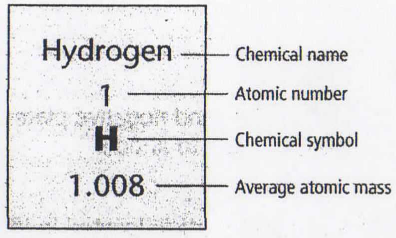
STATION TEKS: C.6.D.

Ever wonder why the atomic mass in the periodic table is not a whole number?



For hydrogen, there are three isotopes that contribute to the average atomic mass.

$^{1}_{1}H \quad ^{2}_{1}H \equiv D \quad ^{3}_{1}H \equiv T$

deuterium   tritium

Different elements have different number of isotopes contributing towards the average atomic mass.

STATION TEKS: C.6.D.
Essential Question: What isotopic composition is required to calculate the average atomic mass of an element?

Question: What is an isotope?

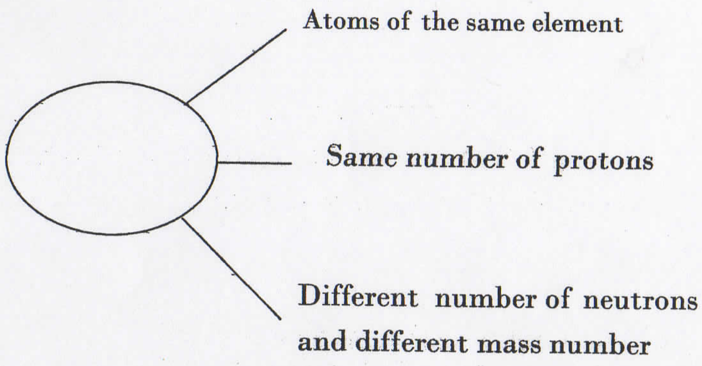
A. Atom of the same element with different number of electrons

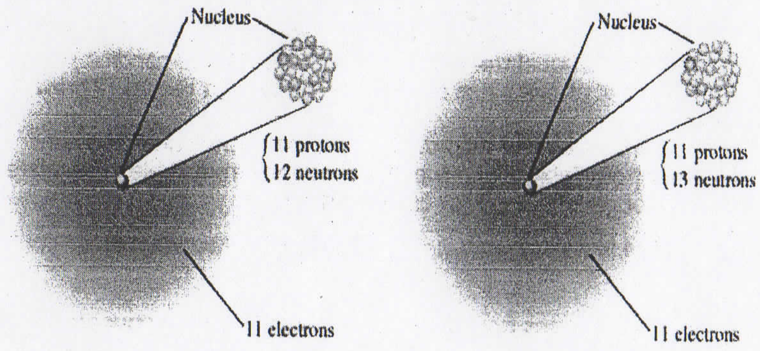
B. Atom of the same element with different number of protons

C. Atom of the same element with different number of neutrons

D. Atoms of a different element with the same number of protons.

Individual:
I chose answer ____ because ______________________________





$^{23}_{11}Na$ $^{24}_{11}Na$

STATION TEKS: C.6.D

Guiding Questions:

1. What is **%** or ***relative abundance***?
2. Define ***mass number***?
3. How are ***relative abundance*** and ***mass number*** used to calculate average atomic mass?

4. How do you calculate average atomic mass given the relative abundance and mass number of the isotopes of an element?

Atomic Mass Lab

Atomic Mass = $(mass_{isotope\ 1})$(% Abundance) + $(mass_{isotope\ 2})$(% Abundance) + . . .

Materials: Bag of multicolored candy such as skittles, m & m's, etc... a calculator, weighing paper and a balance.

Procedures:

- Record all of your data in **Table 1** and **Table 2** (next page)
- Open your bag of candy on a clean surface or paper towel.
- Count the total number of candies and record.
- Count the number of each colored candy by color and record. (The total number of candies should equal the sum of all of these colored candies.)
- Determine the mass of one piece of candy per color and record. Throw these candies away.
- Total the % Abundances and record. This should nearly equal 100%.
- Using the mass from Table 1 and the % Abundance from Table 2 calculate the weighted mass of each isotope (or color) and record.

  Weighted Mass = (mass) (% Abundance)

- Total the weighted masses from Table 2 and record. This is your atomic mass and should be between the smallest and largest masses recorded in Table 1.

