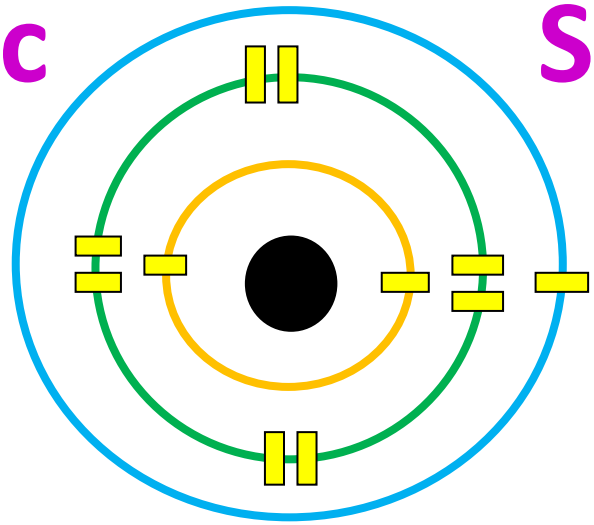
Surviving Chemistry

One Concept at a Time

Atomic Structure



Engaging and Easy-to-learn

Guided Study of High School Chemistry

Guided Study Book

Surviving Chemistry

One Concept at a Time

A *Guided Study* and Workbook for High School Chemistry

2012 Revision

e3Chemistry

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Topic 3 – The Atomic structure

Topic outline

In this topic, you will learn the following concepts:

.The historical development of the modern atom
. The subatomic particles; protons, electrons, neutrons
. Atomic number, mass number and atomic mass
. Isotopes
. Electron shells and electron configurations
. Ground and excited state of atoms
. Bright-line spectra
. Valance electrons, neutral atoms and ions

Lesson 1 - Historical development of the modern atomic model

Introduction:

The **atom** is the most basic unit of matter. Since atoms are very small and cannot be seen with the most sophisticated equipment, several scientists for thousands of years have proposed many different models of atom to help explain the nature and behavior of matter.

In this lesson, you will learn about these historical scientists, their experiments and proposed models of atom.

1. Historical scientists

Many scientists over many years have contributed to the development of the modern atomic model.

*The **wave mechanical-model*** is the current and most widely accepted model of the atom. According to the wave-mechanical model :

. Each atom has small dense positive nucleus

. Electrons are found outside the nucleus in a region called orbital

Orbital is the most probable location of finding an electron with certain energy in an atom.

Below is a list of some historical scientists and their proposed models of atom in order from the earliest model to the current model. Descriptions and key features of each model are also given.

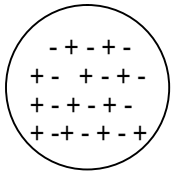
Concept Facts: Study to remember order of proposed atomic models.

John Dalton
(Earliest model)

Hard sphere model
(Cannonball model)

.No internal structure

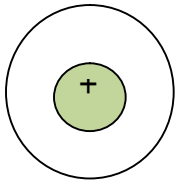
J.J. Thompson



Plum pudding model

.Electrons and positive charges disperse throughout the atom.

Earnest Rutherford

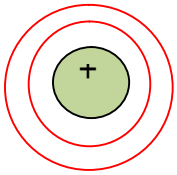


Empty space model
(Nuclear model)

.Small dense positive nucleus

. Electrons revolve around the nucleus

Neil Bohr



Bohr's model
(Planetary model)

. Electrons in specific orbits

. Orbits have fixed energy

.Orbits create electron shells

Many scientists
(Current model)

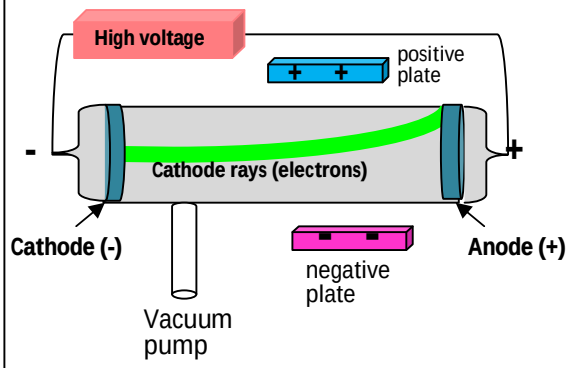
Wave mechanical
(electron cloud)

.Electrons in orbital

. Orbital is the area an electron is likely to be found

2. The Cathode Ray experiment

J.J. Thompson conducted the cathode ray experiment that further supports the existence of negative charge particles in atoms.



The set up

A tube with a metal disk at each end was set up to trace a beam from an electrical source. The metals were connected to an electrical source.

Anode: The Metal disk that becomes + charge

Cathode: The Metal disk that becomes – charge

Results

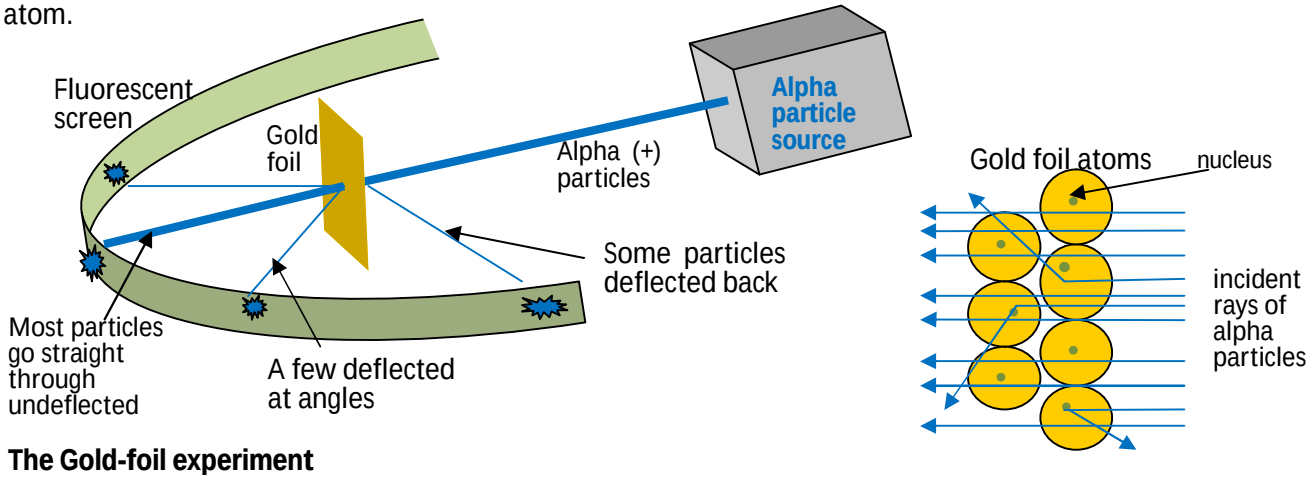
A beam of light (ray) travels from the *cathode* end to the anode end of the tube. When electrically charged **+** and **-** plates were brought near the tube, the beam (ray) is deflected toward (attracted) the positive plate. The beam was repelled by the negative plate.

Conclusions

The beam is composed of negatively charged particles. The term "electron" was used much later to describe the negatively charged particle of an atom.

3. The Gold-Foil Experiment

Earnest Rutherford conducted the gold-foil experiment that led to the proposed empty-space theory of atom.



The Gold-foil experiment

The set up

Equipment was set up to fire alpha particles at a gold foil.

. Alpha particle area positively charged helium nuclei

A Fluorescent screen was set around the foil

. The Screen is to detect the path of the particles once they hit the gold foil

Result 1

Most of the alpha particles went straight through the gold foil undeflected.

Conclusions 1

Atom is mostly empty space .

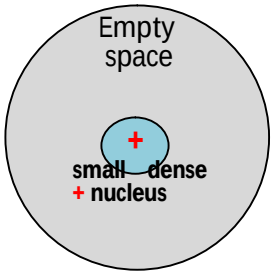
Result 2

A few of the particles were deflected back or hit the screen at angles.

Conclusion 2

The center of the atom is dense , positive, and very small.

