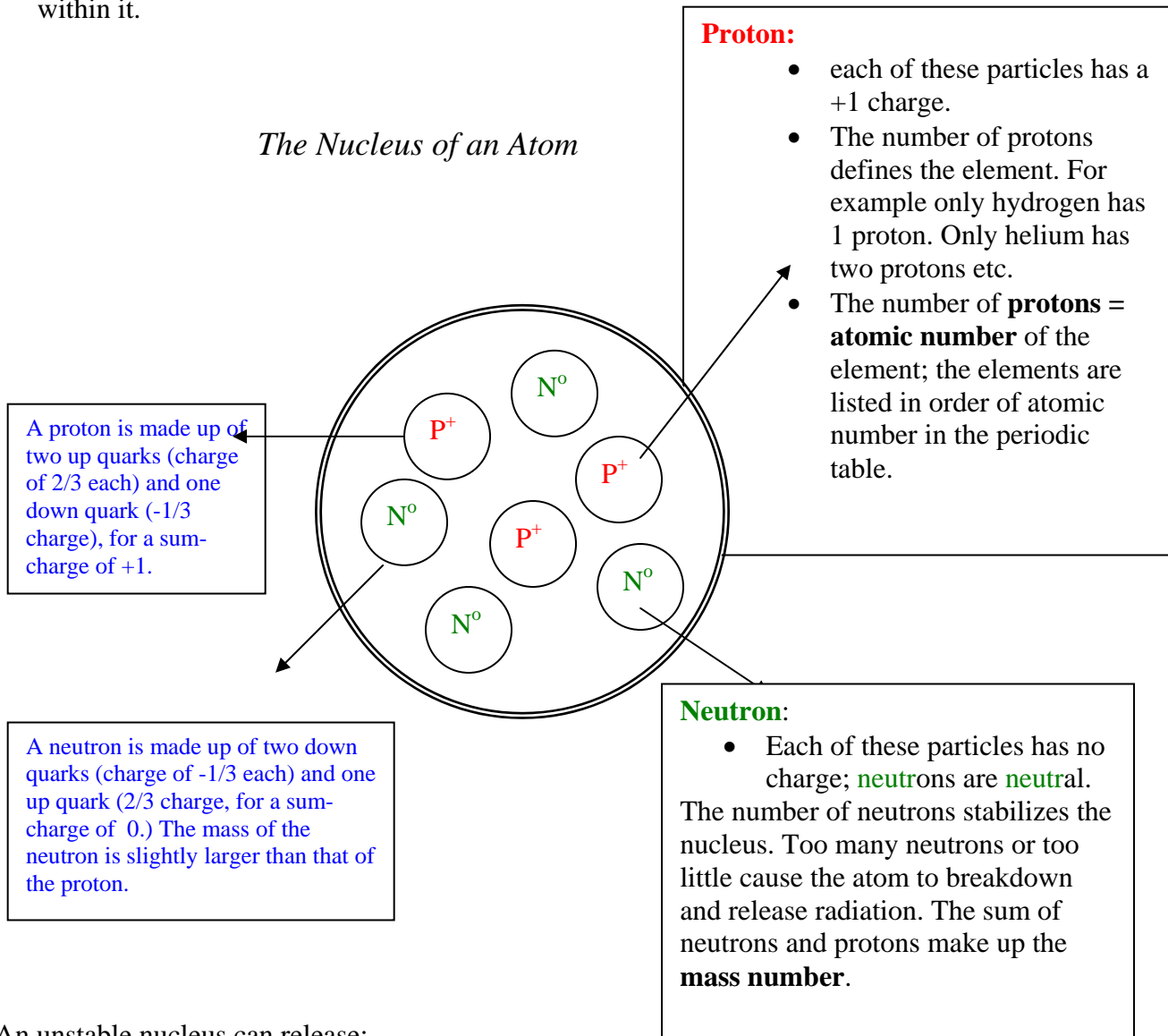


Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

6. A. MODERN MODEL OF THE ATOM: A CLOSER LOOK AT THE NUCLEUS

Since Bohr, the model of the atom has become even more sophisticated. Scientists had to explain why even the thin lines in an emission spectrum could be resolved into more fine lines, and they had to include the discovery of neutrons into their model.

The atom is the smallest unit of an element that still behaves like the entire element, but that's not to say that the smaller parts do not exist. Rutherford showed that every atom's mass is concentrated in its nucleus, and if we zoom into the nucleus, we see a whole new world within it.



An unstable nucleus can release:

- Alpha particle (α) : fast moving helium nucleus(two protons fused together)
- Beta particle (β) : this is a fast moving electron formed when a neutron from an unstable nucleus turns into proton and an electron.
- Gamma rays(γ): energy accompanying for example the release of neutrons

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In Class Examples

1. a. What is the atomic number of hydrogen?_____
- b. Of phosphorus (P)?_____
- c. How many protons are in the nucleus of a hydrogen atom?_____
- d. How many protons are in the nucleus of a phosphorus atom?_____
2. Neutral atoms have the same number of electrons as protons. How many electrons are in each sulfur atom(S)._____
3. What is the charge of a neutron?_____
4. What is the mass number of an atom containing 2 neutrons and 1 proton?_____

6. B. MODERN MODEL OF THE ATOM: ISOTOPES AND ISOTOPE NOTATION

Definition: *Isotopes* are different versions of the same element.

