SCH 3UI Unit 2 Outline Up to Quiz #1
Atomic Theory and the Periodic Table

Lesson	Topics Covered	Homework Questions and Assignments
1	**Note: History of Atomic Theory** • progression of understanding of composition of matter; ancient Greeks and Alchemists • Dalton: his atomic theory, Law of Conservation of Mass, Law of Constant Composition	• Read Handout: In Search of a Model for Matter • Read pages 23 to 25 in your text • Answer questions 1 to 5 on Handout: Practice Questions: The Development of the Modern Atomic Theory
2	**History of Atomic Theory (cont.)** **Note: Discovery of the Sub-atomic Particles** • Wm Crookes: atoms are divisible • J.J. Thomson: "Raisin Bun" model • Ernest Rutherford: "Electron Cloud" model • Niels Bohr: "Planetary" model • James Chadwick: the neutron	• Review and UNDERSTAND the development of the atomic models • Answer questions 6 to 9 on Practice Questions: The Development of the Modern Atomic Theory
3	**Note: Summary of the Sub-atomic Particles** • protons and atomic number (Z) • neutrons, isotopes, mass number (A) • electrons, calculating charge on ions	• Review and UNDERSTAND the definitions of atomic number, mass number and isotope • Complete Handout: Composition of Atoms and the Sub-atomic Particles
4	**Note: Isotopes and Average Atomic Mass** • average atomic mass • calculating average atomic mass	• Give 3 differences between mass number and average atomic mass • Complete Handout: Isotopes and Average Atomic Mass
5	**Note: Nuclear Chemistry** • radioisotopes • types and properties of nuclear radiation: alpha, beta and gamma	• Answer questions 9 and 10 on page 32 of text • Read pages 34 and 35 in text. Answer Q 20, 21 and 22 on page 35
6	**Note: Nuclear Chemistry (cont.)** • Half-lives of Radioisotopes	• Questions 12 and 13 on page 32 of text • Begin Review Questions for Atomic Theory Quiz #1
7	**Note: Summary of Atomic Structure, so far….** Begin Bohr?	• Complete review on Handout: Review Questions for Atomic Theory Quiz #1
8	**Note: Bohr's Model of the Atom** • types of energy (kinetic and potential) • the hydrogen bright line spectrum (demo) • Explaining Neils Bohr's Model of the Atom	• Read pages 37 – 40 in your text and answer questions at the bottom of the handout: The Hydrogen Bright Line Spectrum • Work on Review Questions for Atomic Theory Quiz #1 • STUDY!!!☺
9	**Atomic Theory Quiz #1** (whole period)	• When you have completed the quiz, begin to read articles and answer questions about radio-isotopes

Practice Questions: The Development of the Modern Atomic Theory

Read pages 23 to 25 in Nelson Chemistry 11, the handout "In Search for a Model for Matter: 2400 Years of Atomic Theory" and your class notes, and answer the following questions:

1. For thousands of years, people have wondered what matter is made out of. The ancient Greeks proposed two different theories about the composition of matter.
a) Which ancient Greek philosopher first proposed that the smallest piece of matter should be called the "atom"?
b) Where did the idea for the atom come from (what was his reasoning or logic)?
c) What does the word "atom" mean?

2. The second theory of matter held by the ancient Greeks was the Four-Element Theory.
a) Which ancient Greek philosopher **proposed** the Four-Element Theory of Matter?
b) What are the four elements of the Four-Element Theory?
c) Where did the idea for the Four-Element Theory come from?

3. Just like today, scientific ideas can be very political.
a) Which influential ancient Greek **supported** the Four-Element Theory?
b) For how many years was the Four-Element Theory accepted?

4. The Alchemists in Europe and the Middle East performed many experiments and kept excellent records of their work.
a) What were the Alchemists trying to do?
b) What significant contribution did the Alchemists make to modern science?