STATION TEKS: C.6.D

Table 1.

Candy	# Pieces	Mass (One Piece)
Color "A"		
Color "B"		
Color "C"		
etc...		
Total in Bag		N/A

$$\% \text{ Abundance} = \frac{\#\text{ pieces of one color}}{\text{total in bag}} \times 100\ \%$$

Analysis:

- Assume your candy is a natural source of an element and each of that element's isotopes is represented by a different colored candy.
- Create another table similar to **Table 2** (below)
- Calculate the % Abundance for each colored candy using the following equation and record:

Table 2.

Candy	% Abundance	Weighted Mass
Color "A"		
Color "B"		
Color "C"		
etc...		
Total for Bag		

STATION TEKS: C.6A
GLOSSARY

Anode

Positive electrode

Cathode

negative electrode

Cathode ray tube

sealed glass tube with positive and negative plates that allows negative electrons to travel from cathode to anode.

Electron

negatively charged subatomic particle located in the electron cloud of the atom.

Isotopes

are atoms with the same number of protons (same element) but different numbers of neutrons.

Neutron

neutrally charged subatomic particle located in the nucleus of the atoM

Nucleus

small , positively charged central part of the atom.

Proton

positively charged subatomic particle located in the nucleus of the atom.

STATION TEKS: C.6D
Hints/Glossary

Isotopes

- isotopes: same Z, different M

^1_1H ^2_1H ^3_1H $^{12}_6C$ $^{13}_6C$ $^{14}_6C$ $^{235}_{92}U$ $^{238}_{92}U$

- isotopic abundance: $\frac{\text{\# atoms of isotope present}}{\text{\# atoms of element present}}$

isotope	natural abundance	mass (amu)
carbon-12	98.89 %	12.000000
carbon-13	1.11 %	13.003354

average mass: 12.01₁ amu

Calculating Average Atomic mass:

You can use % abundance of the isotopes:

(mass number of isotope x % abundance) + (mass number of isotope x % abundance)... = average atomic mass
100

Or you can use relative abundance of the isotopes:

Relative abundance = % abundance / 100

(mass number of isotope x relative abundance) + (mass number of isotope x relative abundance) = average atomic mass...

Example: Carbon

mass number	percent abundance
12	98.90
13	1.10

To calculate the average atomic weight, each exact atomic weight is multiplied by its percent abundance (expressed as a decimal).

EX. (12.000000) (0.9890) + (13.003355) (0.0110) = 12.011 amu

Then, add the results together and round off to an appropriate number of significant figures.

Atomic number (Z)

The number of protons in an atom. All atoms of the same element have the same number of protons.
Image

Mass number (A)

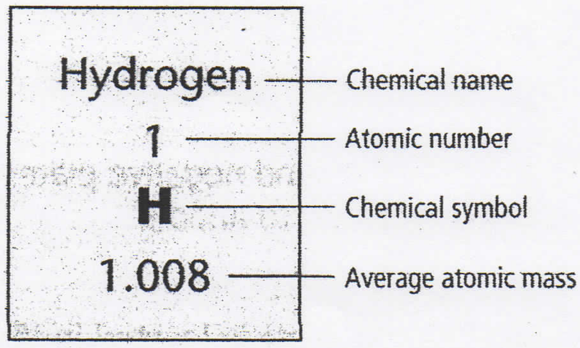
The sum of the number of protons and neutrons in an atom. A different mass number doesn't mean a different element—just an isotope.

Average atomic masses

The weighted average of the masses of the isotopes of an element.

STATION TEKS: C.6.D.

Ever wondered why the atomic mass in the periodic table is not a whole number?



For hydrogen, there are three isotopes that contribute to the average atomic mass.

$$^{1}_{1}H \qquad ^{2}_{1}H \equiv D \qquad ^{3}_{1}H \equiv T$$

deuterium tritium

Different elements have different number of isotopes contributing towards the average atomic mass.

STATION TEKS: C.6.D.

Essential Question: What isotopic composition is required to calculate the average atomic mass of an element?

Question: What is an isotope?