Example

- These different versions have the same atomic number but a different mass number.

What's implied?

- The chemical properties of isotopes are almost identical. The extra weight sometimes slows down the rate at which things react, but it does not affect whether they react.

Example



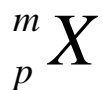
- The physical properties of isotopes differ. They also have different nuclear properties. Some have stable nuclei. Others are radioactive and break down, releasing gamma, alpha or beta radiation.

Example



Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

Isotope Notation



m = mass number = # of protons + # of neutrons

p = atomic number = number of protons (note that the # of protons go up in order in the periodic table)

In Class Examples (we are assuming that all these isotopes are electrically neutral)

1. Complete the table below:

Name	Isotope Notation	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
nitrogen			14			
oxygen					7	
		15	31			18
	${}^{200}\text{Hg}$					
	${}^{127}\text{I}$					

Example 2 Use isotope notation to represent a...

- Na atom with 12 neutrons
- Mg atom with a mass number of 23
- atom with 7 protons and 8 neutrons.
- pair of oxygen isotopes, one with mass number 16; the other with #17

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Exercises

1. Complete the following table:

Name	Isotope Notation	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
carbon			14			
oxygen			15			
		15	31			
	${}^9\text{B}$					
	${}^{79}\text{Se}$					
	${}^{251}\text{Cf}$					
	${}^{19}\text{F}$					
		19	49			
		12	25			
		36	77			
		1	3			
			2		1	
			127		74	
			152		79	
			50		29	
		80			120	
		23			28	
		22			26	
		5			6	
		8			7	
					10	9
					12	11

2. Give two examples of isotope pairs.

3. Discuss the similarities and differences between ${}^{12}\text{C}$ and ${}^{14}\text{C}$.

Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

6. C. Modern Model of the Atom: Ions

Definition: An *ion* is a charged atom, meaning that it has either too many electrons or too many protons.

Its charge can be calculated from the following:

Charge = # of protons - # of electrons or <i>Implied:</i> Electrons = protons - charge

Examples

- Ions are chemically different from their neutral counterparts.

Example: If someone replaced the calcium ions in your bones with *neutral* calcium, you would be killed!

Other Examples

- To *name* positive ions, keep the same name as the one used for the neutral atom.

Examples Na^{+1} = sodium

- To *name* negative monoatomic ions, change the suffix of the neutral name to *ide*

Examples Cl^{-1} = *chloride*, not chlorine
 O^{-2} = *oxide*, not oxygen

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In class examples

Name	Isotope Notation	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Neutral neon			20			
oxide (-2)					7	
		15	31			18
	$^{200}\text{Hg}^{+1}$					
	$^{127}\text{I}^{-1}$					

Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

Exercises

1. Complete the following table.

Name	Isotope Notation	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Neutral carbon			14			
oxide			15			10
		15	31			18
	${}^9\text{B}^{+3}$					
	${}^{79}\text{Se}^{-2}$					
	${}^{251}\text{Cf}^{+2}$					
	${}^{19}\text{F}^{-1}$					
		19	49			18
		12	25			10
		36	77			36
		1	3			2
			2		1	2
			127		74	54
			40		21	18
			140		81	60
		11			12	10
				12	12	10
		13			14	10
				5	6	2
		17			18	18
fluoride			19			
Calcium ion (+2)			40			

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2. Answer the following “who am I?” questions with one of the following terms: *proton, neutron, electron, or ion*.
 - a. I am a positively charged particle found within the nucleus _____
 - b. I am the least heavy of the subatomic particles _____
 - c. If magnesium loses electrons, it turns into one of these _____
 - d. Compared to carbon 13, carbon 14 has one more of these _____
 - e. If an atom loses one of these, it becomes positively charged _____
3. If it was possible to add 2 protons to a neutral neon atom (mass number: 20), what would you end up with? Show the full isotope notation of the newly created atom and all work needed to arrive at your answer.
4. Show through example how the chemical properties of an ion differ from those of its neutral counterpart.

Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

6. D. Modern Model of the Atom: Shell Diagrams (Bohr-Rutherford Diagrams)

The purpose of these diagrams is to show the nucleus with its correct number of protons and neutrons, but also, more importantly, to give a more detailed view of electrons, one that will help explain the chemical properties of elements.



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 shell diagram for ${}^7\text{Li}$.

ANSWER: *Lithium 7* has 3 protons and 4 neutrons, and because it's neutral, it has 3 electrons. We first fill the first shell with 2 electrons (abbreviated 2e): rule #1. The remaining electron has to go into the second shell.

SHOW BELOW!!!

2. Draw a shell diagram for ${}^{40}\text{Ca}$.

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

SHOW BELOW!!!

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Rules for the Elements # 21-54. *Not that important in this course.*

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 **18**. However before placing more than 8 electrons in this shell, you have to place two electrons in the next shell, and then come back to fill the third shell.
5. The maximum number of electrons in the fourth shell is **18**. However before placing more than 8 electrons in this shell, you have to place two electrons in the next shell, and then come back to fill the fourth shell.

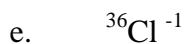
Example:

1. Draw a shell diagram for ^{91}Zr .

ANSWER: *Zirconium 91* has 40 protons and 51 neutrons, and because it's neutral, it has 40 electrons.

Exercises

1. Draw a shell diagram for each of the following:



Modern Model: Nucleus, Isotope Notation, Ions, Shell Diagrams