5. John Dalton (1803? 1808?) revived the Atomic Theory.
a) Summarize the major statements of Dalton's Atomic Theory.
b) State the Law of Conservation of Mass.
c) How does Dalton's Atomic Theory explain the Law of Conservation of Mass?

6. According to Dalton's Atomic Theory, atoms were indivisible; they could not be broken down into smaller pieces. In 1904, J.J. Thomson proposed that he had found a sub-atomic particle.
a) What was the name of the piece of equipment used by Thomson?
b) What did Thomson call the particle that he had discovered, and what was the charge on this particle?
c) Overall, matter is neutral (does not have a charge). What other sub-atomic particle did Thomson suggest must also be present in an atom?
d) What model of the atom did Thomson propose? How are the sub-atomic particles arranged?

7. J.J. Thomson was on the right track, but in 1911, Rutherford showed that Thomson's model of the atom was wrong and he developed a new model.
a) Describe the experiment performed by Rutherford.
b) What is an alpha particle? What charge does an alpha particle have?
c) How does Rutherford's model of the atom differ from that of Thomson? Describe the location of the electrons in Rutherford's model.

8. In 1913, Neils Bohr made a small but significant change to Rutherford's model. What is the difference in the electron arrangement between Bohr's and Rutherford's model?

9. James Chadwick added the finishing touch to the Atomic Theory. What sub-atomic particle did Chadwick discover? What is the charge on this particle and where is it located in the atom?

** The Rutherford-Bohr model of the atom is still not entirely correct. Currently, the "Quantum-Mechanical Theory" is accepted, but more about this theory later.

Discovery of the Sub-Atomic Particles

Dalton's theory of the atom as an ____________________________ held for almost one hundred years. However, during the late 1800's, scientists were rapidly developing new ______________________________, and this equipment led to discoveries about matter that could not be explained using Dalton's atomic theory.

For example, a physicist named ________________________ developed a glass tube that had ____________________________ in it, one at each end. The tube was connected to a vacuum pump and almost all of the air was pumped out, then the glass tube was sealed. When the metal electrodes were connected to a ____________________________, one of the metal electrodes gave off a ________________________ that moved through the tube toward the other electrode. The interesting thing was that __________________________ __________________________. This meant that the particles were _________________ _____________. Because the particles came from the negative electrode, or ___________, they were called________________, and the glass tube was called a __________________.

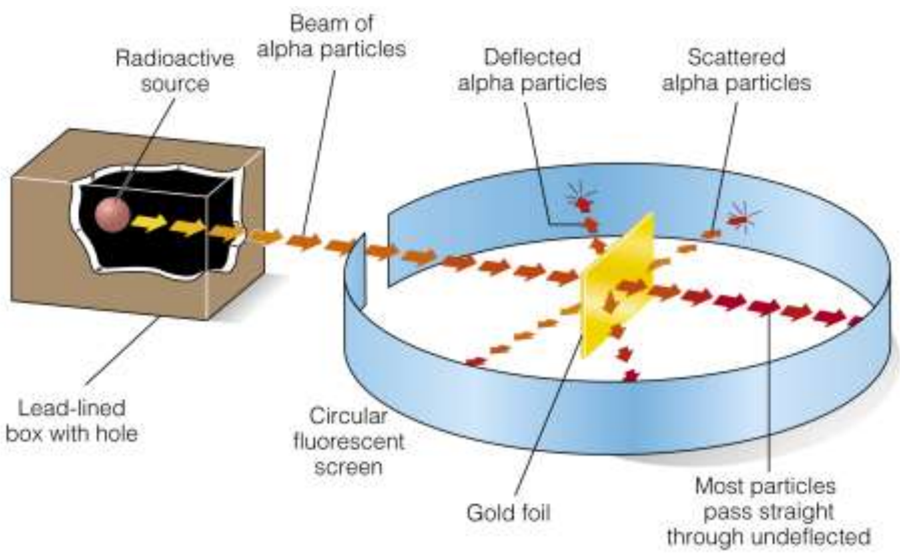
From this, scientists realized that the __________ (uncharged) metal electrode was giving off ___________________________________. This meant that the metal must be made, not from uncharged atoms, but from ___________________________________.