A. Atom of the same element with different number of electrons

B. Atom of the same element with different number of protons

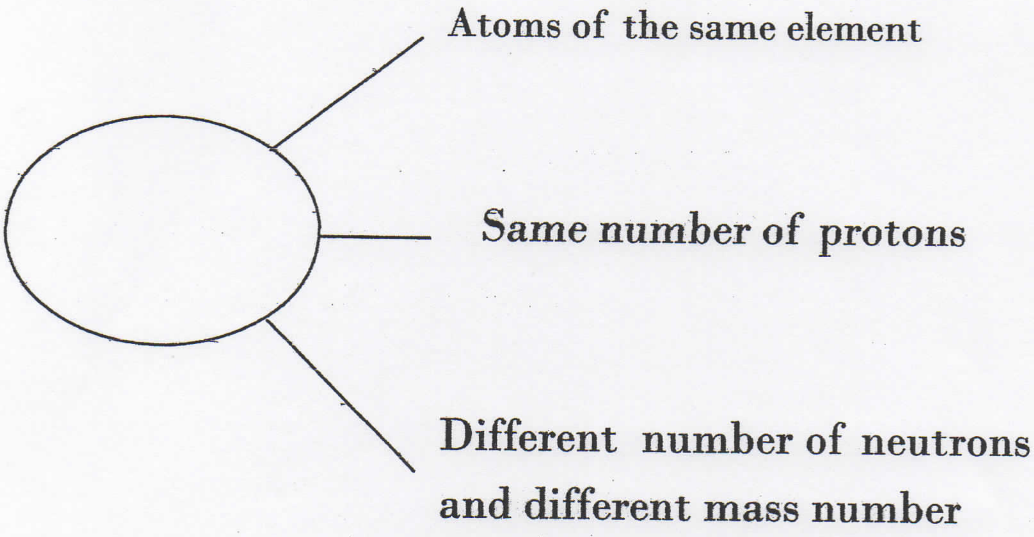
C. Atom of the same element with different number of neutrons

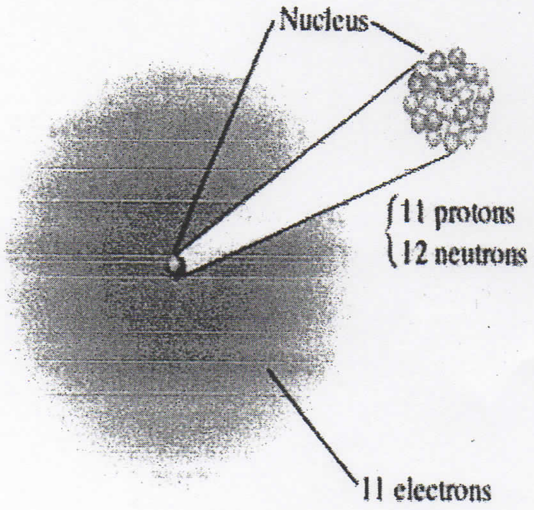
D. Atoms of a different element with the same number of protons.

Individual:

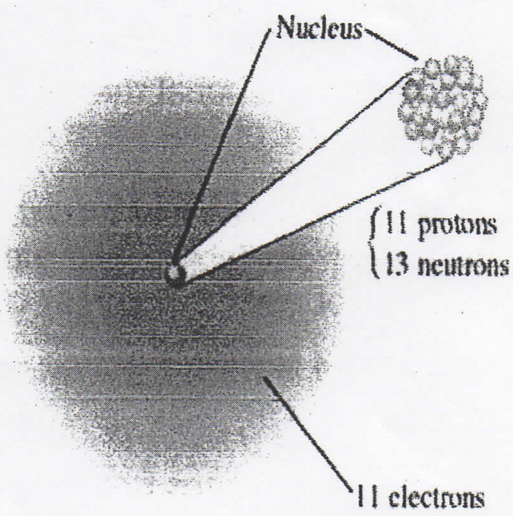
I chose answer ____ because ____

____





$^{23}_{11}Na$



$^{24}_{11}Na$

STATION TEKS: C.6.D

Guiding Questions:

1. What is **%** or ***relative abundance***?
2. Define ***mass number?***
3. How are ***relative abundance*** and ***mass number*** used to calculate average atomic mass?
4. How do you calculate average atomic mass given the relative abundance and mass number of the isotopes of an element?

Atomic Mass Lab

Atomic Mass = $(\text{mass}_{\text{isotope 1}})$(% Abundance) + $(\text{mass}_{\text{isotope 2}})$(% Abundance) + . . .

