

Things you should know when you leave Discussion today:

1. Atomic (matter) Emission and absorption of light.
 - a. Energy Conservation and interaction between light and matter: $\Delta E_{\text{light}} + \Delta E_{\text{matter}} = 0$
 - b. Amount of energy exchange (and sign of ΔE)
2. Calculating the wavelength and frequency of light, and energy of a photon,
3. Read: Hydrogen atom family album, PDF, 7 pages, <http://goo.gl/XPkcxy>

1. If light is in resonance with matter what must be true:

- a. $|\Delta E_{\text{light}}| < |\Delta E_{\text{cloud}}|$ $|\Delta E_{\text{light}}| = |\Delta E_{\text{cloud}}|$ $|\Delta E_{\text{light}}| > |\Delta E_{\text{cloud}}|$
- b. $|\Delta E_{\text{cloud}}| < h\nu_{\text{light}}$ $|\Delta E_{\text{cloud}}| = h\nu_{\text{light}}$ $|\Delta E_{\text{cloud}}| > h\nu_{\text{light}}$

2. Absorption versus *emission*:

- a. During *emission*, light (gains / gives off) energy and an atom (gains / gives off) energy.
- b. $\Delta E_{\text{light}} = (+ / -)$ $\Delta E_{\text{cloud}} = (+ / -)$
- c. During *absorption*, light (gains / gives off) energy and an atom (gains / gives off) energy.
- d. $\Delta E_{\text{light}} = (+ / -)$ $\Delta E_{\text{cloud}} = (+ / -)$

3. When a molecule of substance A is resonant with the red light 700nm and a molecule of substance B is resonant with the blue light (400nm). Which statement is the most accurate? (Hint: unit of energy

$$h\nu = \frac{hc}{\lambda} = E_{\text{photon}}$$

transferred is equal to

- a. When substance A absorbs light it absorbs more energy than substance B.
- b. When substance B absorbs light it absorbs more energy than substance A.
- c. Because each molecule absorbs one quantum of light, the amount of energy absorbed by each substance is the same.
- d. There is no energy absorbed because temperature of the surrounding does not change.

4. Without doing any calculations which of the following beams of electromagnetic radiation transfers the greatest amount of energy per second when one electron is resonant with the light? A watt is an intensity of the light that represent total amount of energy available per second $W=1\text{J/s}$. (Hint: unit of energy

$$h\nu = \frac{hc}{\lambda} = E_{\text{photon}}$$

transferred is equal to (

- a. 0.01 J/s (watt) with wavelength $\lambda = 11000 \text{ nm}$
- b. 100 J/s (watt) with wavelength $\lambda = 600 \text{ nm}$
- c. 1 J/s (watt) with wavelength $\lambda = 400 \text{ nm}$
- d. 0.01 J/s (watt) with wavelength $\lambda = 0.01 \text{ nm}$

5. An atom's emission spectrum contains lines of red light and green light (and nothing else). The reason why there is no orange light in the spectrum is because ...

- a. The atom would need more energy to emit orange light
- b. The atom does not have an energy level corresponding to that of an orange light
- c. The atom is not resonant with the orange light
- d. Atoms always only can give off two lights

6. We have a light bulb that gives off light with the wavelength of 500. nm and produces 120. W of power. (1W=1J/1s, $h=6.62607004 \cdot 10^{-34}$ J·s , 1eV= $1.6021766 \times 10^{-19}$ J)

a. How much energy in J is transferred to matter when the cloud of one electron resonant with that light? (Hint: How much is one unit of energy transferred?)(At home recalculate the energy in eV) (Answer: $3.97 \cdot 10^{-19}$ J)

b. How many electron clouds will it take to absorb all the light provided by the bulb per second? (Answer: $3.02 \cdot 10^{20}$ electron clouds /s)

c. How many moles of the electrons absorb that amount of energy per second? (Answer: $5.02 \cdot 10^{-4}$)

7. A light beam of 10 Watts and 500nm illuminates a sample of matter. The matter is able to absorb 1.5×10^{19} photons of light every second at 500nm. What intensity of light (in Watts) is seen at the detector? (Answer:4W)