Rutherford's atom



4. Historical Development of the modern atomic model: Practice problems

Practice 1
The modern model of an atom shows that electrons are
1) Orbiting the nucleus in fixed path
2) Found in regions called orbital
3) Combined with neutrons in the nucleus
4) Located in a solid sphere covering the nucleus

Practice 2
In the wave-mechanical model, the orbital is a region in space of an atom where there is
1) High probability of finding an electron
2) High probability of finding a neutron
3) Circular path in which electrons are found
4) Circular path in which neutrons are found

Practice 3
The modern model of the atom is based on the work of
1) One Scientist over a short period of time
2) One scientist over a long period of time
3) Many Scientists over a short period of time
4) Many scientists over a long period of time

Practice 4
Which conclusion is based on the "gold foil experiment" and the resulting model of the atom?
1) An atom has hardly any empty space, and the nucleus is positive charge
2) An atom has hardly any empty space, and the nucleus is negative charge
3) An atom is mainly empty space, and the nucleus has a positive charge
4) An atom is mainly empty space, and the nucleus has a negative charge

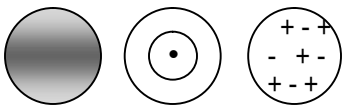
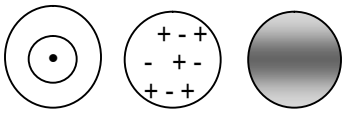
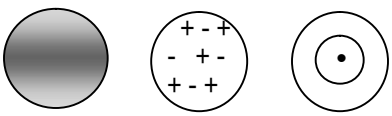
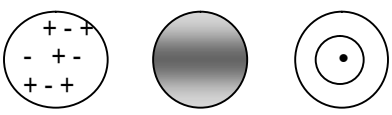
Practice 5
Which group of atomic models is listed in order from the earliest to the most recent?
1) Hard-sphere model, wave-mechanical model, electron-shell model
2) Hard-sphere model, electron-shell model, wave mechanical model
3) Electron-shell model, wave-mechanical model, hard-sphere model
4) Electron-shell model, hard-sphere model, wave-mechanical model

Practice 6
Subatomic particles can usually pass undeflected through an atom because the volume of an atom is composed mainly by
1) Uncharged nucleus
2) Unoccupied space
3) Neutrons only
4) Protons only

Practice 7
Experiment evidence indicates that atoms
1) Have uniform distribution of positive charges
2) Have uniform distribution of negative charges
3) Contains a positively charged , dense center
4) Contains a negatively charged, dense center

Practice 8
Compare to the entire atom, the nucleus of an atom is
1) Smaller and contains most of atom's mass
2) Smaller and contains little of atom's mass
3) Larger and contains most of atom's mass
4) Larger and contains little of atom's mass

Practice 9
Which order of diagrams correctly shows the historical models of the atom from the earliest to the most modern?

1) 
2) 
3) 
4) 

Lesson 2 – Structure of an Atom

Introduction

Although the atom is described as the smallest unit of matter, but it is also composed of much smaller particles called the ***subatomic particles***. The three *subatomic particles* are: proton, electron, and neutron.

In this lesson, you will learn more about the modern atom and the subatomic particles. You will also learn the relationships between subatomic particles, atomic number, and mass number.

5. Atom

The **atom** is the basic unit of matter. It is composed of three **subatomic particles**: Protons, electrons and neutrons. The only atom with no neutron is a hydrogen atom with a mass of 1. (^{1}H)

Concept Facts: Study to remember the followings about the atom.

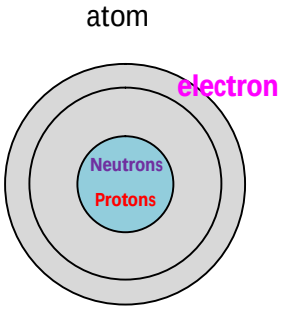
. An atom is mostly empty space

. Atoms have small dense positive core (nucleus), and negative electron cloud surrounding the nucleus

. Elements are composed of atoms with the same atomic number

. Atoms of the same element are similar

. Atoms of different elements are different



6. Nucleus

The **nucleus** is the center (core) of an atom.

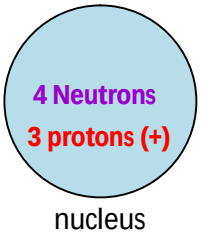
Concept Facts: Study to remember the followings about the nucleus

. The nucleus contains protons (+) and neutrons (no charge)

. Overall charge of the nucleus is positive (+) due to the protons

. The nucleus is very small and very dense relative to the entire atom

. Most of atom's mass is due to the mass of the nucleus



7. Protons

Protons are positively charged subatomic particles that are found in the nucleus of atoms.

Concept Facts: Study to remember the followings about protons

. A proton has a mass of one atomic mass unit (1 amu) and a +1 charge

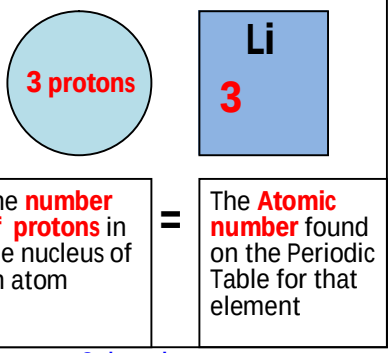
. A proton is about 1836 times more massive (heavier) than an electron

. Protons are located inside the nucleus

. The number of protons is the same as the atomic number of the element

. All atoms of the same element must have the same number of protons

. The number of protons in the nucleus is also the nuclear charge of the element



8. Electrons

Electrons are negatively charged subatomic particles that are found in orbitals outside the nucleus of atoms.

Concept Facts: Study to remember the followings about electrons

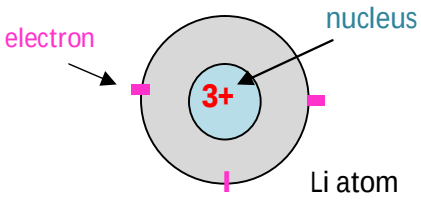
. An electron has insignificant mass (zero) and a -1 charge.

. An electron has a mass that is $^{1}/_{1836^{th}}$ that of a proton (or neutron)

. Electrons are found in ***orbitals*** outside the nucleus

. Electron arrangements in an atom determine the chemical properties of the element

. Number of electrons is always equal to the number of protons in a a neutral atom



In a Li atom, the number of electrons (3 e-) is equal to the number of protons (3+).

In all neutral atoms, there are equal numbers of electrons to protons.

9. Neutrons

Neutrons are neutral (no charge) subatomic particles that are located inside the nucleus of atoms.

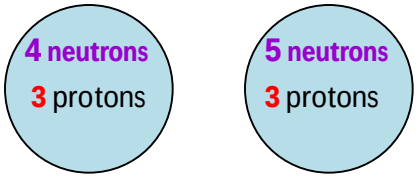
Concept Facts: Study to remember the followings about neutrons

. A neutron has a mass of 1 amu and zero charge

. A neutron has the same mass (1 amu) as a proton

. Neutrons are located in the nucleus along with protons

. Atoms of the same element differ in their numbers of neutrons



Nuclei from two different atoms of Lithium have the same number of protons but different numbers of neutrons.

10. The subatomic particles: Summary Table

Protons, electrons and neutrons are different in mass, charge, and location in an atom.

The table below summarizes information about all three particles.

NOTE: Some information on this Table can be found on **Reference Table O.**

Subatomic particle	*Symbol*	*Mass*	*Charge*	*Location*
Proton	$^{1}_{+1}p$	1 amu	+1	Nucleus
Neutron	$^{1}_{0}n$	1 amu	0	Nucleus
Electron	$^{0}_{-1}e$	0 amu	-1	Orbital (outside the nucleus)

11. Atomic number

Atomic number identifies each element.

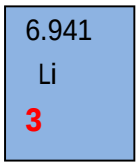
Concept Facts: Study to remember the followings about atomic number

. Atomic number of an element is *equal* to the number of protons

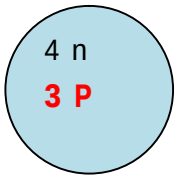
. All atoms of the same element have the same atomic number because they have the same number of protons.

. Atomic number can be found on the Periodic Table

. Elements on the Periodic Table are arranged in order of increasing atomic number



Periodic Table



Lithium Nucleus

Lithium (Li) has *atomic number of 3.*
Nucleus of all Li atoms contains *3 protons.*
No other atoms can have 3 protons.

