Hydrogen Atom Assignment – SCH 4U
(Atomic Structure / Bohr Sturcture of Hydrogen)

1. Use equation #9 to calculate the radius of the first ten Bohr orbits (n = 1 to 10). Convert your answer to the unit of Å (1 Å = 1 x 10^{-10} m). Add an additional calculation for r when n = ∞ (or as n approaches ∞). Make a comment about how you arrived at your answer for n = ∞. Follow the instructions below:

   SHOW ONE GOOD SAMPLE CALCULATION ONLY. This should take six lines:
   i) equation before substitution
   ii) substitution for all constants* (leave n as a variable)
   iii) combined numerical values for all constants with a unit*, keep n as a variable
   iv) substitution of one n value (something other than one would be good – go big)
   v) answer including the unit
   vi) **SEPARATE LINE** for unit conversion from m to Å (just like grade 11!)

   *Provide a separate unit analysis for this calculation. Use the attached guideline for the correct format. This will be challenging!

   Place your answers in a table that combines the result of this question and question #2.

2. Use equation #10B to determine the energy related to the first ten Bohr electron standing wave patterns. Show one good sample calculation. No need to do units separately since this equation is much simpler. Add an additional calculation for E_{e-} when n = ∞ (or as n approaches ∞). Make a comment about how you arrived at your answer for n = ∞.

   Present all answers for this question and question #1 in a table with the following headings.

n	r (Å)	E_{e-} (eV)

3. Using the values for r, draw a full page scaled diagram of a Bohr hydrogen atom for the first five Bohr orbits (assume circular orbits) using a scale of 1 cm = 1 Å. This means that the entire atom will not fit on one page. Don’t forget the nucleus! Label completely (i.e. nucleus, n=1, n=2 etc.).

4. With reference to the previous questions:
   a) What happens to the **<u>relative</u>** distance between orbits as the value of n gets larger?
   b) What is the maximum possible distance from the nucleus that an electron could possibly have? What is the value of n at this distance?
   c) What is the highest possible energy value for an orbiting electron? What is the value of n for this energy?
   d) What is the zero point for the energy of the electron. Comment on the advantage of the choice of zero point.
   e) Why do all values of n other than ∞ provide an energy value of less than zero (i.e. a negative energy value).

5. Using your data from question #1 and #2, make a graph on "good" graph paper of **E_{e-} (eV) vs r (Å)**.
   i) Use the graph paper with the long axis horizontally.
   ii) Be sure to get your axis correct. Use the radius as the independent variable (horizontal) and energy as the dependent variable (vertical). Please do not use any discontinuities in your axis.
   iii) Note that one of your axis should involve negative values. Use the standards for graphing in mathematics. Your graph is a IV quadrant graph (the horizontal axis should therefore be at the top of the page).

6. On your graph from question #5 do the following (**USE pg 297 IN OLD TEXT AS A REFERENCE**):
   i) Add a horizontal line through each point on your curve and label these n=1, n=2 etc.
   ii) Show all possible "inward" electronic transitions that have n = 1 to 5 as a final state. Arrange these inward transitions in groups according to final state
   iii) Label each group accordingly and state the type of electro-magnetic radiation produced by each group

7. Using equation #12 and the fact that 1 m = 1 x 10^9 nm, determine the wavelength of each of the following transitions. Show one good sample calculation only using n_i = 5 and n_f = 2

n_i	n_f	λ (nm)	colour or type of light
3	2		
4	2		
5	2		
6	2		
7	2		
8	2		
9	2		
10	2		
∞	2		

The above calculations determine the observed light frequencies/wavelengths/colours for the visible portion of the hydrogen line spectra:

a) What series do these lines belong to?

b) What is the shortest possible wavelength for this series?

c) What happens to the differences between wavelength as n_i gets larger and larger, approaching ∞?

8. Determine the wavelength in nm for the first transition in each of the series: Lyman, Balmer, Paschen, Brackett and Pfund. Present in a short table. Do not show a calculation.

9. Determine n_i and n_f that would produce the wavelength stated. Pay close attention to whether light in emitted or absorbed. See pg 12 of the for specifics about the sign (+ or –) for your answer. The best way to do this question is to use educated guessing (with reference to your answers in #8) or to create a spread sheet that provides answers to pick from!!

a) 1944.04 nm absorbed

b) 376.97 nm emitted

c) 954.35 nm emitted

d) 92.05 nm absorbed

$R = 0.0109737\ nm^{-1}$