Two hydrogen atoms bumped into each other recently.
One said: "Why do you look so sad?"
The other responded: "I lost an electron."
Concerned, One asked "Are you sure?"
The other replied "I'm positive."
Electronic structure/Quantum mechanics
(20 points; 4 points each response)

1. Name at least two types of electromagnetic waves:

2. Draw two waves in which one wave represents electromagnetic radiation of higher energy than the other. Label which one is higher in frequency and which one has the longer wavelength.

3. When Max Planck (a physicist) first had a feeling that light behaved like particles he was very nervous because it had been established (a century before) that light was made of waves. How were these conflicting views resolved? 1-2 sentences should do it.

4. 1-2 sentences each. Just describe what is observed.
   a. Suppose you took a spectroscope (which separates light into its constituent wavelengths) and used it to look at light from an incandescent light bulb. What would you see? (You did this in class/lab)

   b. How does this differ when you use the spectroscope to look at glass tubes filled with an element (as a gas)? (You did this in class/lab)
5. (20 points total) We discussed the Bohr model of the atom. Here is an example of the model. *Note: The distances between orbits are not equal.*

![Electron Orbits Diagram]

a. (4 points) If there was one electron in the ground state of the atom above, which energy level(s) could it be in:
   
   Circle all that apply:  
   
   n= 1  n=2  n=3  n=4

b. (4 points) If there was one electron in an excited state of the atom above, which energy level(s) could it be in:
   
   Circle all that apply:  
   
   n= 1  n=2  n=3  n=4

c. (5 points) Draw an electron in the n=4 energy level. What are all the possible transitions the electron can undergo as it loses energy? There are five possible transitions (the first one is provided):

1. the n=4 to n=1 transition

2.

3.

4.

5.

d. (4 points) Which transition above (in Part C) results in the longest wavelength of light? Which transition above (in Part C) results in the shortest wavelength of light?

e. (3 points) If this atom was heated and gave off light, would the light given off result in a continuous spectrum of light or a line spectrum?
6. (2 points each)
   a. Bohr was incorrect about the orbits. However, his model was correct about quantized energy levels. What does the term “quantized energy” mean? (1-2 sentences)

   b. What was observed that led scientists to believe that quantized energy levels were correct? (1-2 sentences)

7. (4 points) How are Bohr’s orbits different from Schrödinger’s orbitals? (1-2 sentences)

8. (12 points) For the following elements, provide the full electron configuration. For each one, circle the part of the electron configuration that includes only the valence electrons.

<table>
<thead>
<tr>
<th>Element</th>
<th>Electron configuration (Circle the valence electrons)</th>
<th>Lewis structure</th>
<th>Ion formed from this element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
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<td>Cl</td>
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<td></td>
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</tr>
<tr>
<td>Ar</td>
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</tr>
</tbody>
</table>

9. (3 points) a. What is the Noble gas shorthand electron configuration for Bromine?

   (5 points) b. Draw the orbital (box) diagram for Phosphorous.
Chemical Bonding/Lewis structures

10. (4 points) Is KNO₃ an ionic compound or a covalent compound? _________________
    Draw the Lewis structure below.

11. (4 points) Is SO₃ an ionic compound or a covalent compound? _________________
    Draw the Lewis structure below.

    (2 points) Is the molecular shape: linear, bent, trigonal pyramid, trigonal planar, or tetrahedral?  
    (2 points) Do the dipole moments cancel? Y or N Is it polar or non-polar?

12. (4 points) Is (NO)⁺ an ionic compound or a covalent compound? _________________
    Draw the Lewis structure below.

    (2 points) Is the molecular shape: linear, bent, trigonal pyramid, trigonal planar, or tetrahedral?  
    (2 points) Do the dipole moments cancel? Y or N Is it polar or non-polar?
13. (4 points) Draw the structure of water. Explain why water does not have a linear molecular shape (1-2 sentences).

14. (3 points) Do you believe a compound like NH₃ will dissolve in water? What is your basis for this prediction (1-2 sentences)?

15. (5 points) Draw the Lewis structure for C₄H₈O₂. The HONC rule will work for this compound.

Do not do this problem until you have finished the rest of the exam!

Extra credit: For #16, there are at least 6 other possible structures (isomers) for C₄H₈O₂. Draw them below. You will get the maximum extra credit for all 6 (you will get some credit for any you can draw).