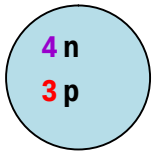
12. Nucleons

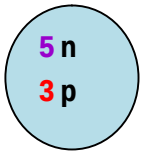
Nucleons are particles (protons and neutrons) in the nucleus of an atom

Concept Facts: Study to remember the followings about nucleons

. Nucleons account for the total mass of an atom

. The total number of nucleons in an atom is equal to the sum of protons *plus* neutrons





The Total number of nucleons for this Li atom is **7**
(**3** p + **4** n = **7**)

The total number of nucleons of this Li atom is **8**
(**3** p + **5** n = **8**)

13. Mass number

Mass number identifies different isotopes of the same element.

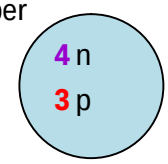
Concept Facts: Study to remember the followings about mass number

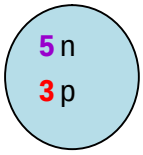
. Atoms of the same element differ by their mass numbers

. Mass number is equal to the number of protons ***plus*** neutrons

. The mass number shows the total number of nucleons

Two different nuclei of Li atoms





The mass number of this Li atom is **7**
(**3** + **4** = **7 amu**)

The mass number of this Li atom is **8**
(**3** + **5** = **8 amu**)

14. Relating one particle to another in neutral atoms. Practice problems

Concept Task: Be able to determine and compare number of subatomic particles.

Summary of relationships between the atomic particles in neutral atoms

protons = atomic # = nuclear charge = electrons = mass # - neutrons = nucleons - neutrons

electrons = atomic # = nuclear charge = protons = mass # - neutrons = nucleons - neutrons

neutrons = mass # - protons = mass# – atomic number = Mass # - electrons = nucleons – protons

mass # = nucleons = protons + neutrons = nuclear charge + neutrons = atomic # + neutrons

Practice 10
Which particles are found in the nucleus of an atom?
1) Electron, only
2) Neutrons, only
3) Protons and electrons
4) Protons and neutrons

Practice 11
Compare to the entire atom, the nucleus of an atom is
1) Smaller and contains most of atom's mass
2) Larger and contains most of atom's mass
3) Smaller and contains little of atom's mass
4) Larger and contains little of atom's mass

Practice 12
Which is true of protons and neutrons?
1) They have approximately the same mass and the same charge
2) They have approximately the same mass but different charge
3) The have different mass and different charge
4) They have different mass but the same charge

Practice 13
An electron has a charge of
1) -1 and the same mass as a proton
2) -1 and a smaller mass than a proton
3) +1 and the same mass a proton
4) +1 and a smaller mass than a proton

Practice 14
The mass of a proton is approximately
1) 1/2000 times the mass of a neutron and a unit positive charge
2) 1/2000 times the mass of a neutron and a unit negative charge
3) 2000 times the mass of an electron and a unit positive charge
4) 2000 times the mass of an electron and a unit negative charge

Practice 15
The mass number of an element is always equal to the number of
1) Protons plus electron
2) Protons plus positrons
3) Neutrons plus protons
4) Neutrons plus positrons

Practice 16
The number of neutrons in the nucleus of an atom can be determined by
1) Adding the mass number to the atomic number of the atom
2) Adding the mass number to the number of electrons of the atom
3) Subtracting the atomic number from the mass number of the atom
4) Subtracting the mass number from the atomic number of the atom

Practice 17
A neutral atom contains 12 neutrons and 11 electrons. The number of protons in this atom is
1) 1 2) 11 3) 12 4) 23

Practice 18
What is the number of electrons in a neutral atom of Fluorine?
1) 9 2) 19 3) 10 4) 28

Practice 19
The number of neutrons in a neutral atom with a mass number of 86 and 37 electrons is
1) 86 2) 37 3) 123 4) 49

Practice 20
What is the atomic number of a neutral element whose atoms contain 60 neutrons and 47 electrons?
1) 13 2) 47 3) 60 4) 107

Practice 21
What is the mass number of an atom that contains 19 protons, 18 electrons, and 20 neutrons?
1) 19 2) 38 3) 39 4) 58

Practice 22
How many nucleons are there in an atom with a nuclear charge of +20 and 23 neutrons?
1) 58 2) 20 3) 3 4) 43

Practice 23
What is the nuclear charge of an atom with 16 protons, 18 electrons, and 17 neutrons?
1) +16 2) +17 3) +18 4) +33

15. Isotopes

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

*For example, t*here are a few different atoms of the element Lithium. All atoms of Lithium contain the same number of protons in their nucleus. The difference between these atoms is the number of neutrons.

Since all Lithium atoms have the same number of protons (3), they all have the same atomic number, 3. Since they have different number of neutrons, they each have a different mass number. These different atoms of lithium are *isotopes* of lithium.

Isotopes of the same element must have:

. *Different* mass numbers (nucleons)
. *Different* number of neutrons

. *Same* atomic number
. *Same* number of protons (nuclear charge)
. *Same* number of electrons
. *Same* chemical reactivity

Symbols showing two isotopes of Lithium

7 Li	mass number	**8** Li
3	atomic number	**3**

16. Isotope symbols

Different isotopes of an element have different mass numbers. Therefore, the mass number of an isotope is written next to the element's name (or symbol) to distinguish it from the other isotopes.

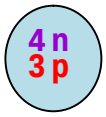
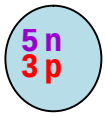
Lithium – 7 and Lithium – 8 are names to two of lithium isotopes. The 7 and the 8 are the mass numbers of these two lithium isotopes.

There are other notations that are used to represent isotopes of elements.

When studying the notations below:

. *Pay attention* to how Lithium-**7** and Lithium-**8** are similar, and also how they are different in each notation

. Also pay attention to how each notation of the same isotope is related to the other notations

Element – **mass number** (isotope's name)	*Lithium* – **7**	*Lithium* – **8**
Symbol – **mass number** notation	*Li* – **7**	*Li* – **8**
Common isotope notation	$^{7}_{3}Li$	$^{8}_{3}Li$
Nuclear diagram notation		

17. Isotope symbols: Practice problems

Concept Task: Be able recognize symbols that are isotopes of the same element.

Practice 24

Which two notations represent isotopes of the same element?

1) $^{40}_{19}K$ and $^{40}_{20}Ca$

2) $^{20}_{10}Ne$ and $^{22}_{10}Ne$

3) $^{23}_{11}Na$ and $^{24}_{12}Na$

4) $^{16}_{8}O$ and $^{17}_{8}N$

Practice 25

Which pair are isotopes of the same element?

1) $^{226}_{91}X$ and $^{226}_{91}X$

2) $^{227}_{91}X$ and $^{227}_{90}X$

3) $^{226}_{91}X$ and $^{227}_{91}X$

4) $^{226}_{90}X$ and $^{227}_{91}X$

Practice 26

Which symbol could represent an isotope of element iron ?

1) $^{55}_{55}Fe$

2) $^{55}_{26}Fe$

3) $^{26}_{55}Fe$

4) $^{26}_{8}Fe$

Practice 27

Which symbol could be an isotope of calcium ?

1) $^{20}_{20}X$

2) $^{40}_{20}X$

3) $^{20}_{40}X$

4) $^{40}_{40}X$

Practice 28

Which two nucleus diagrams are from atoms of the same element?

1) (10 p, 10 n) (11 p, 11 n)

2) (10 p, 11 n) (10 p, 11 n)

3) (18 p, 20 n) (18 p, 22 n)

4) (18 p, 20 n) (20 p, 10 n)

Practice 29

Which two nuclei are isotopes of phosphorous?

1) (15 P, 16 n) (16 p, 15 n)

2) (15 p, 15 n) (15 p, 16 n)

3) (15 p, 15 n) (16 p, 16n)

4) (31 p, 15 n) (15 p, 31 n)

Concept Task: Be able to interpret isotope symbols

Practice 30

The isotope symbol $^{27}_{13}Al$ can also be represented as

1) Aluminum–13

2) Aluminum–14

3) Aluminum–27

4) Aluminum-40

Practice 31

Which nuclide name is correct for the symbol $^{223}_{85}X$

1) Fr – 85

2) Fr – 138

3) Fr – 223

4) Fr – 308

Practice 32

Chlorine – 37 can also be represented as

1) $^{35}_{17}Cl$

2) $^{17}_{35}Cl$

3) $^{37}_{17}Cl$

4) $^{17}_{37}Cl$

Practice 33

Which isotope notation is correct for magnesium -26 ?