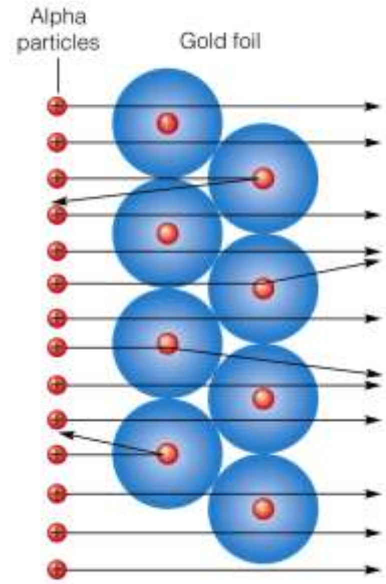
Another researcher, _________________ carried on the work with cathode ray tubes. He reasoned that since the metal electrode was originally neutral (uncharged) and the particles it gave off were ________________ charged, then the electrode must also contain ______________________________________. Thomson also noted that it made no difference what type of metal he made the electrodes out of, the _____________________ were always the same. He called these particles _____________ and concluded that they were a ____________________________.

From his work, J.J. Thomson developed a model of the atom in which atoms are made up of ____. He visualized the atom as a ____________________ in which the protons are spread out over the surface of a spherical atom and the electrons are imbedded in with the protons so that the _________ ____________ of the atom is ______________.

Researchers continued to explore the atom and _______________ were discovered, as J.J. Thomson had predicted. These positive particles were shown to be the same as a ____. They were found to have a mass ___________________________ than the mass of an electron.

Then, in 1911, one of Thomson's colleagues, _______________________, conducted an experiment that seemed to contradict the raisin bun model. Rutherford set up a very thin piece of ______________ inside a fluorescent screen. He then shot __________________ (helium nuclei) at the gold foil, expecting the ____________________________________ ________________________.





Most of the time, the alpha particles did pass straight through the foil. However, a small number of the alpha particles were ___________________________, and some bounced straight back.. Rutherford interpreted this to mean that there are _____________________ _________________________ that are positively charged, which he called the ___________. He concluded that the rest of the foil must be mostly ___________________, which allowed the alpha particles to pass through. Rutherford proposed that the electrons are found in the ___________________________________ in an _________________________.

The atomic model was refined in 1913 by _________________, who showed that electrons move in ____ around the __________.

A further revision to this atomic model was made in 1932 by ______________________. He discovered ____________________________in the nucleus, which he called the ______________. Most (_____________________) atoms contain neutrons in their nuclei.

As an analogy to give you an idea of the relative sizes and positions of the subatomic particles: If the nucleus was the size of a dot "·", the closest electron would be _________ away with just empty space in between. An atom is mostly __________________.

Summary of the Sub-atomic Particles
(Reference: Nelson Chemistry 11, page 26-27)

Atoms are **not** indivisible; that is, atoms __________ broken down into smaller particles.
Atoms are made up of three types of sub-atomic particles: _____________, ______________ & __________

1. Protons:

a) are found in the _____________ of the atom
b) have a charge of ________
c) have a mass of ___________ (_____________________________)

The **atomic number** (symbol "____") is the defined as the number of ________ in the nucleus of an atom. The atomic number determines the ________________ of that atom.
eg. atomic number 11: means that the atom has _____ protons, the atom (element) is ______________
atomic number 13: means that the atom has _____ protons, the atom (element) is _________________
atomic number 33: the atom has _____ protons and the element is __________________

2. Neutrons:

a) are found in the ______________ of the atom
b) have _____ charge (they are ________________)
c) have a mass of _______________

The **mass number** (symbol "____") of an atom is defined as the number of ___________ plus the number of _____________ in the nucleus of an atom.

