

Lesson 7: Part I - Bohr's theory of the Atom

Motivator:

Set up a number of gas discharge tubes and have students view them with spectroscopes. Make sure to include Neon as one of the tubes. Allow students several minutes to view each spectra.

Q: Which colours did you see when you looked at _____?

Q: Was the spectrum of colours continuous like a rainbow or were there spaces in between colours?

A: There should be spaces.

Q: Why are there spaces?(Answer this one in the notes)

Q: Was the spectrum of one element exactly the same as any other?

A: No.

Q: What's significant about the fact that each element has unique line spectra?

A: We can use line spectra to identify elements just like a fingerprint can be used to identify a person.

Notes:

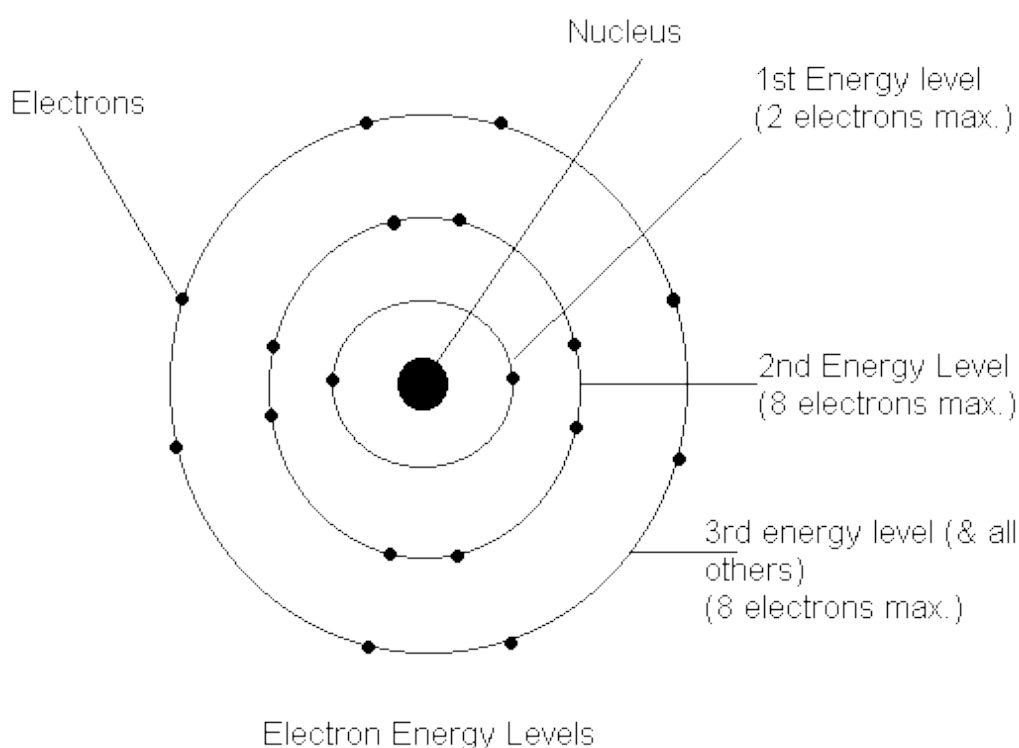
- when energy is absorbed by electrons in an atom in the form of electrical or heat energy, the atoms re-emit the energy as specific wavelengths of light (i.e., the specific bands of colour you see is an emission spectrum).

Niels Bohr:

- the amount of energy an electron has is relative to how far it is from the nucleus (i.e., electrons that are further from the nucleus have more energy)

Orally: *If electrons had no restrictions with respect to their location in an atom one would expect to see a continuous rainbow of colour (i.e., continuous energy distribution) when electrons in a given element were "excited" (by having energy added to them). Therefore Rutherford's model regarding electron placement was inaccurate.*

- Since only certain wavelengths of light are produced for certain atoms, then the electrons which absorb and re-emit energy must be in specific locations around the nucleus. The electrons are limited to locations called shells or orbits. (Refer to the Bohr diagrams on page 209 and 210.)
- The number of shells (orbits) that an atom has depends on the number of electrons. (i.e., the more electrons, the more shells needed). The number of shells is also related to the period the element is located in. e.g., Elements in the first period have one shell, while elements in the 2nd period have two shells, etc.



Q: How do electrons absorb energy in the atom?

A: They move from a low energy shell (i.e., close to the nucleus) to a higher energy shell.