1) $^{26}_{26}Mg$

2) $^{12}_{26}Mg$

3) $^{26}_{12}Mg$

4) $^{12}_{12}Mg$

Practice 34

Which diagram correctly represents the nucleus for the isotope symbol $^{59}_{28}X$?

1) (59 p, 28 n)

2) (31 p, 28 n)

3) (28 p, 59 n)

4) (28 p, 31 n)

Practice 35

The nucleus of an atom is shown below:

(45 n, 35 p)

Which isotope symbol correctly represents this atom?

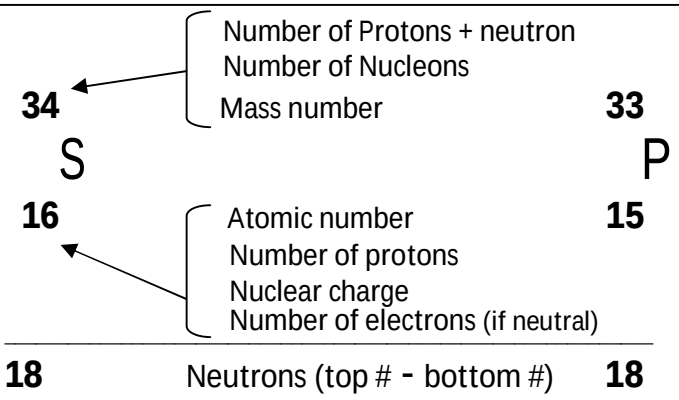
1) $^{35}_{45}Rh$ 2) $^{80}_{45}Rh$ 3) $^{80}_{35}Br$ 4) $^{45}_{35}Br$

18. Determining and comparing particles in Isotope symbols

In any given isotope notations, you should be able to determine and compare the following information.

. Mass number, number of nucleons, and the sum of protons and neutrons
. Atomic number, number of protons, nuclear charge, and number of electrons
. Number of neutrons

Two isotope symbols are given below. Note the differences and similarities in the number of particles between them.



The following comparisons can be made of the two isotope symbols to the left:

$^{34}_{16}S$ has **more nucleons** than $^{33}_{15}P$

$^{33}_{15}P$ has one **fewer proton** than $^{34}_{16}S$

$^{34}_{15}S$ has a **greater nuclear charge** than $^{33}_{16}P$

P-**33** has the **same** number of **neutrons** as S-**34**

19. Determining and comparing particles in Isotope symbols: Practice problems

Concept Tasks: Be able to determine and compare the number of subatomic particles from given isotope notations. *Be sure to utilize the Periodic Table.*

Practice 36
What is the total number of protons and neutrons in the nuclide $^{127}_{53}I$

1) 53 2) 127 3) 74 4) 180

Practice 37
The nucleus of the atom $^{107}_{47}Ag$ contains

1) 60 neutrons, and has a nuclear charge of +47
2) 60 electrons, and has a nuclear charge of +47
3) 47 neutrons, and has a nuclear charge of +107
4) 47 electrons, and has a nuclear charge of +107

Practice 38
What is the structure of of krypton - 85?

1) 49 electrons, 49 protons, and 85 neutrons
2) 49 electrons, 49 protons, and 49 neutrons
3) 36 electrons, 36 protons, and 85 neutrons
4) 36 electrons, 36 protons, and 49 neutrons

Practice 39
The nucleus of chlorine – 35 has

1) 17 protons, and the atom has a mass number of 35
2) 17 electrons, and the atom has a mass number of 35
3) 35 protons, and the atom has a mass number of 17
4) 35 electrons, and the atom has a mass number of 17

Practice 40
An atom of K- 37 and an atom of K – 42 differ in their total number of

1) Electrons 3) Neutrons
2) Protons 4) Positron

Practice 41
Compare to the atom of $^{40}_{20}Ca$, the atom of $^{38}_{18}Ar$ has

1) a greater nuclear charge
2) the same number of nuclear charge
3) greater number of neutrons
4) the same number of neutrons

Practice 42
Which nuclide contains the greatest number of neutrons?

1) ^{207}Pb 2) ^{203}Hg 3) ^{207}Ti 4) ^{208}Bi

Practice 43
Which symbol has the smallest nuclear charge?

1) Cu – 65 3) Zn – 64
2) Ga – 69 4) Ge - 72

Practice 44
In which nucleus is the ratio of protons to neutrons 1 : 1?

1) B – 12 3) C – 13
2) N – 14 4) O – 15

20. Atomic mass unit

Atomic mass unit (amu) is the unit for measuring mass of atoms relative to the mass of carbon – 12.

1 amu = $^{1}/_{12}^{th}$ the mass of ^{12}C

Interpretations:

Hydrogen – **1** (^{1}H) has a mass that is $1/12^{th}$ the mass of ^{12}C

Lithium – **6** (^{6}Li) has a mass that is $6/12^{th}$ or half the mass of ^{12}C

Magnesium – **24** (^{24}Mg) has a mass that is $24/12^{th}$ or 2 times the mass of ^{12}C

Practice 45

Which could have an atom with a mass that is approximately three times that is of C-12 ?

1) O 3) Li

2) Cl 4) Kr

21. Atomic mass

Atomic mass of an element is the average mass of all its naturally occurring stable isotopes.

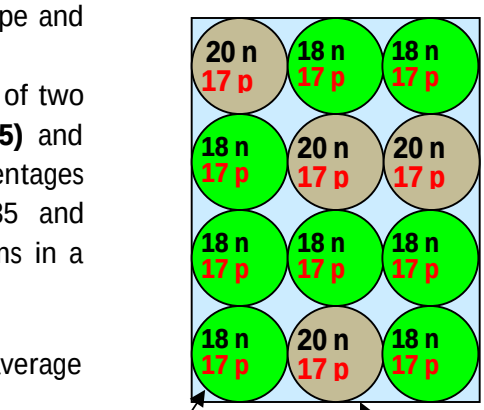
Atomic mass is based on the masses of the stable isotopes and their percent abundance in a sample.

To get a better understanding of what this means, read the explanation below.

A natural sample of an element consists of a mix of two or more isotopes (different atoms). Usually, there is a lot of one isotope and very little of the others.

For an example: a natural sample of chlorine consists mainly of two chlorine isotopes: Chlorine atoms with a mass of 35 **(Cl-35)** and chlorine atoms with a mass of 37 **(Cl-37).** The relative percentages (abundances) of these isotopes are approximately 75% of Cl-35 and 25% of Cl-37. That means three of every four chlorine atoms in a natural sample of chlorine will have a mass of 35 amu.

The atomic mass of Chlorine given on the Periodic Table is the average mass of these two isotopes.



Atomic mass → **35.453** Cl 17

Nucleus of Cl-35 (**3** of 4, or 75% of the nuclei)

Nucleus of Cl-37 (**1** of 4, or 25% of the nuclei **)**

Although the atomic mass of the elements can be found on the Periodic Table, students are often asked to calculate atomic mass of an element from given percentages and mass numbers of its isotopes.

On the next page you will see an example of how to calculate the average atomic mass of an element.

22. Average atomic mass calculation: Example and practice problems

Concept Task: Be able to calculate the average atomic mass of an element given the mass numbers and percent abundances of its isotopes .

Study the steps below.

Example

A natural sample of chlorine contains 75% of ^{35}Cl and 25% of ^{37}Cl. Calculate the atomic mass of chlorine?

	Step 1 *(Change % to decimal)*		***Step 2*** *(multiply by mass #)*		*product*	***step 3*** *(add all products to get **mass**)*
75% of ^{35}Cl	.75	x	35	=	26.25	+ **= 35.5 amu**
25% of ^{37}Cl	.25	x	37	=	9.25	

The above numerical setup (*steps 1 – 3*) can also be written as:

(.75 x 35) + (.25 x 37) = 35. 5 amu

Practice 46

Which statement best explains why most atomic masses on the Periodic Table are decimal numbers?

1) Atomic masses are determined relative to an H–1 standard.
2) Atomic masses are determined relative to an O–16 standard.
3) Atomic masses are a weighted average of the naturally occurring isotopes.
4) Atomic masses are an estimated average of the artificially produced isotopes.

Practice 47

Two isotopes of elements X have average atomic mass of 54 amu. What are the relative percentages of these two isotopes of element X?

