Chemistry 204: Quiz #1

1. The energy difference between a 2*p* and 2*s* orbital of a lithium atom is 2.96×10^{-19} J. When an excited electron in the 2*p* orbital of a lithium atom returns to the 2*s* orbital, what color of light is emitted?

    a) red (625 nm to 700 nm)
    b) orange (585 nm to 625 nm)
    c) yellow (565 nm to 585 nm)
    d) green (470 nm to 565 nm)
    e) blue (420 nm to 470 nm)

2. Imagine two set-ups, each with two identical neutral quantum particles (not electrons). In one case, the two particles are trapped in a 1-D box, and in the other case, the two particles are trapped in a 3-D cube. The dimensions of the cube are the same as the length of the box. Find the ratio of the longest wavelengths required in each to produce an excited state.

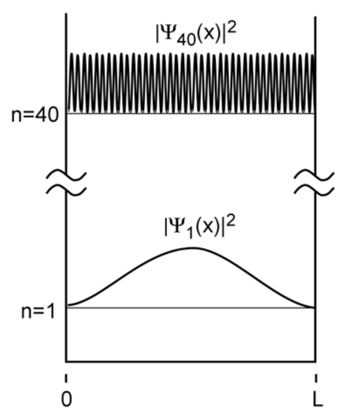
$$\text{Ratio} = \frac{wavelength\ in\ 1\text{−}D\ box}{wavelength\ in\ 3\text{−}D\ cube}$$

    a) 0.60 b) 0.83 c) 1.0 d) 1.2 e) 1.7

3. You remove all but the last electron from an atom and find that to remove the final electron requires 2.10×10^4 kJ/mol. Which atom did you have?

    a) He b) Be c) O d) Cu e) Cannot be determined.

4. Consider the following figure (as seen in lecture!):



Which of the following statements (a-d) concerning this figure is correct?

    a) At *n* = 40 we can see that classical mechanics is simply a special case of quantum mechanics.
    b) The probability of finding a particle trapped in a box at *n* = 40 is greatest at *L*/2.
    c) The probability that the particle is at *n* = 40 is always greater than the probability that the particle is at *n* = 1.
    d) Probability is evenly distributed for a quantum particle in the ground state.
    e) None of the above statements is correct.

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5. How many electrons can be described by the quantum numbers $n = 3$, $l = 2$?

   a) 2   b) 6   c) 8   d) 10   e) 18

6. Two of your friends are reviewing electron configurations, and Friend One says that the electron configuration of nitrogen is $1s^2 2s^2 2p^2 3s^1$. Friend Two laughs and says, "That's not right at all." Which of the following responses by Friend One is correct?

   a) "It is a correct electron configuration for an excited state of nitrogen."
   b) "It is a correct electron configuration for an ion of nitrogen."
   c) "Did I say the nitrogen atom? I meant the sodium atom."
   d) "Oops. You're right – it is not correct for nitrogen in any conceivable way."
   e) "Yes it is."

7. You are pulled over for speeding (nice going). The police officer has clocked you at 25 mph (~11 m/s) in a school zone (where the speed limit is 20 mph). You decide to fight the ticket by using Heisenberg's Uncertainty Principle. Assuming the system (you, the car, anything else in the car) weighs about 2500 lbs. (for a mass on earth of about 1100 kg), what is your best defense, and will it work to get you out of the ticket?

   a) Yes, it will work! The best defense is to say the uncertainty in position is one atom (about 10^{-10} m). This maximizes uncertainty in velocity, and it is large enough so that it may be true that you were within the posted speed limit.
   b) Yes, it will work! The best defense is to say the uncertainty in position is about 10 meters (which is the approximate length you'd travel in the one second or so it takes the police officer to use the radar gun). This maximizes uncertainty in velocity, and it is large enough so that it may be true that you were within the posted speed limit.
   c) Yes, it will work! The best defense is to say the uncertainty in position is the distance of the school zone (about 500 meters). This maximizes uncertainty in velocity, and it is large enough so that it may be true that you were within the posted speed limit.
   d) No, it will not work. The best defense is to say the uncertainty in position is the distance of the school zone (about 500 meters). This maximizes uncertainty in velocity, but it is not large enough to bring the recorded 25 mph to 20 mph.
   e) No, it will not work. The best defense is to say the uncertainty in position is one atom (about 10^{-10} m). This maximizes uncertainty in velocity, but it is not large enough to bring the recorded 25 mph to 20 mph.

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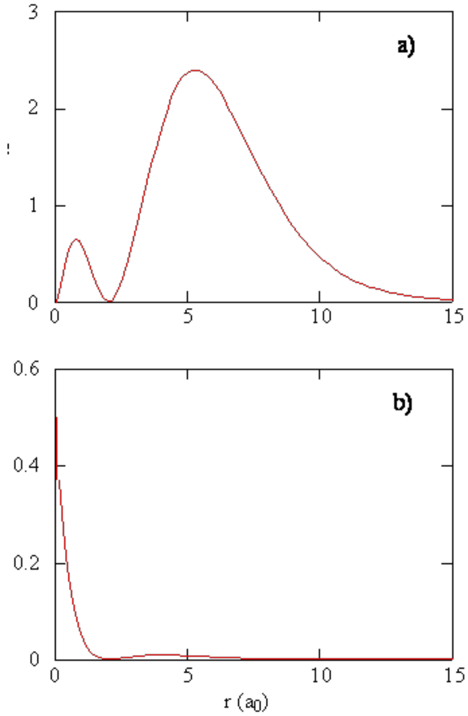
8. The plots below are for the same orbital in the hydrogen atom. Which of the following statements correctly describes these plots?



a) The plots are for the 1*s* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).
b) The plots are for the 2*s* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).
c) The plots are for the 2*s* orbital in hydrogen. The top plot is the probability density of the electron (R^2 vs. distance from the nucleus) and the bottom plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus).
d) The plots are for a 2*p* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).
e) The plots are for a 2*p* orbital in hydrogen. The top plot is the probability density of the electron (R^2 vs. distance from the nucleus) and the bottom plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus).

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9. We have discussed the need for more complex models to answer more questions. For example, in Chemistry 202, without the use of orbitals, we were able to discuss that, **in general**, ionization energies (IE) increase for elements across a row of the periodic table. However, there are some exceptions to this general trend as we can see from the data for the elements lithium through oxygen:

Element	First ionization energy (kJ/mol)
Li	520
Be	900
B	800
C	1100
N	1400
O	1300

a. Explain these numbers. Make sure in your answer to **define** what is meant by ionization energy, **explain** why the general trend for IE values across a row is to increase, and the **nature of the exceptions**. Use concepts such as **shielding**, the **penetration effect**, and **orbital diagrams** (□ □□□) in your answer when appropriate.

Now consider the second ionization energies as well:

Element	First ionization energy (kJ/mol)	Second ionization energy (kJ/mol)
Li	520	7300
Be	900	1800
B	800	2400
C	1100	2300
N	1400	2900
O	1300	3400

b. Determine the ratio of 2nd IE/1st IE for the elements Li to O. **Why is this ratio greater than one** for all of the elements? **Explain the relative ratios** (using concepts such as **shielding**, the **penetration effect**, and **orbital diagrams**, when appropriate).

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KEY:

MC: 1. a, 2. a, 3. b, 4. a, 5. d, 6. a, 7. e, 8. b

9. See videos, lectures, and the textbook. For part c, the correct values are 1681 and 3374, so estimations around 1700 and 3400 work well