4. Ways of Representing Atoms

A- <u>Placing Electrons in Energy Levels (Shells) = Bohr-Rutherford Model</u>

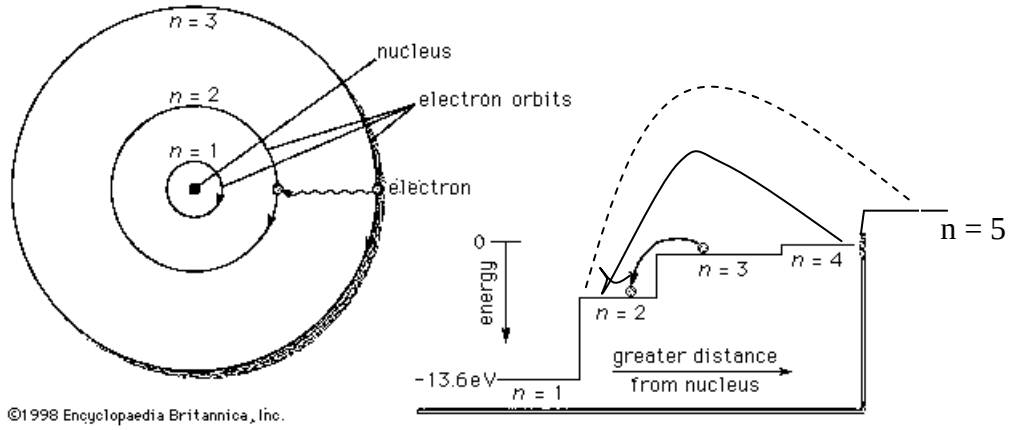


Figure 1: *The Bohr atom.* The electron travels in circular orbits around the nucleus. The orbits have quantized sizes and energies. Energy is emitted from the atom when the electron jumps from one orbit to another closer to the nucleus. Shown here is the first Balmer transition, in which an electron jumps from orbit $n = 3$ to orbit $n = 2$, producing a photon of red light with an energy of 1.89 eV and a wavelength of 656×10^{-9} m.
Encyclopædia Britannica, Inc.

The Hydrogen Spectrum

It was shown by Bohr and others that electrons occupy different energy levels around the nucleus of the atom. <u>For the first twenty elements</u>:

1) The maximum number of electrons in the first shell is 2
2) The maximum number of electrons in the second shell is 8
3) The maximum number of electrons in the third shell is 8 (for elements past atomic number twenty, this is no longer true.)

Examples: Draw an atom for each of the following elements according to the **Bohr-Rutherford Model.**

a) He

b) C

c) **Mg**

d) **K**

B-Lewis Structures

Because chemical reactions only involve valence electrons (last shell electrons), we often use Lewis structures in which dots are used to represent only the valence electrons of an atom.

Examples:

a) **He**

b) **C**

c) **Mg**

d) **K**

Exercises:

1. Draw an atom for each of the following elements according to the Bohr-Rutherford Model.
   a) H
   b) N
   c) Na
   d) Ca
   e) O

2. Draw a Lewis structure for each of the following.

   a) H
   b) N
   c) Na
   d) Ca
   e) O

3. How did Bohr realize that electrons belonged to different energy levels?

5. Ions

An ion is a charged atom. Atoms develop charges from either gaining or losing electrons.

The second period (second row) non metal elements follow ***the octet rule***. That means they try to gain or share electrons so that they end up with a valence of 8.

Example 1: Complete the following table:

Periodic group number	**IA** **Alkali Metals**	**IIA** **Alkaline Earths**	**IIIA**	**IVA**	**VA**	**VIA** **Chalcogens**	**VIIA** **Halogens**	**VIIIA** **Noble Gases**
element	Li	Be	B	C	N	O	F	Ne
valence								
Tendency with electrons								
Common charge								

Example 2: Give the total number of electrons in the following and describe how the neutral atom became that way:

a) Cl^-

b) Na^+

c) Fe^{+2}

d) Al^{+3}

e) S^{-2}

Exercises:

1. Give the total number of electrons in the following and describe how the neutral atom became that way.

   a) F^{-}

   b) K^{+}

   c) Cu^{+2}

   d) B^{+3}

   e) O^{-2}

2. Complete the following table:

Element	Bohr Rutherford Model	Lewis Notation
H		
H^{+}		
P		
P^{-3}		
Ca		
Ca^{+2}		

6. The Periodic Table

The periodic table is organized in sections, each of which reveals something about the character of the elements.

A. For example, the vertical columns consist of groups or families of elements. These have similar chemical properties because of similar valence numbers.

B. The periods are horizontal rows. These elements have atoms with valence electrons that belong to the same shell. There are also patterns of behavior that change along the period.