1) 80% of ^{50}X and 20% of ^{55}X
2) 20 % of ^{50}X and 80% of ^{55}X
3) 50% of ^{50}X and 50% of ^{55}X
4) 75 % of ^{50}X and 25 % of ^{55}X

Practice 48

A 100.00-gram sample of naturally occurring boron contains 19.78 grams of boron-10 (atomic mass = 10.01 amu) and 80.22 grams of boron-11 (atomic mass = 11.01 amu). Which numerical setup can be used to determine the atomic mass of naturally occurring boron?

1) (0.1978)(10.01) + (0.8022)(11.01)
2) $\frac{(0.1978)\,(10.01)}{(0.8022)\,(11.01)}$
3) (0.8022)(10.01) + (0.1978)(11.01)
4) $\frac{(0.8022)\,(10.01)}{(0.1978)\,(11.01)}$

Practice 49

Element X has two naturally occurring isotopes. If 72% of the atoms have a mass of 85 amu and 28% of the atoms have a mass of 87 amu, what is the atomic mass of element X. Show numerical setup and the calculated result.

Practice 50

Show the numerical setup and the calculated atomic mass of silicon given the following three natural isotopes.

92.23% ^{28}Si

4.67% ^{29}Si

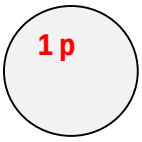
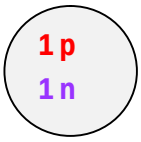
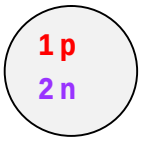
3.10% ^{30}Si

23. Isotopes of hydrogen:

Element hydrogen has three main isotopes: protium, deuterium, and tritium

As with all isotopes, these three isotopes of hydrogen differ in their numbers of neutrons.

Names, symbol notations and nuclear diagrams of these isotopes are shown below.

	Isotopes of hydrogen		
	Protium	*Deuterium*	*Tritium*
Nuclide name	Hydrogen-**1** (H-**1**)	Hydrogen-**2** (H-**2**)	Hydrogen-**3** (H-**3**)
Isotope symbol	$^{1}_{1}H$	$^{2}_{1}H$	$^{3}_{1}H$
Mass number	**1**	**2**	**3**
Protons (atomic number)	1	1	1
Neutrons	0	1	2
Nuclear diagram			

Protium

Hydrogen-1 atom has the most basic atomic structure of all atoms. It is composed of 1 proton and 1 electron. It is the only atom without a neutron in its nucleus. When H-1 loses its only electron, the hydrogen ion (H+) that forms is just a proton.

A sample of hydrogen is composed almost entirely (about 99.9%) of protium (H-1). Only traces of deuterium (H-2) and tritium (H-3) would be found in a natural sample of hydrogen.

The H-1 is the main hydrogen isotope found in water ($^{1}H_2O$).

Deuterium.

In a sample of water, there will be traces of $^{2}H_2O$ *molecules*. This is called *heavy water* because the molecule is composed of the heavier hydrogen atom, deuterium. Heavy water is commonly used in nuclear power plants to cool down the reactors.

Tritium

Tritium's main application is also in nuclear reactions. It is the most commonly used reactant in nuclear fusion. A tritium atom can fuse (join) with another hydrogen isotope to form a helium atom, and a release of a tremendous amount of nuclear energy.

LOOKING Ahead ⇨ Topic 12-Nuclear chemistry: You will learn about nuclear fusion.

Lesson 3 – Electrons location and arrangements

Introduction

According to the wave-mechanical model of atoms, electrons are found in orbitals outside the nucleus.

An **orbital** is the most probable region outside the nucleus where an electron is likely to be found.

The orbital of an electron depends on the energy of the electron. Some electron of an atom may have enough energy to occupy an orbital far from the nucleus, other electrons of the atom may have just enough energy to occupy regions closer to the nucleus. The result is the formation of energy levels (or electron shells) around the nucleus of the atom.

The **Bohr's atomic model** is often used to show arrangement of electrons in electron shells (energy levels) of an atom. Each electron shell in Bohr's atomic model corresponds to a specific amount of energy of the electrons occupying that shell.

Arrangement of electrons in atoms is complex. In this lesson, you will learn the basic and simplified arrangements of electrons in electron shells. You will also learn of electron transition (movement) from one level to another, and the production of spectral lines.

24. Electron shells and electron configurations

Electron shells refer to the energy levels of electrons of an atom.

Electron configuration shows how electrons are arranged in the electron shells of an atom.

Concept Facts: Study to remember the followings about electron shells

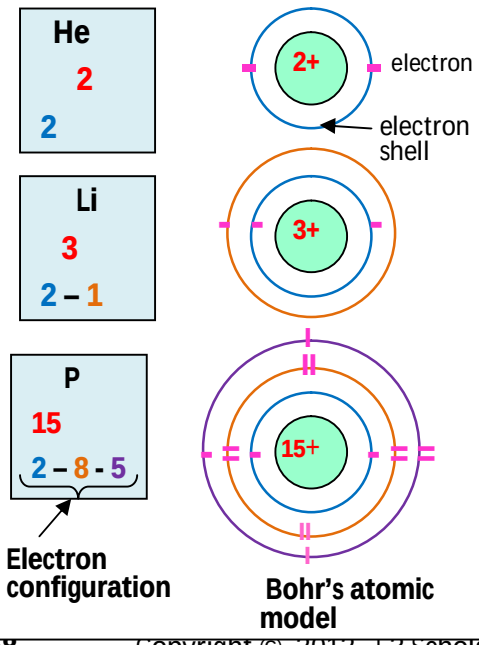
. An atom may have one or more electron shells

. The electron shell (1st) closest to the nucleus always contains electrons with the least amount of energy

. The electron shell farthest from the nucleus contains electrons with the most amount of energy

. On the Periodic Table, the Period (horizontal row) number indicates the total number of electron shells in the atoms of the elements

A Bohr's atomic model (shell diagram**)** can be drawn to show electrons in the electron shells of an atom. Below, Bohr's atomic models for three atoms are drawn using information from the Periodic Table.



According to the electron configuration, a helium atom has all its electrons in **ONE** electron shell:

- **1st** shell: **2** electrons

According to the electron configuration, a lithium atom has all its electrons in **TWO** electron shells:

- **1st** shell: **2** electrons (electrons with lowest energy)
- **2nd** shell : **1** electron (electron with greatest energy)

According to the electron configuration, a phosphorous atom has all its electrons in **THREE** electron shells:

- **1st** shell: **2** electrons (electrons with least energy)
- **2nd** shell : **8** electrons (electrons with a little more energy)
- **3rd** shell : **5** electrons (electrons with greatest energy)

25. Electron Configurations

Concept Task: Be able to interpret electron configurations

Study the electron configuration below.

2 – 8 – 8 – *1*

1st 2nd 3rd 4th

ELECTRON SHELLS

The configuration shows:

4 electron shells (the atom is of a **4th** Period element)
1st shell is the shell containing electrons with lowest energy
4th shell is the shell containing electrons with greatest energy
4th shell is the valance (outermost) shell
1 is the number of valance electrons
19 is the total number of electrons (2 + 8 + 8 + 1 = 19)

Practice 51
How many electron shells containing electrons are found in an atom of strontium?
1) 2 2) 5 3) 18 4) 38

Practice 52
The total number of electron shells in the configuration 2 – 8 – 1 is
1) 1 2) 2 3) 3 4) 11

Practice 53
In which electron shell would an electron with the most energy be found in an atom of astatine?
1) 2 2) 6 3) 7 4) 18

Practice 54
Which electron configuration is of an atom with three electron shells?
1) 2 – 1
2) 2 - 3
3) 2 – 8 - 8
4) 2 – 8 – 18 – 3

Practice 55
Which of these atoms in the ground state has the most number of electron shells containing electrons?
1) Cs-132
2) I - 127
3) Xe - 134
4) Na - 23

Practice 56
In the electron configuration below,
2 – 8 – 3 – 1
Which shell contains electrons with the greatest energy?
1) 1st 2) 2nd 3) 3rd 4) 4th

Practice 57
In a bromine atom in the ground state, the electrons that has the least amount of energy are located in the
1) First electron shell
2) Second electron shell
3) Third electron shell
4) Fourth electron shell

Practice 58
How do the energy and the most probable location of an electron in the third shell of an atom compare to the energy and the most probable location of an electron in the first shell of the same atom?
1) In the third shell, an electron has more energy and is closer to the nucleus.
2) In the third shell, an electron has more energy and is farther from the nucleus.
3) In the third shell, an electron has less energy and is closer to the nucleus.
4) In the third shell, an electron has less energy and is farther from the nucleus.