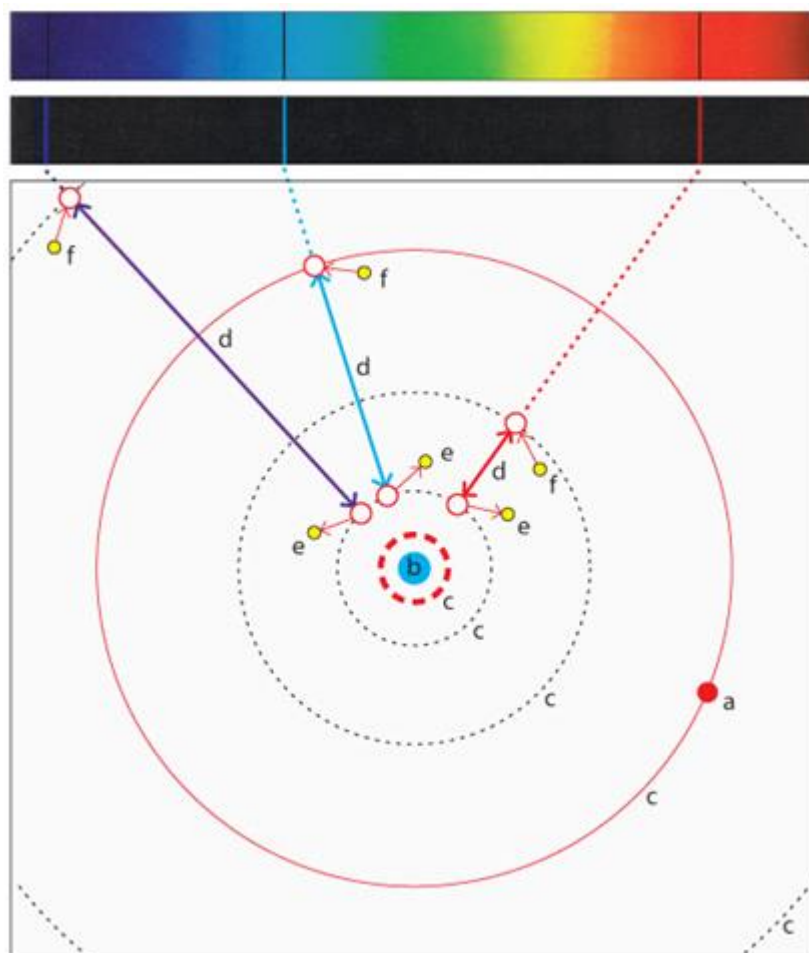
Q: What happens next?

A: The electron "falls" back to the lowest energy shell available and releases the energy in the form of light. The distance that the electron falls and its relative position to the nucleus dictates the wavelength of light produced.

Orally: The following link is a simulation which shows how excited electrons emit specific wavelengths of light depending on the shell they fall from.

<http://physics.gac.edu/~chuck/PRENHALL/Chapter%2031/AABXTEI0.html?I1.x=24&I1.y=34>

Orally: Since electrons do not exist in between shells, we should not expect to see a continuous rainbow of colour when we look at emission spectra of an element. A continuous rainbow of colour would mean that electrons could be anywhere with respect to the nucleus.



Orally: A helpful way of thinking about shells is to think of them as a weird kind of staircase. You have more potential energy at the top of the staircase because you can fall a long way. Now drop a ball down the stairs; the natural inclination of the ball is to find the lowest energy state possible (the bottom). It is possible for the ball to take up a temporary resting place on any stair, but it is impossible that it will stop falling half-way between one stair and the next! Like a staircase, electrons do not occupy spaces between the “stairs” i.e., orbits.

Lesson: Part II - Bohr Diagrams

Notes:

Rules for the *First Twenty Elements*.

1. When placing electrons in shells you have to fill, if possible the innermost shell before beginning to fill the next shell.
2. The maximum number of electrons in the first shell is 2, which is the number of elements in the first horizontal row of the periodic table.
3. The maximum number of electrons in the second shell is 8, which is the number of elements in the second horizontal row of the periodic table.
4. The maximum number of electrons in the third shell is 8, which is the number of elements in the third horizontal row of the periodic table.

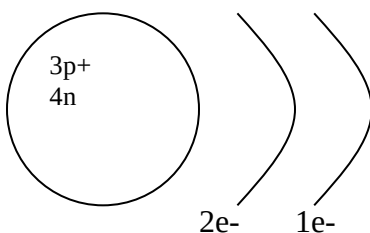
Examples:

1. Draw a Bohr diagram for ${}^7\text{Li}$.

ANSWER: *Lithium 7* has 3 protons and 4 neutrons, and because it's neutral, it has 3 electrons.