C. The periodic table also divides elements in to metals, metalloids, non-metals and noble gases.

A- Periodic Table Families or Groups

Family	Members	Valence Number[1]	Common ion formed	Physical properties	Chemical properties
Alkali metals 	Li, Na, K, Rb, Cs, Fr	1	+1		
Alkaline earth metals 	Be, Mg, Ca, Sr, Ba, Ra	2	+2		

[1] **= number of electrons found in last shell or energy level. (need not be memorized: just count number of horizontal blocks in periodic table from left to right, until you get to that element.)**

Halogens 	F, Cl, Br, I, At	7	-1		
Noble or "Inert gases" 	He, Ne, Ar, Kr, Xe, Rn	8	0		

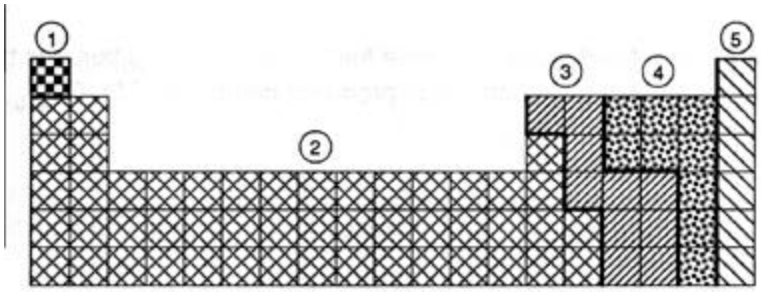
B. <u>Periods</u>

<u>Examples</u>:

1. What are the elements of period 2?

2. An element is in group IIa and is in the third period. What is its atomic number?

C. Metals, Metalloids, Non-metals, and Noble Gases



Example 1: Above is part of the periodic table. What do the five numbers correspond to?

Example 2: Complete the following table

Grouping	**Examples**	**Location**	**Physical Properties**	**Chemical Properties**
Metals	*Alkali metals, alkaline earth metals, transition metals (Sc,Ti, V etc)*	With exception of H and metalloids, all elements to the LEFT of "staircase". (step-like boundary on top of elements with atomic numbers 13,32,51 and 84.)		
Metalloids	*B, Si, Ge, As, Sb, Te, Po:*	With exception of Al, elements that border the staircase (jagged line in periodic table)		

Nonmetals	*N, O, S, P,* *Cl, Br, Se* *etc*	With exception of metalloids and noble gases, elements to the right of the staircase.		
Noble Gases	*He, Ne, Ar,* *Kr, Xe, Rn*	Last column of the periodic family		

3. List four differences between metals and nonmetals.

Metals	**Nonmetals**

4. Why are noble gases *not* classified as nonmetals?

4. List the similarities and differences between metalloids and metals.

Exercises

1. What is a metal? Give two examples.

2. Most elements between the staircase and the noble gases are non-metals. What is a non-metal? Give two examples.

3. What name is given to the elements: B, Si, Ge, As, Sb, and Po?

4. Indicate what kind of ion is formed by the following

   a. Alkali metals form ____
   b. Alkaline earths form ____
   c. Aluminum forms____
   d. copper forms(+) or (-) (choose one)

5. Because metals try to get rid of electrons, they generally do not react with each other. True?

6. a. Fill in the blank: Most metals, however, will react with_____ to form ionic compounds.
   b. Why?

7. In the laboratory, you are given what is supposedly a solid metalloid.

   In order to verify that this solid is, in fact, a metalloid:

   - list three observations or tests you could use;
   - describe a possible result for each observation or test if it is a metalloid;
   - write a conclusion proving that this solid is a metalloid.

8. Four elements from the periodic table are described below.

W It reacts violently with water.

Its electrons are distributed among three energy levels.

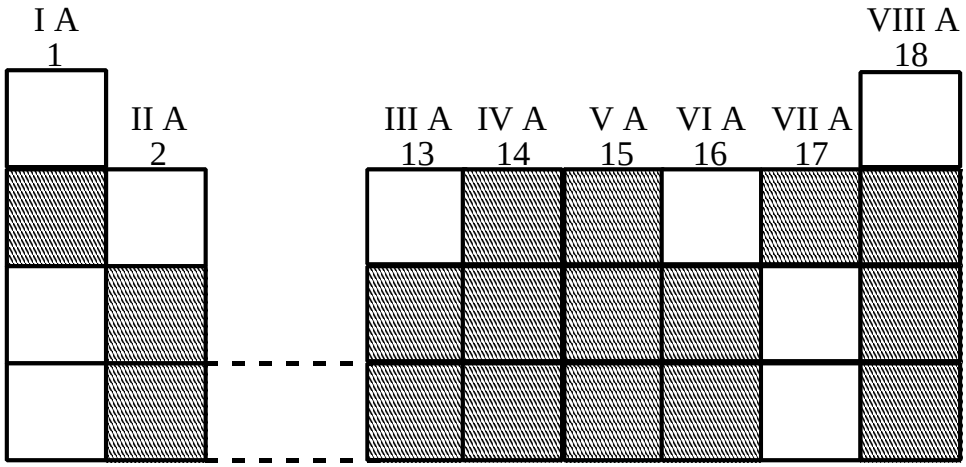
X. It is a gas at room temperature.

