(a) Assuming an atom of $^{11}_{4}$Be is electrically neutral, how many protons, neutrons and electrons does one atom have?

(b) The $^{11}_{4}$ Be atom is ionized such that it can be described as a 'hydrogen-like' beryllium ion. Write down the symbol for this ion, and *state* how many electrons it has.

(c) In the Schrödinger atomic model, each quantum state of an atom (or ion) can be labeled using two quantum numbers, *n* and *l*.

(i) *Write* down the formula that gives the energy of each quantum state of the hydrogen-like beryllium ion. (The equation includes the principle quantum number *n*.)

(ii) *State* how the number of quantum states, for a given value of *n*, depends on the value of the second quantum number *l*. How many 3s, 3p and 3d quantum states are there for the hydrogen-like beryllium ion? Show your workings.

(iii) Why are there no 3f quantum states in the hydrogen-like -beryllium ion?

(d) The energy levels within the hydrogen-like beryllium ion can be calculated using the formula, you identified in part (c) (i), and they can be represented in an energy level diagram.

(i) *Calculate* the energy level of the E_1, E_2, E_3, and E_∞ levels of the hydrogen-like beryllium ion, expressing your answers to an appropriate number of significant figures.

(ii) *Sketch* an energy level diagram for the E_1, E_2, E_3, and E_∞ levels of the hydrogen-like beryllium ion.

(iii) *Calculate* the energy of the photons corresponding to the lowest energy spectral emission line that is a result of electron transitions down to the E_2 energy level of the hydrogen-like beryllium ion (expressing your answer to an appropriate number of significant figures). *State* in which part of the electromagnetic spectrum this spectral line would occur.

(iv) *Calculate* **the energy of the lowest energy photon that the hydrogen-like beryllium ion could absorb, if the ion is in its ground state (expressing your answers to an appropriate number of significant figures).**

(v) In certain circumstances, a hydrogen-like beryllium ion could absorb a photon of a lower energy. *Explain* **why this is. (***One or two sentences***)**

(e) The isotope $^{11}_{4}$ Be undergoes beta-minus decay with a half-life of around 14 s.

(i) *Explain* **what is meant by half-life. (One sentence)**

(ii) Write an equation for the beta-minus decay of $^{11}_{4}$ Be.