- the mass number is a ________________ value, it tells us how many protons and neutrons there are
- the mass number is _______ the actual mass of an atom
- the mass number is always a _________________________ and it has __________________
- the mass number is _______ reported on the Periodic Table

The atomic number and mass number for an atom are written in this standard format:

14 ← mass # = # of protons + # of neutrons
N ← chemical symbol
7 ← atomic # = # of protons

75 As 33	mass number: ___________ atomic number: ____________ number of protons: ___________ number of neutrons: ___________	202 Hg 80	mass number: ___________ atomic number: ____________ number of protons: ___________ number of neutrons: ___________

If you know the mass number of an atom and its atomic number (from its chemical symbol), you can find the number of neutrons in that atom using the relationship:

Mass number = _______________________ + _______________________

or

Number of neutrons = ________________________ – _________________________

The number of protons defines the identity of an atom. All atoms of an element have the __________ atomic number. However, an element can have atoms with different numbers of ______________, and these are called _________________.

Isotopes are defined as atoms of the same element that have different numbers of neutrons. That is, isotopes are atoms that have the same ______________________, but different _______________________.

Isotopes (continued)

- Isotopes have the same chemical and physical properties as other atoms of that element, the only difference is that some atoms are _______________ than others
- there is _____________________________________ between the number of protons and the number of neutrons in an atom
- The number of neutrons does ___________________ equal the number of protons

Isotopes are often written using the format: Cl-35, where 35 is the ___________________ of the isotope

eg. Complete the following chart for the common isotopes of hydrogen

H-1	H-2	H-3
• atomic number: ____________ • # of protons:_____________ • mass number:___________ • # of neutrons:______________ • symbol of isotope: (in standard format) • known as: _________________	• atomic number: ____________ • # of protons:_____________ • mass number:___________ • # of neutrons:______________ • symbol of isotope: (in standard format) • also known as: ______________	• atomic number: ____________ • # of protons:_____________ • mass number:___________ • # of neutrons:______________ • symbol of isotope: (in standard format) • also known as: ______________

eg. Complete the following chart for the common isotopes of oxygen

O-16	O-17	O-18
atomic number: ____________ # of protons:_____________ mass number:___________ # of neutrons:______________ symbol of isotope: (in standard format)	atomic number: ____________ # of protons:_____________ mass number:___________ # of neutrons:______________ symbol of isotope: (in standard format)	atomic number: ____________ # of protons:_____________ mass number:___________ # of neutrons:______________ symbol of isotope: (in standard format)

3. Electrons:

a) are found in the ____________ around the nucleus, arranged in ___________________________
b) have a charge of _________
c) have a ____________________ mass (1 / 1837 of an a.m.u.)

If the number of protons equals the number of electrons, the atom is ______________ (uncharged)

$^{14}_{7}N^{0}$

# of protons: _______
# of neutrons: _______
# of electrons: _______

If the number of protons does not equal the number of electrons, it is called an "_______".
An **ion** is defined as a _______________________.

$^{15}_{7}N^{3-}$

# of protons: _______
# of neutrons: _______
# of electrons: _______

$^{55}_{25}Mn^{4+}$

# of protons: _______
# of neutrons: _______
# of electrons: _______

$^{75}_{33}As^{5+}$

# of protons: _______
# of neutrons: _______
# of electrons: _______

$^{79}_{34}Se^{2-}$

# of protons: _______
# of neutrons: _______
# of electrons: _______

Composition of Atoms: The Sub-atomic Particles

1. Write complete definitions for each of the following terms. Include one additional piece of information such as an example or application:

a) **Atomic number:**

b) **Mass number:**

c) **Isotope:**

d) **Ion:**

2. Complete the following chart:

Element	Atomic #	# of Protons	# of Electrons	Overall Charge	# of Neutrons	Mass Number
He				0		4
	13			+3	14	
Ca			18			40
Ni – 58			26			
	38			+2		90
			23	0	28	
Ag – 107				+1		
		53	54			127
	70			+3	103	
Au				0	118	
	79		76			197
	92		92		143	
		92		0		238
H – 1				+1		
		28	25			59
			18	-3	16	
Zn - 65				+2		
Si - 28			18			

3. Do **ALL** atoms (or ions) contain protons? _______ Electrons? _______ Neutrons? _______

4. Using the standard format (eg. "Ag-107"), identify any isotopes from the above table.

Isotopes and Average Atomic Mass

Isotopes are defined as atoms of the same element, with the same atomic number, but with a different mass number. That is, the number of protons in the atoms is the same, but isotopes have different numbers of neutrons, and this changes the mass of the atom.

