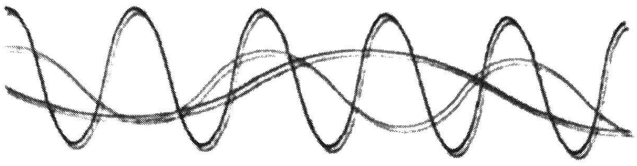
- Anything that has a temperature glows!
- Hotter = brighter



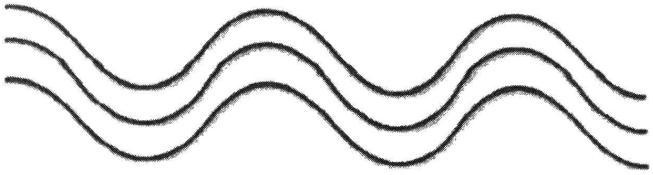
Topic 6: LASERs

Lasers are one of the most important and useful inventions based on light!

- Ordinary light bulbs
  - Give off light that consists of many colors
  - Light spreads out in many directions
- Lasers:
  - Give off light that consists of one color
  - Light spreads very little
  - ****can travel great distances with little loss of intensity ****



Sunlight (many different colors)



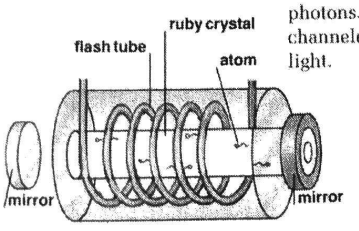
LASER: One color (monochromatic) and waves in phase (coherent)

- How is laser light used?
  - Wegman's barcode scanner
    - Can reflect light off of a barcode from a relatively long distance
    - Light detector measures the pattern of reflected light
    - Scanner send signal to computer, which identifies the item
  - CD players
  - Telecommunication devices
  - Printers
  - Medical field
    - Different wavelengths of laser light are useful for different applications
      - Surgeon uses a laser to perform Lasik corrective eye surgery using one λ
      - Surgeon can safely examine human tissue using a different λ

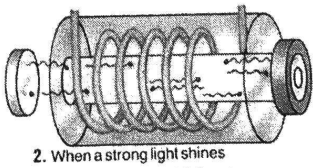
LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION

How does a laser work?

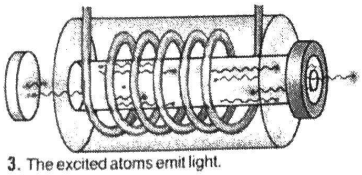
In one type of laser, a powerful flash tube is coiled around a crystal, such as a ruby crystal. The flash tube sends a strong light through the ruby, causing the energy level of the ruby's atoms to increase. The atoms are said to be in an excited state. As the atoms become more and more excited, they give off photons. The photons multiply millions of times and are channeled out of the end of the tube as rapid bursts of laser light.



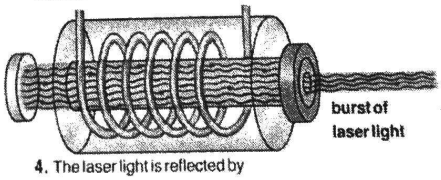
1. The atoms in the ruby crystal contain a certain level of energy.



2. When a strong light shines through the ruby crystal, the atoms absorb the light energy and become excited.



3. The excited atoms emit light. Some light escapes through the sides of the tube. The rest comes out of the end as laser light.



4. The laser light is reflected by mirrors at each end of the tube. It causes other excited atoms to release their light energy, too.