FLUORESCENCE & PHOSPHORESCENCE.

How do fluorescent lights and fluorescent brightening agents in laundry and paper work?
How do phosphor coatings in fluorescent light and television/ computer screens emit light?

You are all familiar with the ELECTRON energy level diagram from quantum theory, yes?

	Bohr's quantum shell model		Wave-mechanical model:	
High energy n=∞	________________________	OR		
	________________________		etc.	
	________________________		4s	__
			3p	__ __ __
	________________________		3s	__
			2p	__ __ __
	________________________		2s	__
Low Energy n=1	________________________		1s	__

Just to review:

WORD BANK: absorption, emission, excitation, gamma ray, infrared, microwave, radio, relaxation, ultraviolet, visible, Xray

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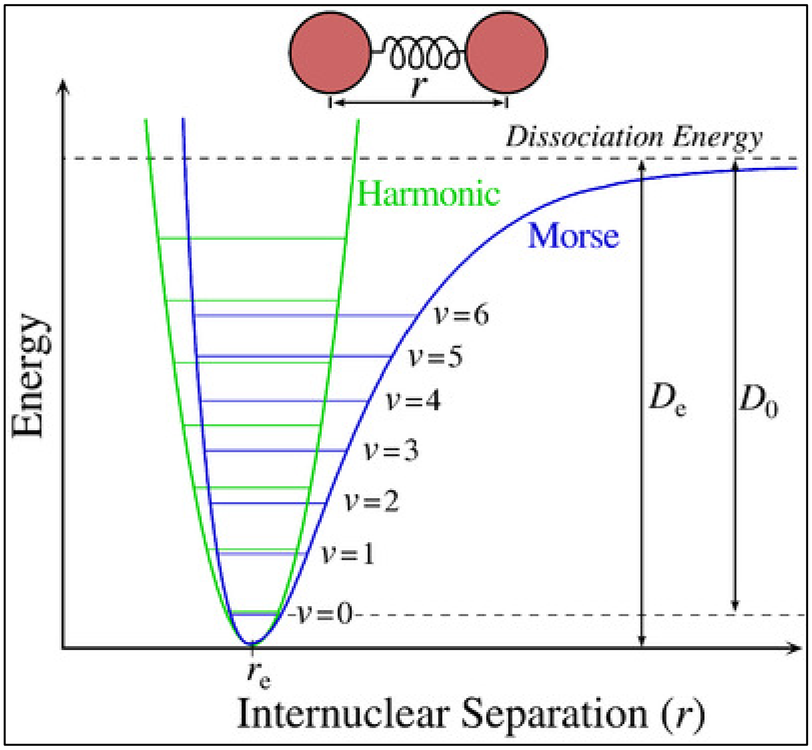
1. To go from a low energy level to a high energy level, what must an electron do, energy-wise?
   absorb energy
2. What is this electronic transition called?
   excitation
3. To go from a high energy level to a low energy level, what must an electron-do, energy-wise?
   emit energy
4. What is this electronic transition called?
   relaxation
5. Not all electronic transitions are accompanied by energy absorptions or emissions in the visible range. To refresh your memory, write out the different parts of the electromagnetic spectrum from low to high energy:

Low Energy____High Energy

Radio → Microwave → Infrared → Visible → Ultraviolet → Xray → Gamma ray

Well, before we continue, we will need to refine this model a bit. Some points to consider:

1. EVERY MOLECULE—not just atoms, but molecule has a related energy diagram, which is much more complicated than what we have learned.



2. The ELECTRONIC energy levels for these molecules, instead of having an energy represented by a flat line, are represented by CURVED lines (also called the Morse energy potentials) because the energy of a molecule changes as its bonds vibrate and move about.
3. Within each electronic energy level, there are VIBRATIONAL energy levels that correspond to certain movements within the molecule.

Image of Morse potential for a molecule. http://en.wikipedia.org/wiki/File:Morse-potential.png (April 18, 2009).