Most elements have two or more naturally occurring isotopes. Tin has 11 isotopes, magnesium has three but aluminum and fluorine have only one. A sample of an element contains a mixture of the different isotopes of that element, with some of the isotopes being more common than others. For example, 99.985% of all hydrogen is the H-1 isotope, 0.015% is H-2 (deuterium) and only a trace amount is H-3 (tritium). The proportion, or percent abundance, of the various isotopes is fairly constant for each element.

On our Periodic Table, in the top right hand corner for each element, is a number called the "Average Atomic Mass" (AAM) for that element. The **average atomic mass** is the weighted average of the masses of all of the isotopes of that element.

eg. To calculate the average atomic mass for an element:

The element chlorine has two naturally occurring isotopes, Cl-35 and Cl-37.
- 75.77% of all chlorine atoms are Cl-35, mass 34.9689 u
- 24.23% of all chlorine atoms are Cl-37, mass 36.9659 u.

Calculate the average atomic mass of chlorine.

Average Atomic Mass = (Mass of Isotope Cl-35 x % abundance of isotope Cl-35) +
(Mass of Isotope Cl-37 x % abundance of isotope Cl-37)

$$= \left(34.9689\text{ u} \times \frac{75.77}{100}\right) + \left(36.9659\text{ u} \times \frac{24.23}{100}\right)$$

$$= 35.4527\text{ u}$$
$$= 35.45\text{ u}$$

Practice Questions:

1. Answer questions 2, 4, 5, and 6 on page 29 of Nelson Chemistry 11.

2. a) What are ***isotopes***?
   b) Gold has four isotopes. Their mass numbers are 195, 196, 198 and 199. Find the number of protons, electrons and neutrons in **neutral** atoms of these isotopes.

3. a) What information is given by each part of the expression $^{35}_{17}Cl$?
   b) We identify isotopes with symbols such as "U-238". What does the number "238" represent?

4. a) Carbon has two common isotopes: 98.89 % of carbon is C-12, atomic mass 12.000 u and 1.11% of carbon is C-13, atomic mass 13.0034 u. (A teeny, tiny amount of carbon is C-14, but the amount is too small to include in this calculation). Calculate the average atomic mass of carbon. (12.01 u)

   b) Naturally occurring chromium consists of the following:
   - 4.31% of Cr-50, atomic mass of 49.946 u
   - 83.76% Cr-52, atomic mass of 51.941 u
   - 9.55% of Cr-53, atomic mass of 52.941 u
   - 2.38% Cr-54, atomic mass 53.939 u. Calculate the average atomic mass of chromium. (51.998 u)

   c) Naturally occurring silicon consists of a mixture of three isotopes, as follows:
   - 92.23% of Si-28, atomic mass of 27.988 u
   - 4.67% Si-29, atomic mass of 28.976 u
   - 3.10% of Si-30, atomic mass of 29.974 u. Calculate the average atomic mass of silicon. (28.096 u)

Nuclear Chemistry: Radioisotopes and Types of Nuclear Radiation

The nucleus of an atom contains the ____, all packed together. But, like charges ___________. Neutrons act as "_____________" in the nucleus. They separate the protons and help to ________________________________. The larger the nucleus of an atom, the ________________________________ to stabilize it. As far as we know, a neutron is made up of __________________________________.

