Topic 20: The Atom

Source:	*Conceptual Physics* textbook and lab book
Types of Materials:	Hewitt's textbook and lab book; also, other high school textbooks and lab books presenting the atom
Building on:	A photon of energy conceived by Max Planck and the photoelectric effect created by Albert Einstein illustrate energy levels in atoms which lead to Niels Bohr model of the atom. Quantum mechanics enhanced the Bohr model by showing probability playing a role in today's atomic model. Early physics topics like potential energy, kinetic energy, circular motion, momentum, electromagnetic waves and other previously studied physics topics all contribute to the understanding of the atom.
Leading to:	After kinematics, dynamics and all other physics topics have been studied including the atom, the only thing left is the universe. How the universe was formed, what is out there, and how it works complete the picture, as we understand it.
Links to Physics:	The understanding of the atom in physics including nuclear structure is needed for such things as building and using an MRI machine (Magnetic Resonance Imaging) for medicine and the X-ray machine. Material properties of elements such as strength, elasticity, durability and temperature tolerances for the building of bridges and buildings is a requirement in addition to design. Atomic makeup understanding is needed for the making of lasers and masers and their operation. One other example of atoms for peaceful purposes is the coal and nuclear power plants. These energy sources require many physics topics to achieve the energy outcome. Some specific examples of physics topics needed for the production of energy include, heat, turbines, generators, AC electricity (voltage and current), transformers, power, and so on.
Links to Chemistry:	The atom is the foundation to chemistry. To understand the mechanisms to create molecules to build useful items requires some physics knowledge like mechanical energy, energy quantum, motion, electromagnetic waves, and force (electrical and nuclear). Items like foods, metals, paints, glass and so on, are useful to humans and form a profession for many people such as scientists, sales people, business people and so forth.
Links to Biology:	The same underlying physics to explain chemistry is needed, but now chemistry is applied to living organisms in biology to explain things like how nerves work, how a stomach puts bulky foods into our blood stream for energy, and how the triceps and biceps push and pull. The atom builds molecules and molecules build cells, so biology quickly becomes complex

very soon. Photosynthesis is a good example of seeing the relationship of physics, chemistry and biology. Photons of light change water and carbon dioxide into sugar and oxygen (physics-chemistry). In the process, mass and energy are conserved.

Materials:

(a) Hewitt
1. Nuclear Marbles
2. Half-Life
3. Chain Reaction

(b) Hsu – None*

(c) My Lab
Hydrogen's Lowest Energy Level

(d) Worksheet – The Atom

(e) Demonstration
Spectral Lines*

(f) Video and Websites*

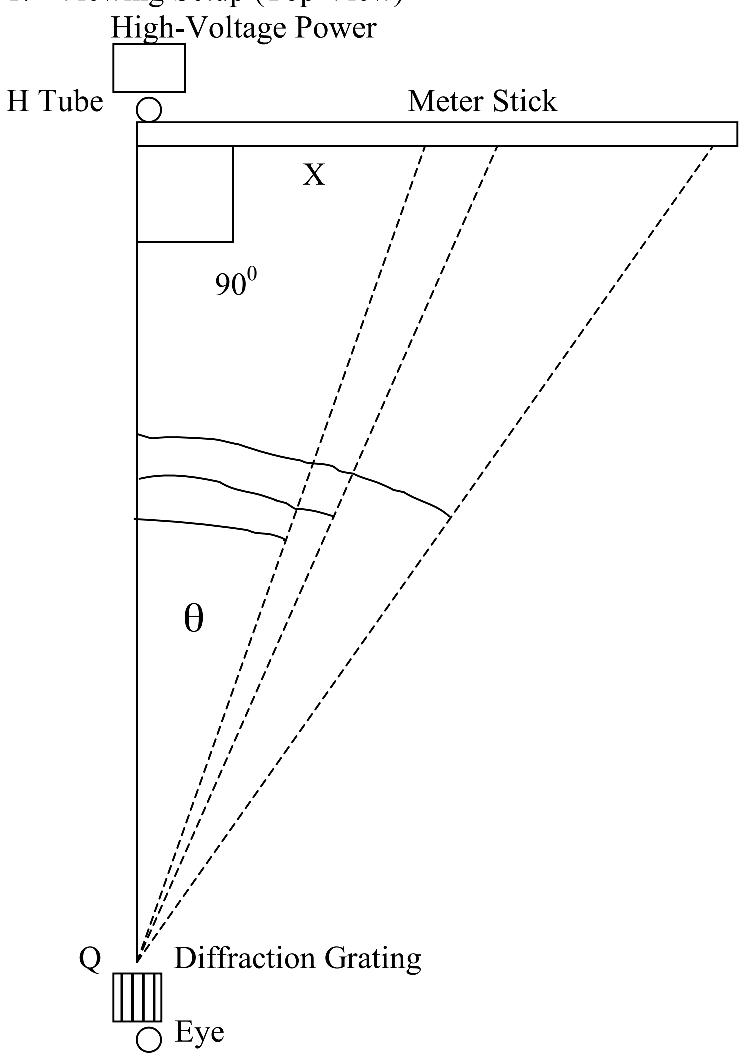
(g) Good Stories
1. Marie Curie (1867-1934) and the Little Curies
2. Fermi's Paradox, "Where Is Everybody?"