8. Red light emitted by an atoms has wavelength at 650 nm. A typical IR frequency is $\nu_{IR} \sim 1 \times 10^{13}$ Hz. This means that, compared to the mass, m_{atom} , of what is moving in response to visible light, the moving mass in IR spectra, m_{IR} , is ... (Answer: 2000 times heavier)

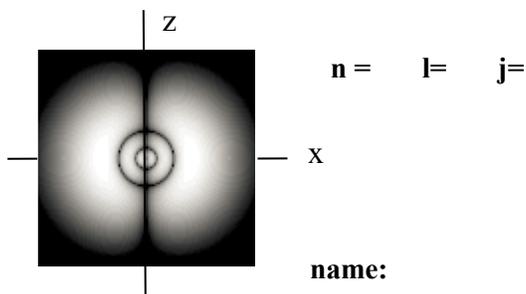
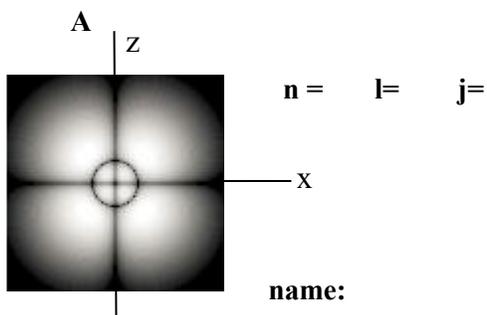
9. A red laser of 700nm and a violet laser of 350nm are both pointed at the same detector. The detector reads that the same amount of red light is absorbed per second as the amount of violet light is absorbed per second. If the violet laser is 10 Watts, then what the intensity of the red laser?(Answer:5)
10. You have light with an intensity of 10.0 Watts and frequency of $6.00 \cdot 10^{14}$ Hz. Calculate the change of energy of the light, in Joules, if the electron clouds of one trillion (10^{12}) atoms are excited per second. ($h=6.626 \times 10^{-34}$ J·s). (Answer: $-39.6 \cdot 10^{-8}$ J)
- a. What was fraction of the light that was lost in 1s?(Answer:0.000004%)
11. Calculate the amount of energy transferred in joules when one mole of electrons absorbs red light frequency of $4.00 \cdot 10^{14}$ Hz.(Hint: what is the value of one unit of energy transferred?)(Answer:159kJ)
12. Would a mole of light with wavelength of 500 nm provide enough energy to vaporize 10 moles of water? (ΔH_{vap} for water = 44 kJ/mol)(Answer:No)
13. How many times more energetic is a light corresponding to $\lambda = 5.0$ nm than a light corresponding to $\lambda = 1.0 \times 10^2$ nm light?(Hint: compare units of energy transferred?)(Answer:20)
14. Using the information in question 4, calculate the following for practice:
- How much energy is transferred to matter when the cloud of one electron resonant with light in each beam of electromagnetic radiation.
 - How many electron clouds per second will it take to absorb all the light provided by each light?

15. Fill the table below

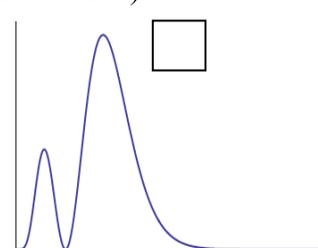
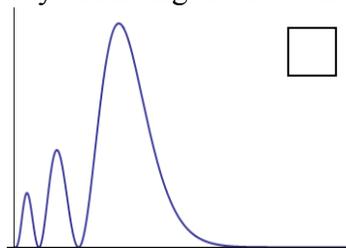
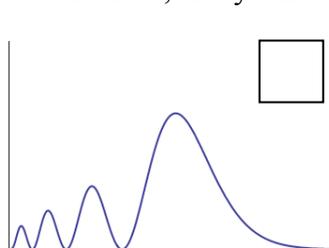
Orbital	l	$n=j+l$	$j= n-l$	Shape	Number of orbitals in a subshells(m_l)	# e^-
s	0	1 2 3 etc		Sphere		
p	1	2 3 4 etc		Dumbbell		
d	2	3 4 etc		Cloverleaf		
f	3	4 5 etc				

