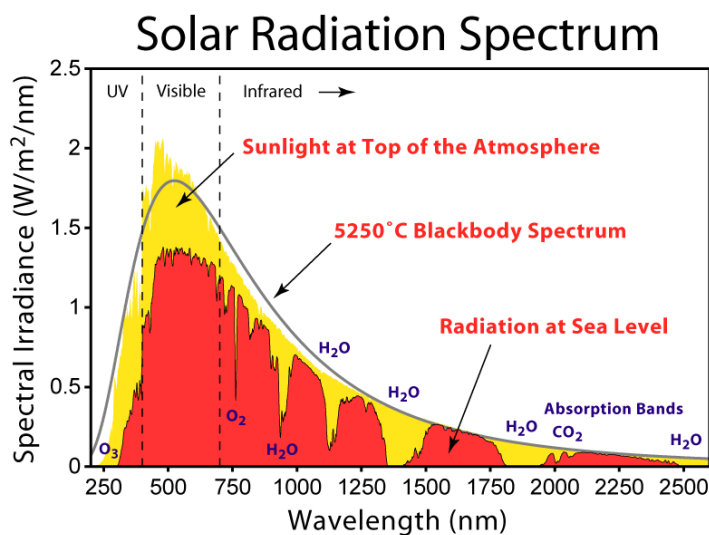


CH301H – Principles of Chemistry I: Honors  
Fall 2017, Unique 50135

Homework, Week 6

1. There are two basic ways in which matter (atoms or molecules) interact with light. 1) Light can be absorbed by the material to move an electron to a state of higher quantum number. 2) Light can be emitted from a material to move an electron to a state of lower quantum number. In words and equations, describe each of these processes. If this event occurs in the visible region of the spectrum, what will be the color of the atom? Although we have only quantified this process for 1-electron atoms (through the Bohr model), we will see that the basic concept is generalizable to multi-electron atoms and molecules. Find an example of a familiar absorption or emission event from your textbook or from our last problem set.

2. Our sun is a 5000 K blackbody. The figure below shows the solar radiation spectrum at the top of the atmosphere (yellow), at sea level (red), and compared to a perfect 5250°C blackbody. The chemical identities responsible for the most significant absorption bands are labeled on the figure.



- How close is the sun to a theoretical 5250°C blackbody?
- Explain the difference between the yellow and red curves. (Don't worry about the visible region of the spectrum – we can't explain that yet.)
- Molecules in the atmosphere that absorb strongly in the infrared region of the spectrum result in warming the atmosphere, and thus the surface of the earth. These are generally called "greenhouse gases." Based on the data given in the figure, what is the most significant greenhouse gas in our atmosphere?
- High energy light can be damaging to cells and tissues. What would happen if ozone (O<sub>3</sub>) were eliminated from the atmosphere?

3. Use the Bohr model of the atom to calculate the radius and the energy of the  $B^{4+}$  ion in the  $n = 3$  state. How much energy would be required to remove the electrons from 1 mol of  $B^{4+}$  in this state? What frequency and wavelength of light would be emitted in a transition from the  $n = 3$  to  $n = 2$  state of the ion?

4. a) In class we discussed the Balmer lines, which are visible emission lines from the H atom. These represent light that is emitted from the H atom from  $n = 3, 4, 5$  and  $6$  to  $n = 2$ . Determine the energy of each of these 4 transitions and the corresponding wavelength of light that is observed.

b) Lyman discovered another set of emission lines from the H atom, corresponding to transitions from  $n = 2, 3, 4, 5$ , and  $6$  to  $n = 1$ . Determine the energies of these 5 transitions and the region of the electromagnetic spectrum all 5 lines fall into.

c) Paschen discovered yet another set of emission lines from the H atom, this time corresponding to transitions from  $n = 4, 5, 6$ , and  $7$  to  $n = 3$ . Determine the energy of each of these 4 transitions and the region of the electromagnetic spectrum that all 4 lines fall into.

If you draw all of this information on one (large) figure, you will have essentially recreated Figure 4.15 in your textbook.

5. An electron in a chemical bond can be thought of as a standing wave with fixed ends.

a) If the bond is  $1 \text{ \AA}$  long, determine the wavelength of the electron in its ground and first excited states.

b) Determine the number of nodes in the ground and first excited states. Draw these waves.

6. The position of an electron is known within  $10 \text{ \AA}$ . What is the minimum uncertainty in its velocity?

7. Photons of green light are used to determine the position of a baseball to the precision of one wavelength. Determine the minimum uncertainty in the velocity of the baseball. Is it likely that this uncertainty would effect a batter's ability to hit the ball? Estimate the mass of a baseball as  $150 \text{ g}$ .

8. When an intense beam of green light is directed onto a copper surface, no electrons are ejected. What will happen if the green light is replaced with red light?

9. Alarm systems use the photoelectric effect. A beam of light strikes a piece of metal, which ejects electrons continuously to induce a small electric current. When a person steps into the light beam, the current is interrupted and the alarm is triggered. What is the maximum wavelength of light that can be used in such an alarm system if the metal is sodium, which requires a minimum energy to eject an electron to be  $4.41 \times 10^{-19} \text{ J}$ ?

10. Name a transition in  $C^{5+}$  that will lead to the absorption of green light.