TOPIC 20: Lab: Hydrogen Spectra (H Emission Spectra of Colors/Wavelengths)

Purpose: To view and to compare some of hydrogen's colors. To also think about the meaning of the resulting emission spectra.

A. Qualitative Analysis

1. Viewing Setup (Top View)



Make or purchase a black and white meter stick so you see each centimeter line clearly. Mark the location of a point Q that is 2.0 m from the emission tube. Hold the diffraction grating at Q and look through at the operating tube. To calculate wavelengths in part B, you need to know the lines per mm of the grating. Inexpensive commercial gratings generally have 530 groves/mm or a spacing between the groves at $d = 1.89 \times 10^{-\Delta}$m. d is a variable in the grating equation.

2. Procedure/Questions:

(a) When viewing directly at the tube through the grating, do you see any spectra (a rainbow of colors) at the tube location?

____

(b) Do you see different colors if you view to the right of the tube? If so, what are they?

____

(c) Do you see different colors if you look to the left of the tube? If so, what are they?

____

(d) Of the colors you see, what color is closest to the tube? Brightest?

____

(e) Of the colors you see, which color is most distant from the tube?

____

(f) If you look a lot to the right and left (big X) from the tube, can you see another spectra of colors?

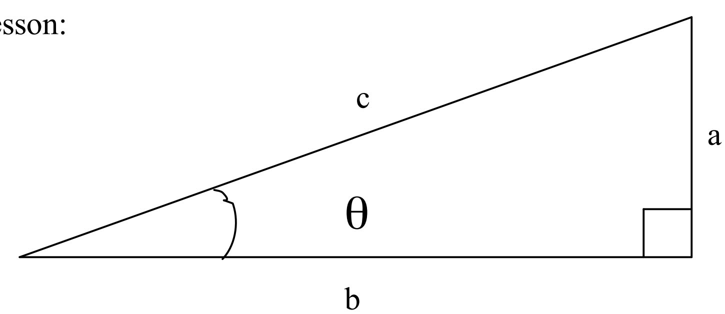
____

(g) The equation relating color wavelength as related to a grating is:

$$n \lambda = d \sin \theta$$

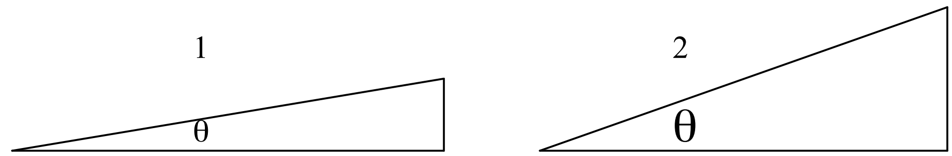
(n) is called the spectra "order" so the first spectra from the source would be 1.
(λ) is the color wavelength. If d is measured in m, then λ is in m.
(d) is the space between adjacent lines of the grating.
(e) θ is the angle of deviation from the straight-away view.

Small trigonometry lesson:



$\sin \theta = a/c$, or the opposite side divided by the hypotenuse (a ratio of the sides)

Question: Is the sine of θ in triangle 1 larger or smaller than for triangle 2?



____

(h) Now using the grating equation, is the wavelength of red light longer or shorter than blue light?

____

(i) Is the wavelength of blue light longer or shorter than violet light?

____

(j) Is the spectra observed continuous or individual color lines?

____

(k) Can you give any reason why the spectra you see is the way it is?