Orally:

We first fill the first shell with 2 electrons(abbreviated 2e-); The remaining electron has to go into the second shell.

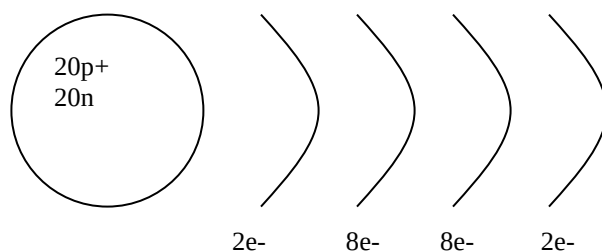


2. Draw a Bohr diagram for ^{40}Ca .

ANSWER: *Calcium 40* has 20 protons and 20 neutrons, and because it's neutral, it has 20 electrons.

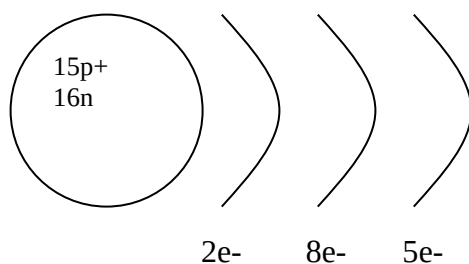
Orally:

We first fill the first shell with 2 electrons (rule #1) The second shell can hold 8 more, so a total of 10 electrons have been placed, so far. (rule #2) The third shell can hold 8 more (for the first 20 elements; rule # 3), so the last two electrons end up in the fourth shell.

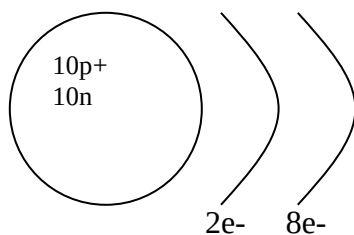


3. Draw a Bohr diagram for ^{31}P

ANSWER: *Phosphorus 31* has 15 protons and 16 neutrons, and because it's neutral, it has 15 electrons.



4. Draw a Bohr Diagram for ^{20}Ne



Orally:

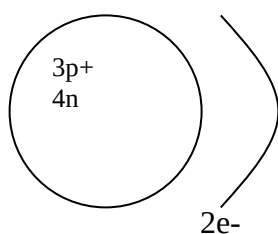
Q: Why is Neon a non-reactive element?

A: Chemists have found, through experimentation, that elements that have a full outer shell of electrons are chemically stable (i.e., they don't react or they stop reacting)

Part III: Predicting the charge on elements when they react.

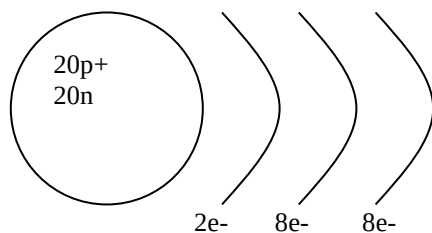
Orally:

Look at the previous examples of Bohr diagrams and ask yourself this: Is it easier to fill the outer shell by gaining or losing electrons? (i.e., which method is the quicker of the two?)



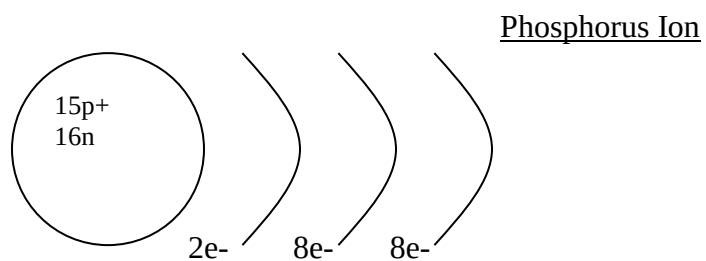
Lithium Ion

For the lithium atom it is “easier” to lose 1e- than it is to gain 7e-. When lithium reacts it forms a +1 ion (Li^+). i.e., when lithium reacts it gives one of its electrons to another element.



Calcium Ion

Have students predict what happens to Calcium. Answer: Ca^{+2} (easier to lose 2e- than gain 6e-)



For Phosphorus, it's easier to gain 3e⁻ in the outer shell than it is to lose 5e⁻, so the predicted ion after Phosphorus reacts is **P⁻³**. i.e., Phosphorus gains 3e⁻ from another element when it reacts.

Isoelectronic: When two substances have the same electronic configuration. E.g., P⁻³ is isoelectronic with Ar and Li⁺ is isoelectronic with He.

Assignment: Worksheet on Bohr diagrams.