Physics 122, sections 502-4 and 8101
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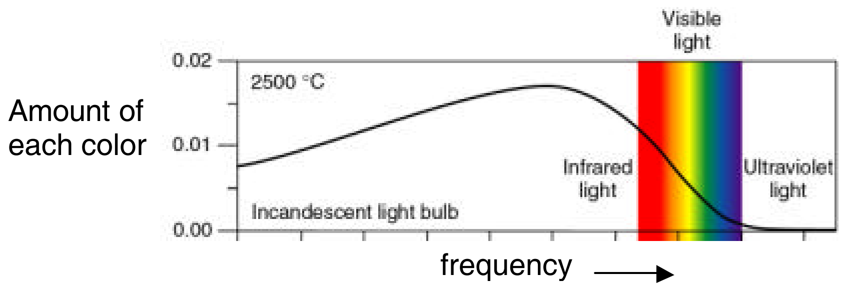
Extra problems
Not due, just for practice

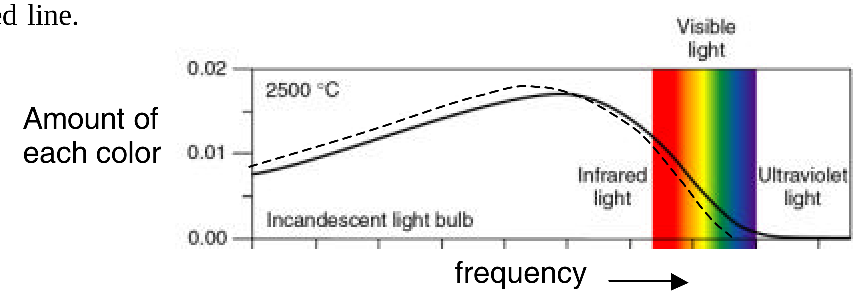
1) (optional, you won't actually be tested on any of this. I just wanted to give it to you to give you some more practice thinking about the different colors and frequencies.) When a light bulb is on,the filament gets very hot. Hot things emit light (because objects contain charges and when charges wiggle they emit light), and the hotter the object he higher the frequencies the object emits (hotter = faster wiggling.) (People are warm objects and emit light, but mostly in the infrared, too low a frequency to be visible.)

a) For a regular light bulb, the amount of light varies by frequency according to this graph.



What percentage, roughly, of the light is wasted (not useful for lighting things up so you can see them)?

b) A long-life bulb actually burns a little cooler and has a slightly longer filament. Running the filament cooler makes the filament last longer because filaments "burn out" by slowly evaporating away. (That's why a used bulb gets darker inside. It's the evaporated tungsten from the filament depositing on the inside of the glass.) The graph of colors for the cooler filament looks like the dotted line.



Is the percentage of useful light larger or smaller than for the regular bulb? And why do you need a longer filament?

c) Two students are talking about the bulbs.

Amy: The regular bulb must use more energy and be less "efficient" because it burns out quicker.
Bonnie: No, the regular bulb is more efficient because it wastes less light. It uses less energy over the same amount of time as the long-life bulb.

With whom do you agree and why?

2) Suppose you have a light bulb and a concave parabolic mirror.

a) Where should you put the bulb if you want a real image the exact same size as the bulb?

b) If the focal length is 10 cm and you put the bulb 3 cm from the mirror, what is the image distance? Where is the image? How big is it and is it real or virtual?

3) In class I explained how a neutron can decay to a proton, since the mass energy of the proton (which is lighter) is less than the mass energy of the neutron. But, we talked about two reasons why there has to be at least one more particle produced in the decay. For practice, explain what those two reasons are and what they would predict about the properties an extra particle or set of particles must have.

4) The radioactive nucleus we talked about in class was ^{238}U, which has a half-life of 4.5 billion years. . This is the main component of "depleted uranium," natural uranium with most of the ^{235}U removed for use in nuclear reactors and weapons. Natural uranium is found in uranium ore, but it isn't that dangerous to us because it is usually deep underground (it must be mined) and because it doesn't have that much uranium in it (it's not that concentrated.) Once extracted and then depleted, depleted uranium (DU) is very concentrated and also often contaminated with plutonium and other things and thus must be treated as nuclear waste, meaning it must be carefully (and expensively) stored away in shielded containers.

However, rather than spend money storing the DU, the US government and the energy companies have come up with an ingenious plan - use it for weapons so we can get rid of the DU in wars or sell the weapons to other countries (for much profit.) DU is plentiful and 1.7 times more dense than lead and thus easily cuts through armour and buildings. In Iraq, Afghanistan, and Serbia, we used more than 1000 tons of DU.

a) Many human rights organizations have complained about the use of DU. One argument that you might hear (although not from them) is that DU has a 4.5 billion year half-life and as such is a huge radioactive danger. Others argue that it is precisely this long half-life that makes it safe. Evaluate these arguments from what you know about radioactive decay and half-lives.

b) In class we discussed how different types of particles are more dangerous than others because they have different energies and different masses and different charges. ^{238}U emits a series of alphas, betas, and gammas of differing energies. The effect of radiation in humans is measured in "rem" and the effective dose rate is given in rem/hour. This number includes how many particles are being absorbed by the person in an hour, multiplied by how dangerous each particle is. If the air contained tiny particles of DU, the dose rate an average human breathing at an average rate would get would be 11 rem/hour for every gram of DU in each cubic meter of air.

When a Lockheed Martin Bunker Buster bomb, which contains over 1000 kg of DU, explodes, the bits of DU spontaneously ignite. (DU is pyrophoric, which means it spontaneously combusts when hot). The oxidized particles go airborne. If you assume that 70% of the DU becomes airborne and takes several days to settle, estimate what total dose (in rem) will the people living near the impact point receive?

c) The maximum recommended dose of radiation for the general public is 0.1 rem per year. How do these numbers compare?