____

B. Quantitative Analysis:

1. Use the grating formula and data collected to calculate each color of wavelength observed.

2. Do a % error for each color. Look up accepted wavelengths.

Topic 20: Lab – H Spectra Answer Sheet

A. 1. NA

2. (a) No, only see light bulb

(b) Yes, get line spectra to right showing violet, blue and red

(c) No, same colors of violet, blue and red, BUT in reverse order

(d) Violet is closest to the tube – red is brightest

(e) Red is most distant.

(f) Yes, a second set of line spectra, but really far to the side of the tube

(g) $\sin \theta_1$ = small/hypotenuse $\sin \theta_2$ = large/hypotenuse
So, $\sin \theta_1$ is smaller than $\sin \theta_2$.

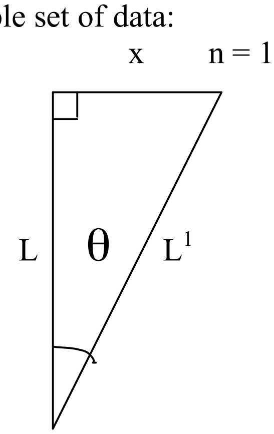
(h) $n \lambda = d \sin \theta$
If $n = 1$, $\lambda \propto \sin \theta$, so $\sin \theta$ greater for red; so, λ greater for red.

(i) Blue light would have a longer wavelength than violet.

(j) Individual color lines (line spectra)

(k) NO, just shows the colors (thus energy amounts) come in distinct (discrete) energy amounts.

B. One sample set of data:



$n \lambda = d \sin \theta$

$n = 1$

$d = 1.89 \times 10^{-6}$m

$\sin \theta = x/L^1 = 0.72 \text{ m}/2.0 \text{ m} = 0.360$

1. $\lambda = (1.89 \times 10^{6}\text{m}) \times (0.360)$
2. $\lambda = 6.57 \times 10^{-7}$m (2.5% off)

Worksheet – The Atom (Search the Internet)

1. (a) Who did the experiment to show that atoms have a massive positive center?

____

(b) Describe that experiment.

____

____

____

____

2. (a) Who discovered the electron?

____

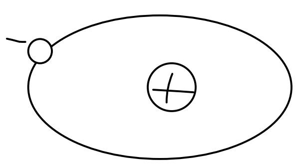
(b) What common evidence do people have to confirm that most atoms (non-ions) are electrically neutral?

____

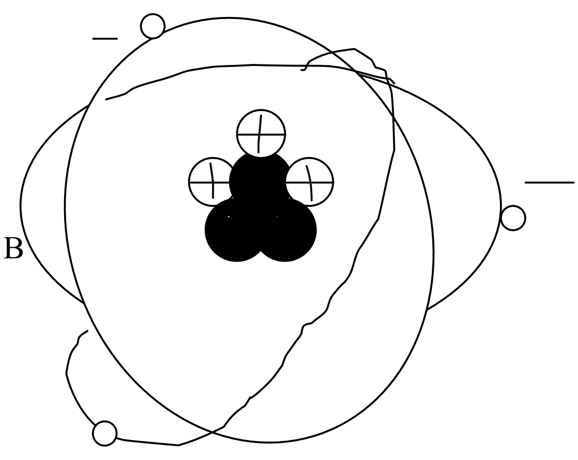
____

____

3.



Atom A



Atom B

(a) How many protons in atom A? ____________________ Atom B? _______________

(b) How many neutrons in atom A? ___________________ Atom B? _______________

(c) How many electrons in atom A? ___________________ Atom B? _______________

(d) What is the atomic weight of atom A? _______________ Atom B? _______________

(e) What is the atomic number of atom A? _______________ Atom B? _______________

(f) What element is atom A? __________________________ Atom B? _______________

(g) What orbits the center of the atom? ____

(h) What is the atom's center called? ____

(i) What makes up the center of the atom? ____

Worksheet – The Atom (Search the Internet) Answer Sheet

1. (a) Who did the experiment to show that atoms have a massive positive center?

   Ernest Rutherford

   (b) Describe that experiment.

   A beam of alpha particles was shot at a thin metal foil. Most of the particles passed through the foil as if it were empty space. However, some reflected at large angles and some bounced straight back. His explanation was that the atom has a small, dense positive center, which he called the nucleus.

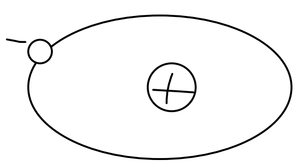
2. (a) Who discovered the electron?