UNDERSTAND THE MODEL:

1. What is the x-axis in this energy diagram?
   Internuclear separation (bond length)
2. When a molecule stretches, what happens to the internuclear separation, r?
   It increases
3. When a molecule contracts, what happens to the internuclear separation, r?
   It decreases
4. When is the energy lowest (i.e. what does x= when the energy is lowest?)?
   When the internuclear separation = r_e (the equilibrium bond length)
5. If I double the internuclear separation to $2r_e$, what vibrational energy level am I at?
   v=6
6. *Vibrational* energy levels span from an r value less than r_e to an r value greater than r_e, explain why—think about what vibration entails…..
   A vibrational energy level spans a range of r's because when a molecule vibrates, it expands and contracts its bonds, changing the internuclear separation.

FLUORESCENCE (which helps you understand phosphorescence).

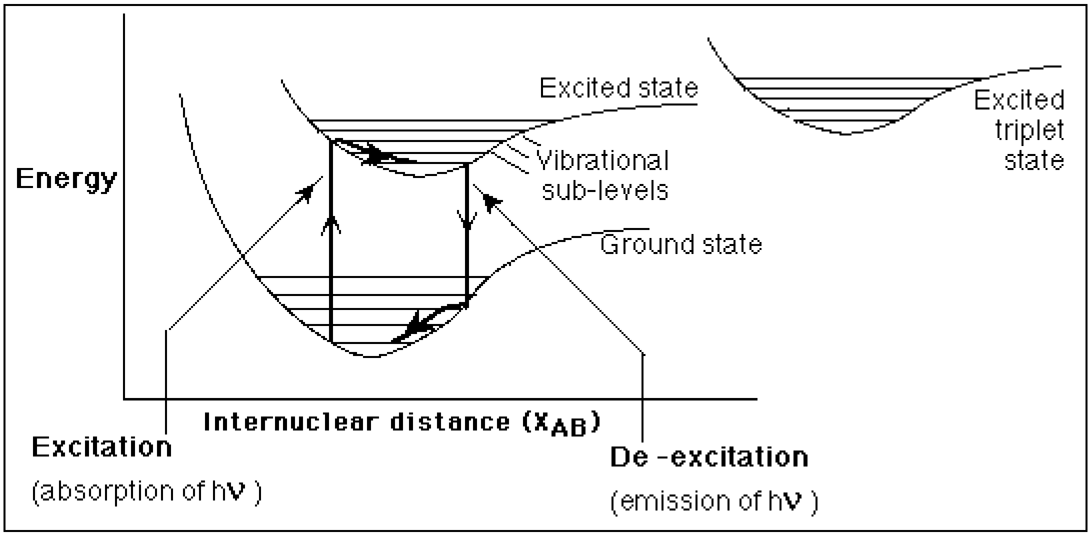


Image of electronic and vibrational energy level diagram related to fluorescence. http://www.resonancepub.com/spectrofluor.htm (April 2, 2009).

Let's look at a model with two excited electronic states, a ground state and an excited state. The model above shows what happens during fluorescence.

a) First, an molecule absorbs energy to go from a ground electronic state to an excited electronic state without changing its internuclear distance.
b) Second, the molecule relaxes down to a lower vibrational level in the excited state, usually by vibrating or colliding with something else.
c) Third, molecule emits energy as it relaxes from the excited electronic state back down to the ground electronic state. It may or may not do further vibrational relaxation.

Phosphorescence works in a similar manner, but it lasts longer—I'm not going into details!

WHAT DO I NEED TO KNOW?

1. I want you to focus on the arrows representing the transitions between the ground and excited electronic states. What is higher energy, the energy absorbed or the energy emitted?

   The energy absorbed is higher energy.

2. I shine white and ultraviolet light on a fluorescent (or phosphorescent) object. The white light is completely reflected, but the UV light is absorbed causing blue light to be emitted.
   •Compare the total number of **visible light** photons in the initial light and in the reflected/ emitted light:

   The total number of visible light photons in the emitted light is greater.

   •How would this object appear next to a normal white non-fluorescent object?

   It would appear brighter, and blue-tinged.