<u>Materials:</u> Bag of multicolored candy such as skittles, m & m's, etc... a calculator, weighing paper and a balance.

<u>Procedures:</u>

- Record all of your data in **Table 1** and **Table 2** (next page)
- Open your bag of candy on a clean surface or paper towel.
- Count the total number of candies and record.
- Count the number of each colored candy by color and record. (The total number of candies should equal the sum of all of these colored candies.)
- Determine the mass of one piece of candy per color and record. Throw these candies away.
- Total the % Abundances and record. This should nearly equal 100%.
- Using the mass from Table 1 and the % Abundance from Table 2 calculate the weighted mass of each isotope (or color) and record.

Weighted Mass = (mass) (% Abundance)

- Total the weighted masses from Table 2 and record. This is your atomic mass and should be between the smallest and largest masses recorded in Table 1.

STATION TEKS: C.6.D

Table 1.

Candy	# Pieces	Mass (One Piece)
Color "A"		
Color "B"		
Color "C"		
etc...		
Total in Bag		N/A

$$\% \text{ Abundance} = \frac{\# \text{ pieces of one color}}{\text{total in bag}} \times 100\ \%$$

Analysis:

- Assume your candy is a natural source of an element and each of that element's isotopes is represented by a different colored candy.
- Create another table similar to **Table 2** (below)
- Calculate the % Abundance for each colored candy using the following equation and record:

Table 2.

Candy	% Abundance	Weighted Mass
Color "A"		
Color "B"		
Color "C"		
etc...		
Total for Bag		

STATION TEKS: C.6A
GLOSSARY

Anode

Positive electrode

Cathode

negative electrode

Cathode ray tube

sealed glass tube with positive and negative plates that allows negative electrons to travel from cathode to anode.

Electron

negatively charged subatomic particle located in the electron cloud of the atom.

Isotopes

are atoms with the same number of protons (same element) but different numbers of neutrons.

Neutron

neutrally charged subatomic particle located in the nucleus of the atoM

Nucleus

small , positively charged central part of the atom.

Proton

positively charged subatomic particle located in the nucleus of the atom.

STATION TEKS: C.6D

Hints/Glossary

Isotopes

- isotopes: same Z, different M

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$ $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$ $^{235}_{92}U$ $^{238}_{92}U$

- isotopic abundance: $\frac{\text{\# atoms of isotope present}}{\text{\# atoms of element present}}$

isotope	natural abundance	mass (amu)
carbon-12	98.89 %	12.000000
carbon-13	1.11 %	13.003354

average mass: 12.01_{11} amu

Calculating Average Atomic mass:

You can use % abundance of the isotopes:

$$\frac{(\text{mass number of isotope x \% abundance}) + (\text{mass number of isotope x \% abundance})\ldots}{100} = \text{average atomic mass}$$

Or you can use relative abundance of the isotopes:

$$\text{Relative abundance} = \frac{\text{\% abundance}}{100}$$

(mass number of isotope x relative abundance) + (mass number of isotope x relative abundance) = average atomic mass...

Example: Carbon

mass number	percent abundance
12	98.90
13	1.10

To calculate the average atomic weight, each exact atomic weight is multiplied by its percent abundance (expressed as a decimal).

EX. (12.000000) (0.9890) + (13.003355) (0.0110) = 12.011 amu

Then, add the results together and round off to an appropriate number of significant figures.

Atomic number (Z)

The number of protons in an atom. All atoms of the same element have the same number of protons.
Image

Mass number (A)

The sum of the number of protons and neutrons in an atom. A different mass number doesn't mean a different element—just an isotope.

Average atomic masses

The weighted average of the masses of the isotopes of an element.

Atoms and Their Isotopes

Why?

Atoms and isotopes are identified by the numbers of protons, neutrons and electrons that they contain. Before you can understand the properties of atoms, how atoms combine to form molecules, and the properties of molecules, you must be familiar with the number of protons, neutrons and electrons associated with atoms.

Success Criteria

- Identify the composition of atoms and their isotopes in terms of the numbers of protons, neutrons, and electrons.
- Use atomic symbols to represent different atoms and their isotopes.
- Efficient use of Periodic Table as a source of data.