Practice 59
How many electrons are in the 4th electron shell of a neutral zirconium atom ?
1) 2 2) 5 3) 8 4) 10

Practice 60
The total number of electrons in the configuration 2 – 8 – 17 – 2 is
1) 4 2) 2 3) 29 4) 11

Practice 61
What is the total number of valence electrons in a germanium atom in the ground state?
1) 8 2) 2 3) 14 4) 4

Practice 62
Which element has a total of 5 valance electrons present in the fifth shell?
1) Sb 2) Bi 3) I 4) Br

Practice 63
Which set of symbols represents atoms with valence electrons in the same electron shell?
1) Ba, Br, Bi
2) Sr, Sn, I
3) O, S, Te
4) Mn, Hg, Cu

26. Maximum number of electrons in an electron shell : Practice problems

Each electron shell has the maximum number of electrons that can occupy that shell.
If **n** represents the electron shell in question: For example: n = 1 means the 1st shell, n= 3 means 3rd shell .

Maximum number of electrons in a shell = $2(n)^2$ Square the electron shell in question, then multiply by 2

Concept Task: Be able to determine maximum number of electrons in any given electron shell

Example

What is the maximum number of electrons that can occupy the third shell of an atom?

For third shell: **n = 3**
Maximum e- = $2(n)^2 = 2(3)^2 = 2(9) = 18$ electrons in 3rd

Practice 64
What is the maximum number of electrons that can occupy the second energy level of an atom?
1) 2 2) 8 3) 7 4) 17

Practice 65
What is the most number of electrons that can be found in the 4th energy level of an atom?
1) 2 2) 8 3) 18 4) 32

Practice 66
Which electron shell of an atom can hold a maximum of 72 electrons?
1) 7th shell
2) 6th shell
3) 5th shell
4) 4th shell

27. Completely and partially filled shells: Example and practice problems

An electron shell (n) is completely filled if it has the maximum number of electrons according to the equation $2(n)^2$. A partially or an incompletely filled shell, therefore, has less than the maximum number of electrons that can occupy that shell.

Concept Task: Be able to determine an atom with a completely or partially filled electron shell

Example
Which of these elements has a completely filled third electron shell?
1) Al 2) Ca 3) Ar 4) Kr

Note their electron configurations (use Periodic Table)

Al	Ca	Ar	Kr
2 – 8 – 3	2 – 8 – 8 – 2	2 – 8 – 8	2 – 8 – **18** – 8

Note:
18 is the maximum number of e- in the third shell.
(see example above)

An atom with a completely filled third shell must have 18 in the third spot of its configuration.

Choice 4: Of the the four choices, only Kr has 18 electrons in the third shell

Practice 67
Which of these ground state electron configurations is of an atom with two partially filled electron shells?
1) 2 – 8 – 8 – 1
2) 2 – 8 – 18 – 7
3) 2 – 8 – 18 – 2
4) 2 – 8 – 2

Practice 68
Which element has an incomplete 4th electron shell?
1) Hg 2) Rn 3) Cs 4) W

Practice 69
An atom of which element in the ground state has a partially filled second electron shell ?
1) Hydrogen
2) Potassium
3) Lithium
4) Sodium

Practice 70
Which Period 5 atom in the ground state has a half-filled fourth shell?
1) Rh 2) Tc 3) Y 4) Rb

28. Ground state, Excited state, and Spectral lines

An atom is most stable when its electrons occupy the lowest available electron shells. When this is the case, the atom is said to be in the **ground state.** When one or more electrons of an atom occupy a higher energy level than they should, the atom is said to be in the **excited state**. The electron configurations given for all the elements on the Periodic Table are of atoms in the ground state. This means that each configuration on the Periodic Table shows electrons of the atoms filling from the lowest to the highest electron shells.

Below are definitions and facts related to ground and excited state atoms and spectral lines

Concept Facts: Study to remember the followings

Ground state

When an atom is in the ground state:

. Electron configuration is the same as given on the Periodic Table

. Electrons are filled in order from lowest to highest energy shells

. The energy of the atom is at its lowest, and the atom is stable

. An electron in a ground state atom must absorb energy to go from a lower level to a higher level

. As an electron of a ground state atom absorbs energy and moves to the excited state, the energy of the electron and of the atom increases

N
7
2 – 5

Ground state configuration for Nitrogen.

Same as on the Periodic Table

Excited state:

When an atom is in the excited state:

. Electron configuration is different from that of the Periodic Table

. The energy of the atom is at its highest , and the atom is unstable

. An electron in the excited state atom must release energy to return from a higher level to a lower level

. As an electron in the excited state atom releases energy to return to the ground state, the energy of the electron and of the atom decreases.

. *Spectrum of colors* are produced when excited electrons release energy and return to the ground state

N
7
2 – 4 – 1
1 – 6

Two possible excited state configurations for Nitrogen.

NOTE:

Configurations are different from that of the Periodic Table for Nitrogen

BUT

the total number of electrons in each excited state configuration is still **7**

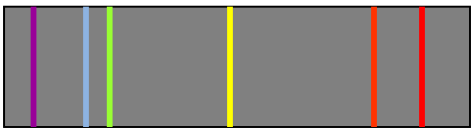
Quanta is a discrete (specific) amount of energy absorbed or released by an electron to go from one level to another.

Spectral lines:

Spectral lines are band of colors produced when the energy released by excited electrons is viewed through a spectroscope.

. Spectral lines are produced from energy released by excited electrons as they returned to the ground state

. Spectral lines are called "fingerprints' of the elements because each element has its own unique patterns (wavelength of colors)



Spectral lines (bright-line spectra)

29. Excited and Ground State: Examples and practice problems

Concept Task: Be able to determine which electron configuration is of an atom in the ground or excited state. Be sure to utilize the Periodic Table.

Examples:

2 – 8 – 5 is the ***ground state*** configuration for P

2 – 7 – 6 is an e***xcited state*** configuration for P

Practice 71

Which is the ground state configuration for a chlorine atom?

1) 2 – 8 – 7 – 1
2) 2 – 8 – 8 – 1
3) 2 – 8 – 8 – 7
4) 2 – 8 – 6 – 1

Practice 72

What is the ground state electron configuration of a neutral atom with 27 protons?

1) 2 – 8 – 14 – 3
2) 2 – 8 – 8 – 8 – 1
3) 2 – 8 – 15 – 2
4) 2 – 8 – 17

Practice 73

Which electron configuration is possible for a strontium atom in the excited state?

1) 2 – 8 – 18 – 10
2) 2 – 8 – 18 – 7 – 3
3) 2 – 8 – 18 – 8 – 1
4) 2 – 8 – 18 – 8 – 2

Practice 74

Which is an excited state electron configuration for a neutral atom with 16 protons and 18 neutrons?

1) 2 – 8 – 5 – 1
2) 2 – 8 – 8
3) 2 – 8 – 6 – 2
4) 2 – 8 – 6

Practice 75

The electron configuration 2 – 8 – 2 is of a

1) Sodium atom in the ground state
2) Magnesium atom in the ground state
3) Sodium atom in the excited state
4) Magnesium atom in the excited state

Practice 76

The electron configuration 2–8–18–5–1 could be of

1) an arsenic atom in the ground state
2) an arsenic atom in the excited state
3) a selenium atom in the ground state
4) a selenium atom in the excited state

Practice 77

The electron configuration 2 – 8 – 18 – 2 – 1 is of

1) Ga atom in the excited state
2) Al atom in the excited state
3) Ga atom in the ground state
4) Al atom in the ground state

30. Spectral lines: Example and practice problems

Concept Task: Be able to determine which electron transition will produce spectral lines.

Note:

Electron transition from:

Low to **higher** shell

Ex: 5^{th} shell to 6^{th} shell

. Energy is absorbed (gained) by the electron

. Energy of the atom increases

High to **Lower** shell

Ex: 6^{th} shell to 5^{th} shell

. Energy is released (emitted) by the electron

. Produces bright-line spectrum (spectra) of colors

. Energy of the atom decreases

NOTE:

The greater the difference between the two electron shells, the more energy is absorbed or released.