Most atomic nuclei are _______________- they do not break down. However, the nuclei of some _____________ of some elements are unstable and tend to __________________. Unstable isotopes that break down or decay in this way to give off __________________ ___________________________________ are called _________________________ or they are said to be "______________________". When a nucleus breaks down, it is a ______________ _____________ called "______________________". Nuclear fission releases _____________ ___________ of energy. Nuclear reactors such as the _____________________________ (developed in Canada, it stands for ____) trap this energy and convert it to _________________.

There are three main types of nuclear radiation: ____________________________________:

1. Alpha radiation ( ) is the release of a ______________________ (written _________).
- alpha radiation is "relatively" ______________________ and _________________
- it can travel only a ________________________________ through the air
- it can be stopped by a _______________________, it does not _______________ matter

eg.

eg.

eg.

2. Beta radiation ( ) is the release of a _________________________________, which is also called a ______________________. Beta particles are released when a neutron breaks down into a _____________ and a _______________________________
- beta radiation is relatively _____________________ and is _______________________ than alpha radiation
- it can travel a ________________________ through the air
- it can be stopped by a ________________________ that is 1 to 2 mm. thick

eg.

(the neutron is converted into a _____________ and _____________)

eg.

eg.

3. Gamma radiation ( ) is the release of ___________, but _______________________ that we can detect; it is a form of ___________________________________ (the same "family" of radiation as ________: ____)

- gamma radiation is __________________________ and ______________________
- it can travel ____________________________ through the air (eg.from the sun to the Earth). This is the form of radiation that _________________________ and _________________are concerned about
- it can be stopped by ____________________________________

eg. cobalt-60 produces gamma radiation which is used for:

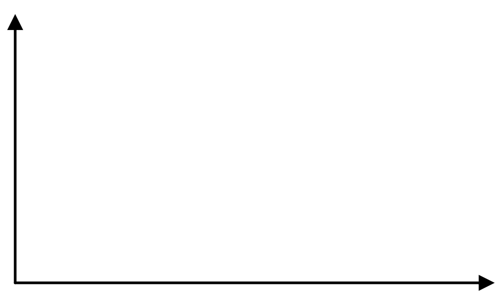
- ____
- ____________________________ in spices and grains
- sterilize male insects to ____
- irradiate potatoes and onions to _____________________________________
- sterilize _____________________________________
- irradiate food to ________________________ (but not in Canada)

Because there are _______________________________, we can not shon w gamma radiation with a nuclear equation

Half-lives of Radioisotopes

Each radioisotope breaks down, or decays, at a __________________________ called its "________________". The half-life of a radioactive substance is the _________________ ____. The more unstable the radioisotope, the _____________ the half-life and the ___________ __________________. Radioactive iodine (iodine-131) has a half-life of ____________, while radioactive plutonium (created in nuclear reactors) has a half-life of _____________ (annum, or years) and oxygen-15 has a half-life of 9.98 minutes.

eg. The half-life of radioactive iodine (iodine-131). If we began with a 120 g sample of iodine-131, draw a graph showing the rate of radioactive decay of iodine-131.



Time (a)

The radioactive decay of different isotopes can be used to _________________________ _________________________. (pg 30-31 in your text).