Resources

- Periodic Table

Information

From the perspective of a chemist, the entire world is composed of atoms, and atoms are composed of protons, neutrons and electrons. Protons and neutrons are about 2000 times heavier than an electron. A proton has a charge of +1, a neutron has no charge and an electron has a charge of -1. The nucleus is very dense and very small compared to the entire atom.

The properties of atoms are determined by the numbers of protons, neutrons and electrons that they contain. Atoms with the same number of protons but different number of neutrons are called isotopes of an element.

The isotopic notation for an atom includes the following information: symbol of the element, the element's atomic number (Z) which specifies the number of protons in the nucleus, and the mass number (A) which indicates the number of protons plus neutrons in the nucleus. [The number of electrons in a neutral atom is equal to the number of protons in the nucleus of the atom. The mass contributed by the electrons in an atom is very small, so it is not included when calculating the mass number.]

Atomic Symbol Notation

$^{A}_{Z}X$

Mass Number
Atomic Symbol
Atomic Number

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

Subatomic Particles

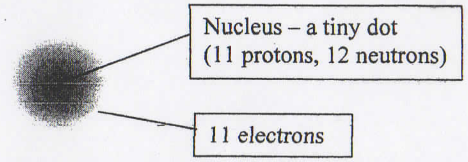
Particle	Symbol	Relative Charge	Absolute Mass	Relative Mass
electron	e^-	-1	9.109×10^{-31} kg	0
proton	p^+	+1	1.673×10^{-27} kg	1
neutron	n^0	0	1.675×10^{-27} kg	1

Model: Two Isotopes of Sodium

The diagrams below show representations of sodium isotopes. [Note: the diameter of an atom is about 10,000 times larger than the diameter of the atomic nucleus so the relative sizes of the atom and the nucleus are not accurately depicted in these diagrams.]

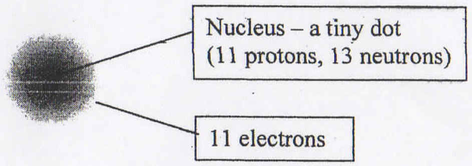
Isotope 1

$^{23}_{11}Na$



Isotope 2

$^{24}_{11}Na$



Key Questions

1. What information is provided by the atomic number, Z?

2. What information is provided by the mass number, A?

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

3. What is the relationship between the number of protons and the number of electrons in an atom?

4. Because of the relationship between the number of protons and number of electrons in an atom, what is the electrical charge of an atom?

5. Where are the protons and neutrons located in an atom?

6. What do the two sodium isotopes shown in the model have in common with each other?

7. How do the two sodium isotopes shown in the model differ from each other?

8. What distinguishes an atom of one element from an atom of another element?

Exercises

1. Describe the similarities between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.

2. Describe the differences between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.

3. Write the atomic symbols for two isotopes of carbon, C, one with 6 neutrons and the other with 7 neutrons.

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

4. Use a periodic table to fill in the missing information in the following table.

Name	Symbol	Atomic Number Z	Mass Number A	Number of Neutrons	Number of Electrons
oxygen	$^{16}_{8}O$	8	16	8	8
		7		7	
	$^{34}_{16}S$			18	
		1		1	
		1	3		
		12	24		
		12	25		
			238		92
	$^{84}_{36}Kr$		84		36

Problems

1. The radius of a Cl nucleus is 4.0 fm, and the radius of a Cl atom is 100 pm. (1 fm = 1 x 10^{-15} m; 1 pm = 1 x 10^{-12} m).How many times larger is the diameter of the Chlorine atom than the diameter of the Chlorine nucleus?

2. Identify two objects that have this same ratio of lengths.

3. How many times larger is the volume of the atom than the volume of the nucleus?

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

Atoms and Their Isotopes

Why?

Atoms and isotopes are identified by the numbers of protons, neutrons and electrons that they contain. Before you can understand the properties of atoms, how atoms combine to form molecules, and the properties of molecules, you must be familiar with the number of protons, neutrons and electrons associated with atoms.

Success Criteria

- Identify the composition of atoms and their isotopes in terms of the numbers of protons, neutrons, and electrons.
- Use atomic symbols to represent different atoms and their isotopes.
- Efficient use of Periodic Table as a source of data.

Resources

- Periodic Table

Information

From the perspective of a chemist, the entire world is composed of atoms, and atoms are composed of protons, neutrons and electrons. Protons and neutrons are about 2000 times heavier than an electron. A proton has a charge of +1, a neutron has no charge and an electron has a charge of -1. The nucleus is very dense and very small compared to the entire atom.

