1 Cognitive reasoning in the chemical sciences 3.4

1. Please answer the questions.

   (a) For an electron in a box. If n doubles and L stays constant, what happens to λ?

   (b) For an ideal gas. If T is constant, and one doubles, what happens to v_{rms}?

   (c) For the Bohr model. If one doubles Z and halves n, what happens to E_{tot}?

   (d) For the van der Waals equation. If $b > 0$ and $a = 0$, what happens to pV/nRT?

   (e) For a molecule. If E_{tot} becomes more negative, what happens to E_K?

   (f) For an atom. If one doubles E_{tot}, what happens to E_{pot}?

   (g) For effusion. If one doubles the molar density, keeping m and T constant, what happens to the rate of effusion?

2. In this set you need to state the equations, the pictures, and the procedure you would use to solve the problem.

   (a) Given: the volume, the pressure, the temperature, and the number of grams of a flask of ideal gas. Find the molar mass.

   (b) Given: the volume, v_{rms}, molecular mass, and pressure of a flask of ideal gas. Find: the mass density of the gas.

   (c) Light is absorbed by a molecule and an electron is released. Given: the wavelength of the incoming light and the energy of the electron before the light is received. Find: the velocity of the released electron.

   (d) Given for a particle in a box: the mass of the particle, the length of the box, and the value of n. Find the momentum of the particle.

   (e) Light is absorbed by a molecule and an electron is released. Given: the wavelength of the incoming light and the average potential energy of the electron before the light is received. Find: the velocity of the released electron.

   (f) Given: the volume and pressure of a flask of diatomic ideal gas. Find: the kinetic energy/mole.

   (g) Light is absorbed by a molecule and an electron is released. Given: the wavelength of the incoming light and the average potential energy of the electron before the light is received. Find: the wavelength of the released electron.

   (h) Given: the mass of the particle, the length of the box, and the value of n. Find the kinetic energy of the particle.

   (i) For an atom. Given: the average velocity of an electron. Find: the average potential energy of this electron.

   (j) Given: The wavelength of light of an incoming photon hitting an electron in a molecule (the electron is not ejected from the molecule). Also given: the percent change in wavelength which accepting this light causes to the electron. Find: the initial energy of the electron.

   (k) The muon has a charge of minus one. Its mass is 200 times bigger than an electron's. A proton and a muon form an object much like a hydrogen atom. State procedure to find the ratio of the $n = 3$ to $n = 1$ transition energy for the muon-proton system and that for the hydrogen atom.

   (l) Given the number of radial nodes and the number of angular nodes, how would you determine if the state is $1s$, $3p$ etc...?

   (m) Given the radial distribution function for an electron , give a procedure which will allow you to estimate the value of λ.

(n) Given the radial distribution function for an electron , give a totally different

3. State answers to the following questions:

   (a) The volume of a gas increases by 3%, the number of moles increases by 2%, the pressure decreases by 3% and the temperature remains unchanged. Is this gas an ideal gas?

   (b) Incoming light is accepted by a hydrogen-like atom and an electron is released. The velocity of the exiting electron is recorded. Now a new frequency light is absorbed by a hydrogen-like atom which was in the same initial state as the first. This exiting electron kinetic energy triples. Can we calculate the difference between the frequencies of the first and second electrons.? If yes, how do we do so?

   (c) Given: Two van der Waals gases. They have the same a value but different b values. At a given p and T, does one mole of the one with a bigger b value occupy more or less volume than a mole of the other gas?

   (d) An electron in a box. The length increases by 20%, what happens to the energy of the $n = 3$ state?

   (e) Helium and oxygen molecules have a molecular masses of respectively 4 and 32. If the moles of effusing He and O_2 are the same, what is the ratio of the molar densities of the two gases in the original flask?

   (f) The wavelength of an electron in an atom decreases. Does the potential energy increase or decrease? Please state your logic.

   (g) Given: Two van der Waals gases. They have different a values and b values from each other. In the limit of very high volume and assuming constant temperature, how many of these four constants control which of these gases has greater molar density? Please state reasoning.

   (h) An electron in a hydrogen-like atom transists from the $n = 3$ to $n = 2$ state. What is the percent change in potential energy?

   (i) The volume of a van der Waals gas in a sealed piston decreases by 2%, the temperature decreases by 2%. and the pressure increases by 1%. Are you more likely in the high pressure or low pressure regime of this gas?

   (j) Can the energy of an electron bound to an atom ever exactly equal zero?

   (k) What is the potential energy for a particle in the box?

   (l) For a particle in the box, what is E_{pot}/E_K?

   (m) For an electron in an atom, what is E_{pot}/E_K?

   (n) On a drum, which "orbital" is higher in energy, the one with one radial node and two angular nodes, or the one with two radial nodes and two angular nodes?