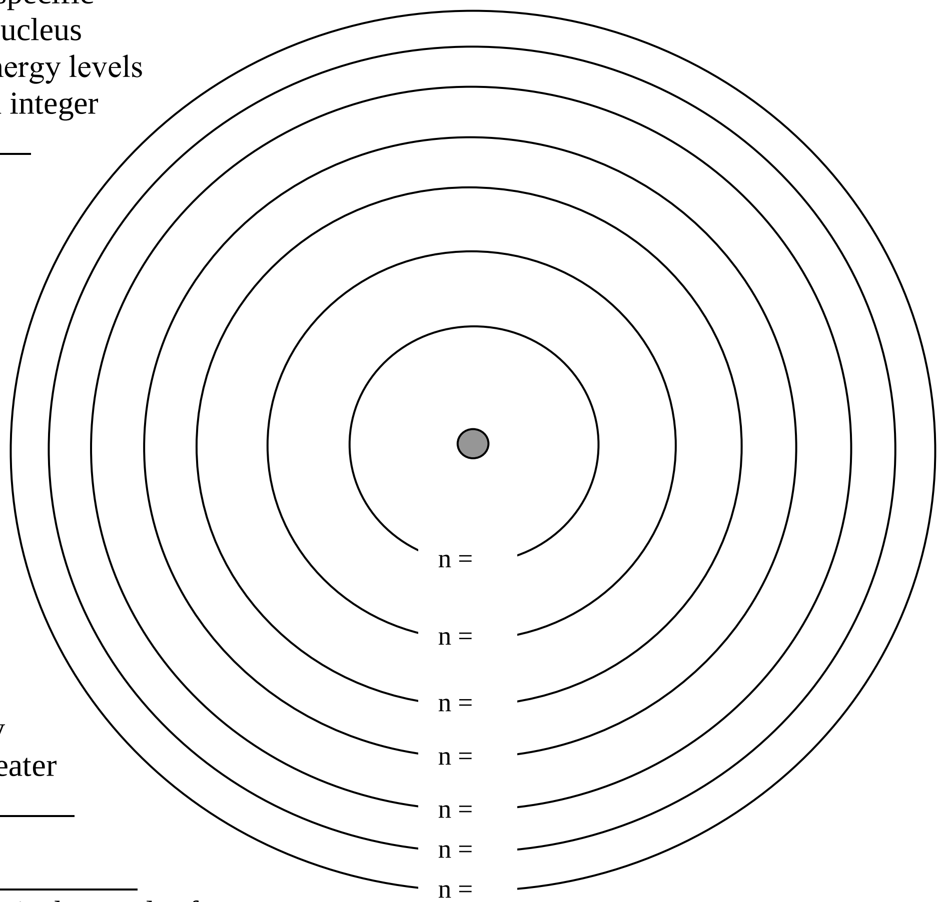
Homework: Questions 9, 10, 12 and 13 on page 32 of your text.
Read pages 34 and 35. Answer Q 20, 21 and 22 on page 35.

The Hydrogen Bright Line Spectrum

When hydrogen atoms are excited, they produce the following line spectrum:

_______ wavelength _______ wavelength
_______ energy _______ energy

The lines on the hydrogen line spectrum are produced when electrons drop between energy levels:



- electrons can occupy only certain, specific energy levels or shells around the nucleus
- electrons can't stay __________ energy levels
- the energy levels are labelled by an integer called the ______________________ ______________
- a quantum is a ____________ ______________
- when an electron is as close to the nucleus as possible, it is in its ____________________
- when an electron absorbs energy, it moves further from the nucleus and its potential energy ______________
- when an electron drops back to a lower quantum (energy) level, it releases its extra energy as ____________ of _________
- the colour of light given off depends on the difference in energy between the quantum levels; the greater the energy difference, the ____________ the wavelength of light
- each line in the ________________________ (bright line) spectrum of an element is the result of electrons falling from some high-energy level to a lower level

Based on his experiments, Bohr proposed the "_______________" model of the atom: electrons orbit the nucleus in ___________, ________________ paths, ____________ distances from the nucleus.

Bohr's model stated that every electron in a principal quantum level (or shell) was ____________ ________________________ from the nucleus, so every electron in each quantum level had ____________ _______________ amount of ______________ energy.

Each quantum level can hold a maximum of ______ electrons. The first quantum level can hold ________ electrons, the second level can hold ________, the third ________, the fourth ________, and fifth _______.

Read section 1.4 in your text (Nelson 11, p. 37-40) and answer the following questions:

1. Which two questions could not be answered by Rutherford's model of the atom? (p.37)
2. What factor determines how much energy an "energy level" possesses?
3. Summarize the three assumptions made by Bohr in his model of electron arrangement.
4. Define quantum, ground state, bright line spectrum and continuous spectrum.