16. For the two hydrogen electron clouds below identify the quantum number “n”, the quantum number “l” number of nodal planes, the number of radial loops “j”, and the specific name of the orbital($S: l=0$, $P:l=1$, $D;l=2$)

$$n=j+l$$



a. Match each of the electron clouds above to one corresponding electron cloud cross section below. Indicate your answer by putting in the box next to the function.(x axis is distance from the nucleus, and y axis is a probability of finding an electron at the given distance)

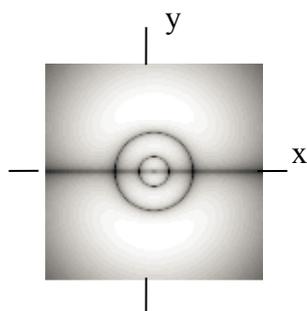


17. Fill out the table:

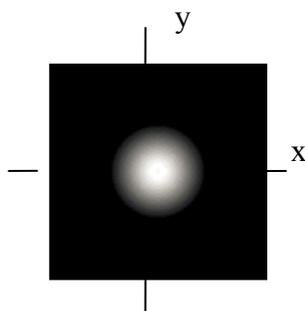
n, l, j	Name the orbital	Draw the orbital
n=2, l=0		
n=4, l=2		
n=2, l=1		
n=2, l=2		
l=2, j=1		
l=0, j=3		

18. Shown below are displays of the *density* in the *xy* plane of an electron in several hydrogen atom orbitals. The brightness of the displays is proportional to the probability density. For each display, correctly name the orbital, for example, 1s, 2p_x, etc.

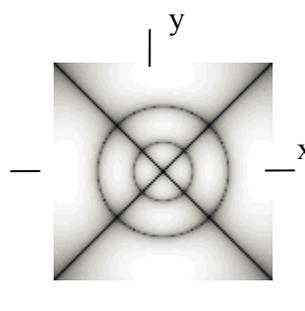
Display A: _____



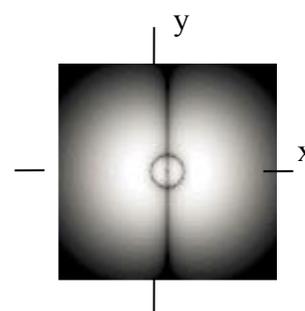
Display B: _____



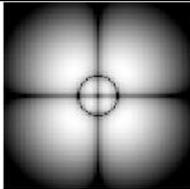
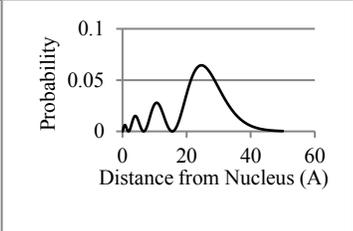
Display C: _____



Display D: _____



19. Complete the table below about the hydrogen atom:

	Electron Cloud Name	Principle quantum number, n	Angular momentum quantum number, l	j (number of radial loops)
-----	name = 2s	$n = \underline{\quad}$	$l = \underline{\quad}$	$j = \underline{\quad}$
	name = $\underline{\quad}$	$n = \underline{\quad}$	$l = \underline{\quad}$	$j = \underline{\quad}$
-----	name = $\underline{\quad}$	$n = \underline{\quad}$	$l = 2$	$j = 3$
	name = $\underline{\quad}$	$n = 4$	$l = \underline{\quad}$	$j = \underline{\quad}$
-----	name = $\underline{\quad}$	$n = \underline{\quad}$	$l = 3$	$j = 6$

Read: Hydrogen atom family album, PDF, 7 pages, <http://goo.gl/XPkcxv> and answer the following questions:

20. How does the relative size of the ns orbitals compare?
21. Does the size of the np and of the nd orbitals increase with n ?
22. How does the relative size of the innermost loop of the ns orbitals compare?
23. How does the relative size of the innermost loop of the np orbitals compare?
24. How does the relative size of the outermost loop of the ns orbitals compare?
25. How does the relative size of the outermost loop of the np orbitals compare?
26. Which of the orbitals 4s, 4p, and 4d is the largest, that is, has the electron density distributed over the greatest volume?
27. Which of the orbitals 4s, 4p, and 4d is the smallest, that is, has the electron density distributed over the smallest volume?
28. Is the relative size ordering $ns > np > nd$ true for $n = 3$ as well?