Practice 78

As an electron moves from 3^{rd} electron shell to the 4^{th} electron shell, the energy of the atom

1) Increases as the electron absorbs energy
2) Increases as the electron releases energy
3) Decreases as the electron absorbs energy
4) Decreases as the electron releases energy

Practice 79

Electron transition between which two electron shells will produce bright-line spectrum of colors?

1) 2^{nd} to 3^{rd}
2) 3^{rd} to 4^{th}
3) 1^{st} to 4^{th}
4) 2^{nd} to 1^{st}

Practice 80

As an electron in an atom moves between electron shells, which transition would cause the electron to absorb the most energy?

1) 1^{st} to 2^{nd}
2) 2^{nd} to 1^{st}
3) 2^{nd} to 4^{th}
4) 4^{th} to 2^{nd}

31. Flame test and spectral chart

Flame test is a lab procedure in which compounds of metallic ions are heated to produce different flame colors.

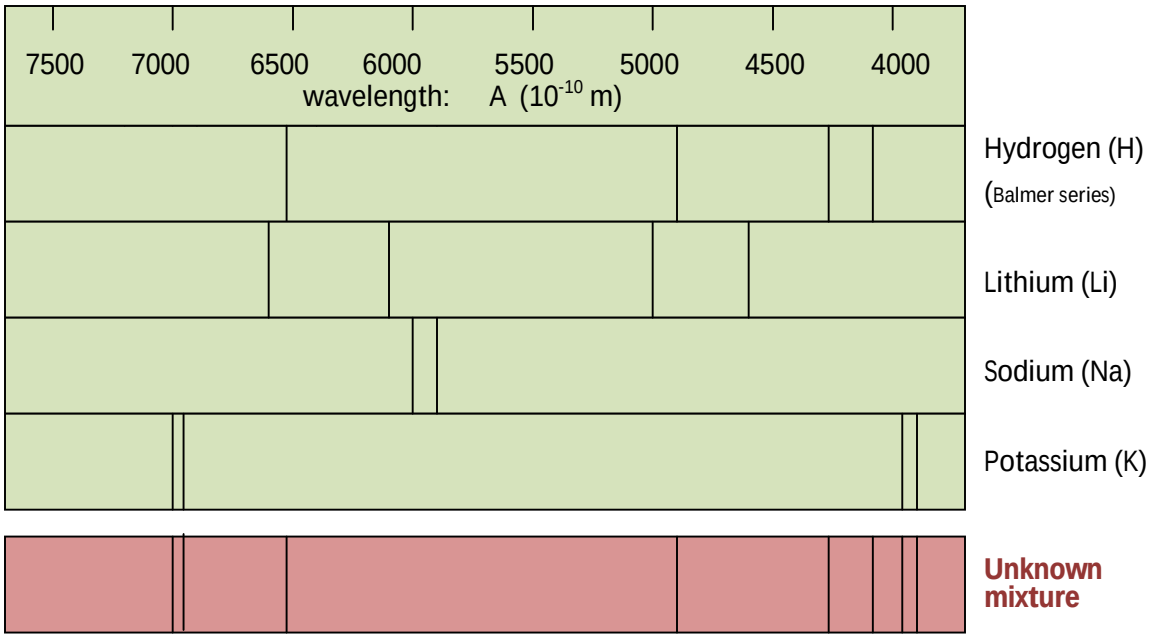
. Flame colors produced are due to the energy released by excited electrons in the metal atoms as they return from high (excited) state to low (ground) state

. Flame colors produced can be used to identify the metal ions present in the substances. However, since two or more metallic ions can produce flame colors that are similar, flame test results are not very reliable for identification.

Spectroscope is equipment that is used to separate a light into color patterns (spectrum of colors) at different wavelengths. Color flames produced during flame tests can be viewed through a spectroscope. The bright-line spectra of each color flame will be unique to each metallic ion, and will provide a more reliable result for identification.

A chart showing bright-line spectra for hydrogen, lithium, sodium and potassium is shown below.

Bright-line spectra of an unknown mixture was compared to those of H, Li, Na and K. Substances in the unknown can be identified by matching the lines in the unknown to the lines for H, Li, Na and K.



Concept Task: Be able to interpret spectral lines chart

Practice 81

Which elements are in the unknown substance?

1) H and Na 2) K and Li 3) H and K 4) K and Na

Practice 82

Which element produces bright line spectra with the following wavelengths:

6600 x10^{-10} A, 6100 x 10^{-10} A, 5000 x 10^{-10} A and 4600 x 10^{-10} A

1) H 2) Li 3) Na 4) K

Lesson 4 – Valance electrons and ions

Introduction:

Most atoms (with the exception of the noble gases) are unstable because they have incomplete valance (outermost) electron shells. For this reason, most atoms need to lose, gain or share electrons to fill their valance shell so they can become stable. When an atom loses or gains electrons, it forms an ion.

In this lesson, you will learn about valance electrons, neutral atoms and ions.

LOOKING Ahead ⇨ Topic 4: Chemical Bonding. You will learn more about the role of valance electrons in chemical bonding.

32. Valance electrons

Valance electrons are electrons in the outermost electron shell of an atom. Valance shell of an atom is the last (outermost) shell that contains electrons.

Recall: Elements in the same Group (vertical column) of the Periodic Table have the same number of valance electrons, and similar chemical reactivity.

Concept Task: Be able to determine the number of valance for any atom or a given configuration.
In any electron configuration, the last number is always the number of valance electrons.

P
15
2 – 8 – 5

LOOK on the Periodic Table for Phosphorous:
The configuration for phosphorous is : 2 – 8 – **5**
The last number is **5**.
Phosphorous has **5** valance electrons in its valance (third) shell.

33. Ions (charged atom) and neutral atoms

For most atoms, a completely filled valance shell must have eight (8) electrons.
NOTE: H and He need only two (2) to fill their valance shell.
A neutral atom may lose its entire valance electrons to form a new valance shell that is completely filled.
A neutral atom may also gain electron(s) to fill its valance shell.
An Ion is formed when a neutral atom loses or gains electrons.
Below, definitions and facts related to neutral atoms and ions

Concept Facts: Study to remember these facts.

Neutral atom
. A neutral atom has equal number of protons and electrons
. The electron configurations given on the Periodic Table are for neutral atoms of the elements in the ground state

Ion
. An ion is a charged atom with unequal number of protons to electrons
. An ion is formed when an atom loses or gains electrons

Positive ion
. A positive ion is a charged atom containing *fewer* electrons (-) than protons (+)
. A positive ion is formed when a neutral atom loses one or more electrons
. Metals and metalloids tend to lose electrons and form positive ions

Negative ion
. A negative ion is a charged atom containing *more* electrons (-) than protons (+)
. A negative ion is formed when a neutral atom gains one or more electrons
. Nonmetals tend to gain electrons and form negative ions

Symbols of neutral atoms and ions	
Na	a neutral sodium atom
S	a neutral sulfur atom
Na^+	a positive sodium ion
S^{2-}	a negative sulfide ion

34. Ion vs. neutral atom

When electrons are lost or gained by a neutral atom, the ion formed will be different in many ways from the neutral atom. Number of electrons, electron configuration, size, as well as properties of the ion will all be different from that of the neutral atom.

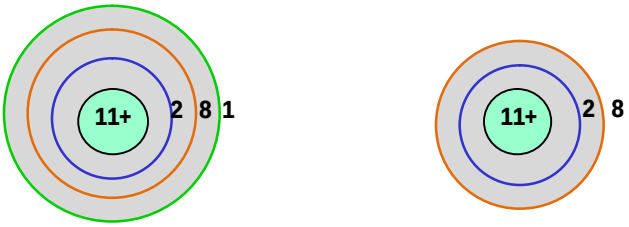
The following note summarizes the comparisons between positive and negative ions to their parent neutral atoms.

Concept Facts: Study to learn these comparisons.

Comparing a positive ion to its neutral (metallic) atom.
When a neutral atom (usually a metal or metalloid) loses its valance electron(s):

. The positive ion has *fewer* electrons than the parent neutral atom
. The positive ion electron configuration has one fewer electron shell than the neutral atom
. As the neutral atom loses electrons, its size (atomic radius) decreases
. Ionic radius (size) of a positive ion is always smaller than the atomic radius of the neutral atom
. The positive ion has a different chemical reactivity than the neutral atom

Below, Bohr's diagrams showing size comparison of a neutral Na atom to Na^+ ion.