   Joseph John (J.J.) Thompson, using extensive work deflecting cathode rays.

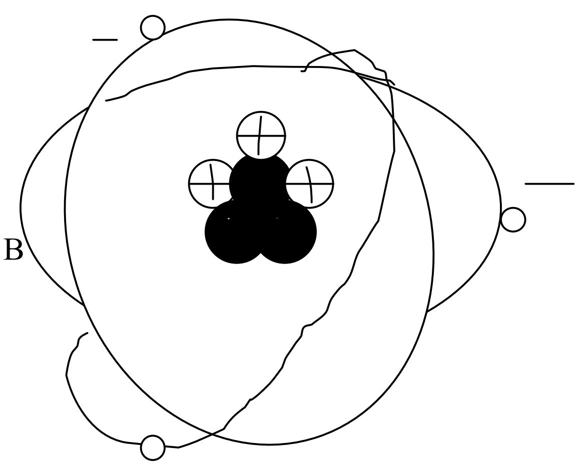
   (b) What common evidence do people have to confirm that most atoms (non-ions) are electrically neutral?

   Most everything we touch has no net charge, or we would get a shock.

3.



Atom A



Atom B

(a) How many protons in atom A? *1* Atom B? *3*

(b) How many neutrons in atom A? *0* Atom B? *3*

(c) How many electrons in atom A? *1* Atom B? *3*

(d) What is the atomic weight of atom A? *1* Atom B? *6*

(e) What is the atomic number of atom A? *1* Atom B? *3*

(f) What element is atom A? *Hydrogen* Atom B? *Lithium*

(g) What orbits the center of the atom? *Electrons*

(h) What is the atom's center called? *Nucleus*

(i) What makes up the center of the atom? *Protons and electrons*

Marie Curie (1867-1934) and the Little Curies

Marya Sklodowska was born on November 7, 1867, in Warsaw, Poland. In 1891 she moved to Paris, attended school and met her future husband, Pierre. She began a family tradition when she became the first woman in Europe to earn a Ph.D. in Physics and to win a Nobel Prize in Physics in 1903 for her work on the "radiation phenomenon." Eight years later she became the first person, ever, to win a second Nobel Prize, this time in chemistry for her discovery of the element radium. In 1935 Marie's oldest daughter, Irene, won the Nobel Prize in Chemistry for her discoveries in artificial radiation.

Pierre had a reputation as a "pure scientist" and had little interest in the social implications of his work, but Marie understood that society saw science as a means to an end and took a great interest in the applications of her work.

1914 brought World War I to Europe and a halt to all research. Marie and Irene saw an opportunity to apply their scientific talents in the new field of radiology. Marie realized that on the battlefield X-rays could help doctors "see" imbedded bullets, shrapnel and broken bones in wounded soldiers. She convinced the government to set up France's first military radiology center. As director of the Red Cross Radiology Center she had automobile body shops transform cars into hospital vans, begged wealthy patrons for money to equip the vehicles and hounded manufacturers to donate parts and equipment. Within two months the first mobile radiological unit was in service. Marie, Irene and their trained technicians supervised over one million X-rays. Soldiers in the field called the loaded little vans "Petit Curie" (Little Curies).

Fermi's Paradox, "Where Is Everybody?"

It was in 1950 when Enrico Fermi was at lunch with a number of his colleagues when the topic of conservation turned to the idea of extraterrestrial life. His remark came when he was discussing the possibility that many intelligent societies might populate the galaxy. It seemed reasonable to assume that we should have a lot of company in the universe. At some point Fermi realized that if there are alien civilizations out there, then some of them might have spread out.

He rationalized that any society with a modest amount of rocket technology and an average amount of ambition could rapidly colonize the entire galaxy. Within ten million years, every star system could be incorporated within a galactic federation. Ten million years is not a long time considering that the age of the galaxy is roughly ten thousand million years. It would seem that colonizing the Milky Way should be an easy task. This meant that the aliens had more than enough time to scatter their presence throughout the galaxy.

Looking around, Fermi didn't see any clear evidence that we were not alone in the universe. This led the physicist to ask the obvious question: "Where is everybody?" This may sound ridiculous at first, but the lack of evidence for alien existence leads us to the conclusion that we are alone. Surely there must be some way to account for our apparent loneliness in a galaxy that is supposed to be populated with intelligent life.

Some have insisted that there is no paradox at all. The reason that we don't see evidence of extraterrestrials is because there aren't any.