Practice Chem 6 Exam 2

These problems are from exams given in 1993 and 1994. Each exam contained a page of universal constant values and common equations; yours will, too!

1. Here are three questions based on H atom orbital pictures.

   (a) One H atom orbital has three planar nodes, no radial nodes, and is cylindrically symmetric about the z axis. The quantum numbers for this orbital are:

   \[ n = \quad , \quad l = \quad , \quad m = \quad \]

   (b) How many maxima are in the radial probability function for the 5pz wavefunction of H?

   (c) The three H atom orbital pictures below represent different states, but they all three have one quantum number in common. Which is it, and what is its value? What is the principal quantum number for each?

\[ n = \quad , \quad n = \quad , \quad n = \quad \]

   common quantum number (circle one): \[ n \quad l \quad m \quad m_s \]

   value of that quantum number = ____________________
2. Which element or elements in the sequence from H through Ne

(a) has the largest first ionization energy
(b) has the smallest atomic radius
(c) has the largest electron affinity
(d) has a 2+ cation with the 1s² configuration
(e) has a stable anion with the configuration 1s² 2s² 2p²
(f) is isoelectronic to He⁺ when it is a neutral atom
(g) has one unpaired e⁻ in an orbital with one nodal plane
(h) can absorb light to form the excited configuration 1s² 2s² 3s
(i) has a half-filled sub-shell
(j) forms the largest anion

3. Answer the following questions about atomic electron configurations.

(a) If I assign \( m_s \) values to all the electrons in Ge, I find that ______ of them have one value and ______ of them have the other value.
(b) Among the elements from H through Kr, those that are spherical in shape in their ground electron configuration is/are:
(c) The electrons gained by Se when it forms the Se²⁻ anion enter the sub-shell(s):
(d) Explain briefly why Fe readily forms both Fe²⁺ and Fe³⁺ ions.
(e) The yellow-orange light emitted by Na atoms in, for example, sodium vapor street lights can also be absorbed by Na atoms in their ground state. This absorption excites the atom to the first excited energy electron configuration. What is this configuration?

4. I prepare a bunch of H atoms in the 4p state. If I leave them alone, they spontaneously emit light and eventually, all of them end up in the 1s ground state.

(a) How many different wavelengths of light can I expect to measure from the whole bunch (with a photon detector that is sensitive to all wavelengths)?
(b) Calculate the longest wavelength of them all. (Note that blind calculation of all the possibilities will take you a very long time. Think first, then let logic indicate the single wavelength calculation you need to make.)
(c) Is this photon of longest wavelength sufficiently energetic to ionize a hydrogen atom in the 4p state? (Give me more than a yes/no answer. Use a simple calculation to back up your answer.)
5. (a) Draw a graph of the particle in a box wavefunction for the state with quantum number \( n = 4 \).

(b) If an electron is in this state and \( L = 2.0 \, \text{Å} \), how much energy do I need to give the electron to excite it to the state with quantum number \( n = 5 \)?

6. Some quick, short, succinct answers, please:
   (a) Which has the larger second ionization energy, B or C, and why?
   (b) Which is the largest and which is the smallest of these three isoelectronic species: K\(^-\), Sc\(^+\), or Ca, and why?
   (c) If the 4s orbital energy was significantly higher than the 3d orbital energy (which it isn’t), one of the first row transition elements would probably be an inert gas. Which one would it be and why?

7. The work function for Cs, \( \phi = 3.43 \times 10^{-19} \, \text{J} \), is the lowest of any element, as you might guess. Consequently, Cs surfaces used to be used for photocells, devices that generate an electric current when illuminated by light. (More sensitive and cheaper devices have replaced the Cs photocell now.)
   (a) A Cs surface is irradiated with light from a H discharge lamp that is filtered so that only the emission at 486 nm (which we saw in class) strikes the surface. What is the kinetic energy of the electrons emitted from the Cs surface?
   (b) What is the deBroglie wavelength of the electrons emitted in (a)? (If you didn’t get a numerical answer in (a), assume the answer to (a) is \( 2 \times 10^{-19} \, \text{J} \) (not the right answer) and work this problem with that assumption.)