Na (atom)	symbols	Na^+ (ion)
11+	protons	11+
11 e-	electrons	10 e-
2 – 8 – 1	electron configurations	2 – 8

Comparing a negative ion to its neutral (nonmetallic) atom.
When a neutral atom (usually a nonmetal) gains electrons to fill its valance shell:

. The negative ion has *more* electrons than its parent neutral atom
. The negative ion electron configuration has the same number of electron shell as the neutral atom
. As the neutral atom gains electrons, its size (atomic radius) increases
. Ionic radius (size) of a negative ion is always larger than the atomic radius of the neutral atom
. The negative ion has a different chemical reactivity than the neutral atom

Below, Bohr's diagrams showing size comparison of a neutral S atom to S^{2-} ion

S (atom)	symbols	S^{2-} (ion)
16 +	protons	16 +
16 e-	electrons	18 e-
2 – 8 – 6	electron configurations	2 – 8 - 8

NOTE: Electron configuration of an ion is similar to that of the nearest Group 18 Noble gas element.

Sulfur is Atomic # 16

Argon, atomic # 18, is the closest noble gas to Sulfur.

The configuration of a sulfur ion (2 – 8 – 8) is the same as that of Argon. (Look on the Periodic Table to confirm)

35. Ions: Examples and practice problems

Concept Task: Be able to determine number of electrons and electron configuration of ions.

Number of electrons in ion = Atomic # - Charge
= Protons - Charge

Charge of an ion = protons - electrons

Electron configuration of an ion **is** similar to that of the nearest noble gas atom.

Concept Task: Be able to recognize the correct comparisons between ion and atom.

Examples:

Na^+ ion has 1 ***FEWER*** electron than Na atom

S atom is ***SMALLER*** than S^{2-} ion.

Practice 83
The total number of electrons in a Br^- ion is
1) 36 2) 35 3) 34 4) 54

Practice 84
How many electrons are in a N^{2-} ion?
1) 7 2) 9 3) 10 4) 5

Practice 85
What is the total number of electrons in a Cr^{3+} ion?
1) 3 2) 21 3) 24 4) 27

Practice 86
How many electrons will be found in a particle with a nuclear charge of +41 and a +5 charge?
1) 41 2) 46 3) 205 4) 36

Practice 87
An atom has a nuclear charge of +50 and 46 electrons. The net ionic charge of this atom is
1) +46 2) -46 3) -4 4) +4

Practice 88
An atom has a nuclear charge of +7, 10 electrons, and 8 neutrons. What is the ionic charge of this atom?
1) +7 2) -1 3) -3 4) +3

Practice 89
Which electron configuration is correct for B^{3+} ion?
1) 2 – 2 – 1 2) 2 – 2 – 1 3) 2 – 3 4) 2

Practice 90
Which is the correct electron configuration for Ca^{2+}?
1) 2 – 8 – 2
2) 2 – 8
3) 2 – 8 – 8
4) 2 – 6 – 1 – 1

Practice 91
The electron configuration for As^{3-} is
1) 2 – 8 – 18 – 5
2) 2 – 8 – 18 – 8
3) 2 – 8 – 17 – 6
4) 2 – 8 – 18 – 5 – 3

Practice 92
The electron configuration 2 – 8 – 18 – 8 could represent which particle?
1) Ca^{2+} 2) Ge^{4+} 3) Cl^- 4) Br^{5+}

Practice 93
Which changes occur as an atom becomes a positively charge ion?
1) The atom gains electrons, and the number of protons increases
2) The atom gains electrons, and the number of protons remains the same
3) The atom loses electrons, and the number of protons decreases
4) The atom loses electrons, and the number of protons remains the same

Practice 94
Compared to a phosphorus atom, a P^{3-} ion has
1) More electrons and a larger radius
2) More electrons and a smaller radius
3) Fewer electrons and a larger radius
4) Fewer electrons and a smaller radius

Practice 95
A neutral oxygen atom (O) differs from an ion of oxygen (O^{2-}) in that the atom has
1) More protons
2) More electrons
3) Fewer protons
4) Fewer electrons

Practice 96
Which changes occur as a cadmium atom, Cd, becomes a cadmium ion, Cd^{2+}?
1) The Cd atom gains two electrons and its radius decreases.
2) The Cd atom gains two electrons and its radius increases.
3) The Cd atom loses two electrons and its radius decreases.
4) The Cd atom loses two electrons and its radius increases.

Practice 97
How does the size of N^{3-} ion compares to N atom?
1) N^{3-} is bigger than N because the N^{3-} has 3 more electrons
2) N^{3-} is bigger than N because the N^{3-} has 3 fewer electrons
3) N^{3-} is smaller than N because the N^{3-} has 3 more electrons
4) N^{3-} is smaller than N because the N^{3-} has 3 fewer electrons

Concept Terms

Key vocabulary terms and concepts from Topic 3 are listed below. You should know definition and facts related to each term and concept.

1. Atom
2. Hard sphere model
3. Plum-pudding model
4. Empty space model
5. Bohr's atomic model
6. Wave mechanical model
7. Gold foil experiment
8. Cathode ray experiment
9. Orbital
10. Nucleus
11. Neutron
12. Proton
13. Electron
14. Nucleon
15. Nuclear charge
16. Atomic number
17. Mass number
18. Atomic mass
19. Atomic mass unit
20. Isotope
21. Electron shell
22. Electron configuration
23. Ground state
24. Excited state
25. Flame test
26. Spectral lines (bright line spectrum)
27. Balmer series
28. Valance electron
29. neutral atom
30. Ion
31. Positive ion
32. Negative ion
33. Ionic configuration
34. Ionic radius

Concept Tasks

Concept tasks from Topic 3 are listed below. You should know how to solve problems and answer questions related to each concept task.

1. Determining and comparing number of one subatomic particle to another
2. Determining or recognizing which two symbols are of isotopes of the same element
3. Determine number of subatomic particles from a given isotope notation
4. Comparing number of subatomic particles of two given isotope symbols
5. Calculating average atomic mass from mass numbers and percentages of isotopes
6. Drawing Bohr's atomic model from electron configuration
7. Determine number of electron shells in an atom or a configuration
8. Determining the electron shell containing electrons with highest or lowest energy.
9. Determining number (or total number) of electrons in any electron shell of an atom or configuration
10. Determining electron transition between electron shells that will produce spectral lines
11. Interpreting electron transition between electron shells
12. Determining and interpreting electron configuration in ground or excited state.
13. Interpreting spectral lines chart
14. Determining and comparing number particles between an ion and the neutral atom.
15. Determining number of electrons and/or protons of an ion.
16. Determining the correct charge of an atom from number of protons and electrons
17. Determining and interpreting ionic configuration

Answers to Practice Questions

Topic 3 - The Atomic Structure

1. 1	**17.** 2	**33.** 3	**49.** 85.56 amu	**65.** 4	**81.** 3
2. 1	**18.** 1	**34.** 4	**50.** 28.1087 amu	**66.** 2	**82.** 2
3. 4	**19.** 4	**35.** 3	**51.** 2	**67.** 1	**83.** 1
4. 3	**20.** 2	**36.** 2	**52.** 3	**68.** 3	**84.** 2
5. 2	**21.** 3	**37.** 1	**53.** 2	**69.** 3	**85.** 3
6. 2	**22.** 4	**38.** 4	**54.** 3	**70.** 1	**86.** 4
7. 3	**23.** 1	**39.** 1	**55.** 1	**71.** 3	**87.** 4
8. 1	**24.** 2	**40.** 3	**56.** 4	**72.** 4	**88.** 3
9. 3	**25.** 3	**41.** 4	**57.** 1	**73.** 2	**89.** 4
10. 4	**26.** 2	**42.** 3	**58.** 2	**74.** 1	**90.** 3
11. 1	**27.** 2	**43.** 1	**59.** 4	**75.** 2	**91.** 2
12. 2	**28.** 3	**44.** 2	**60.** 3	**76.** 4	**92.** 2
13. 2	**29.** 2	**45.** 2	**61.** 4	**77.** 1	**93.** 4
14. 3	**30.** 3	**46.** 3	**62.** 1	**78.** 1	**94.** 1
15. 3	**31.** 3	**47.** 2	**63.** 2	**79.** 4	**95.** 4
16. 3	**32.** 3	**48.** 1	**64.** 2	**80.** 3	**96.** 3
					97. 1

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