The properties of atoms are determined by the numbers of protons, neutrons and electrons that they contain. Atoms with the same number of protons but different number of neutrons are called isotopes of an element.

The isotopic notation for an atom includes the following information: symbol of the element, the element's atomic number (Z) which specifies the number of protons in the nucleus, and the mass number (A) which indicates the number of protons plus neutrons in the nucleus. [The number of electrons in a neutral atom is equal to the number of protons in the nucleus of the atom. The mass contributed by the electrons in an atom is very small, so it is not included when calculating the mass number.]

Atomic Symbol Notation

A X Z	Mass Number Atomic Symbol Atomic Number

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

Subatomic Particles

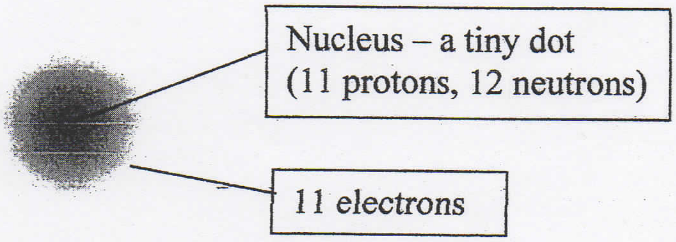
Particle	Symbol	Relative Charge	Absolute Mass	Relative Mass
electron	e^-	-1	9.109×10^{-31} kg	0
proton	p^+	+1	1.673×10^{-27} kg	1
neutron	n^0	0	1.675×10^{-27} kg	1

Model: Two Isotopes of Sodium

The diagrams below show representations of sodium isotopes. [Note: the diameter of an atom is about 10,000 times larger than the diameter of the atomic nucleus so the relative sizes of the atom and the nucleus are not accurately depicted in these diagrams.]

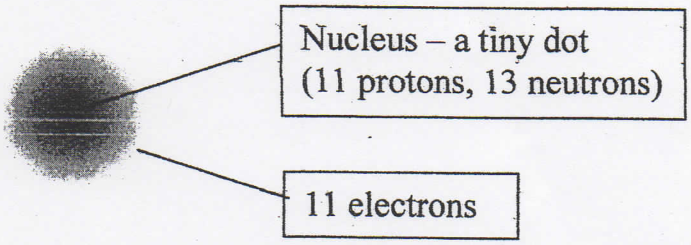
Isotope 1

$^{23}_{11}Na$



Isotope 2

$^{24}_{11}Na$



Key Questions

1. What information is provided by the atomic number, Z?

2. What information is provided by the mass number, A?

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

3. What is the relationship between the number of protons and the number of electrons in an atom?

4. Because of the relationship between the number of protons and number of electrons in an atom, what is the electrical charge of an atom?

5. Where are the protons and neutrons located in an atom?

6. What do the two sodium isotopes shown in the model have in common with each other?

7. How do the two sodium isotopes shown in the model differ from each other?

8. What distinguishes an atom of one element from an atom of another element?

Exercises

1. Describe the similarities between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.

2. Describe the differences between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.

3. Write the atomic symbols for two isotopes of carbon, C, one with 6 neutrons and the other with 7 neutrons.

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University

4. Use a periodic table to fill in the missing information in the following table.

Name	Symbol	Atomic Number Z	Mass Number A	Number of Neutrons	Number of Electrons
oxygen	${}^{16}_{8}O$	8	16	8	8
		7		7	
	${}^{34}_{16}S$			18	
		1		1	
		1	3		
		12	24		
		12	25		
			238		92
	${}^{84}_{36}Kr$		84		36

Problems

1. The radius of a Cl nucleus is 4.0 fm, and the radius of a Cl atom is 100 pm. (1 fm = 1×10^{-15} m; 1 pm = 1×10^{-12} m).How many times larger is the diameter of the Chlorine atom than the diameter of the Chlorine nucleus?

2. Identify two objects that have this same ratio of lengths.

3. How many times larger is the volume of the atom than the volume of the nucleus?

Authored by David Hanson, Revised by L. Giloni, E. Graham, M. Campiglia, M. Chiolo, M. Fusaro, E. Kannengieser, K. Levy
Edited by Linda Padwa and David Hanson, Stony Brook University