It has one electron on its outermost energy level.

Y The electrons in its first three shells follow this pattern: 2-8-7.

Z It is a metalloid.

Use the above info to write the letters W, X, Y, Z in the appropriate blank boxes of the periodic table drawn to the right.



7. Solutions

A solution is a homogeneous mixture. By strict definition air is a solution because it is a mixture of basically air and oxygen and the mixture has only one phase. Alloys such as the gold and copper that make up a gold ring or the mixture of copper and zinc that make up bronze are also solutions for the same reason.

In a solution the major part is known as the **solvent.** So in air (78% nitrogen) nitrogen is the solvent. In most solutions, water is the solvent because water is so common and such a good solvent.

The minor part of the solution is the **solute**. If you dissolve 1 g of sugar in 100 g of water, sugar is the minor component and hence the solute.

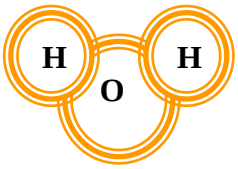
Examples of everyday solutions

Homogeneous Mixture	***Solvent***	***Solute(s)***

If we add more solvent to a solution we are *diluting* it. We lower its concentration of solute. In other words, a given amount of solution we will find less solute and more solvent.

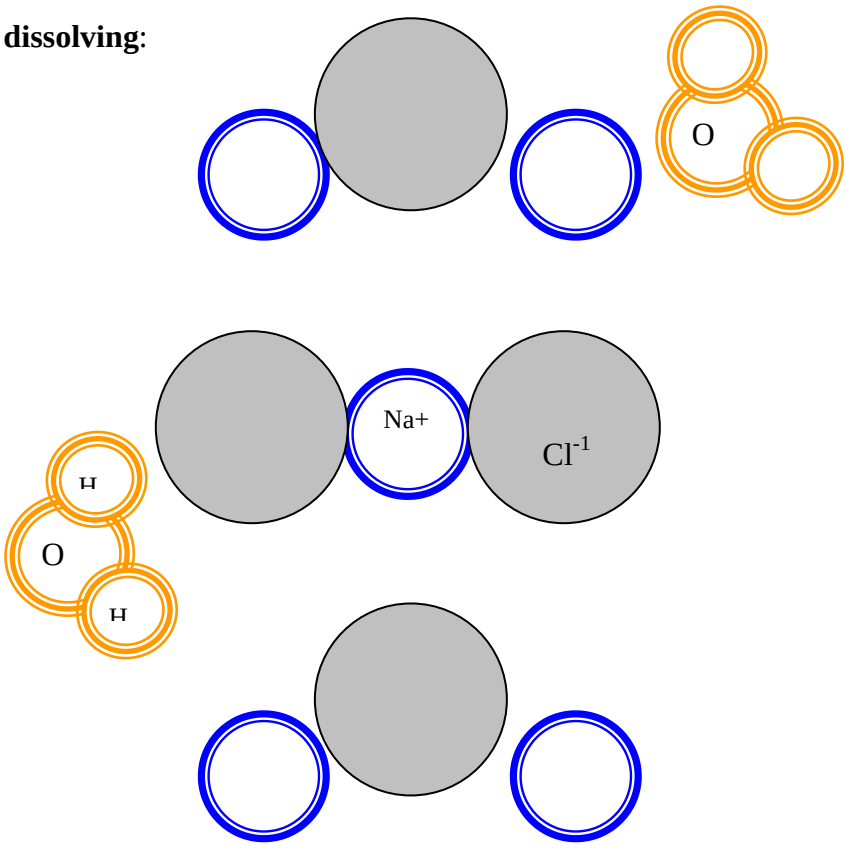
Before venturing more deeply into concentration, let's explain what happens when a substance dissolves in water. Why is for instance that when salt is added to water, it eventually disappears?

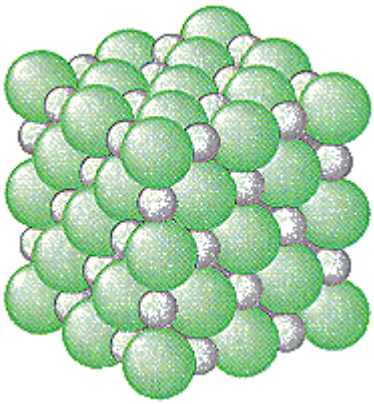
Water is a polar molecule. This does not imply that it has relatives in Northern Canada, but it means that the electronegative (greedy) oxygen atom in water has a partial negative charge, which allows it to attract the positive sodium ion in salt.



The wimpy hydrogen atoms in water allow the electrons they share to actually move towards the oxygen, and so thee H's carry a partial positive charge. This allows the H's to attract salt's negative chloride ion .The attractions between water and salt are strong enough that they overcome the bonds that keep sodium chloride solid.

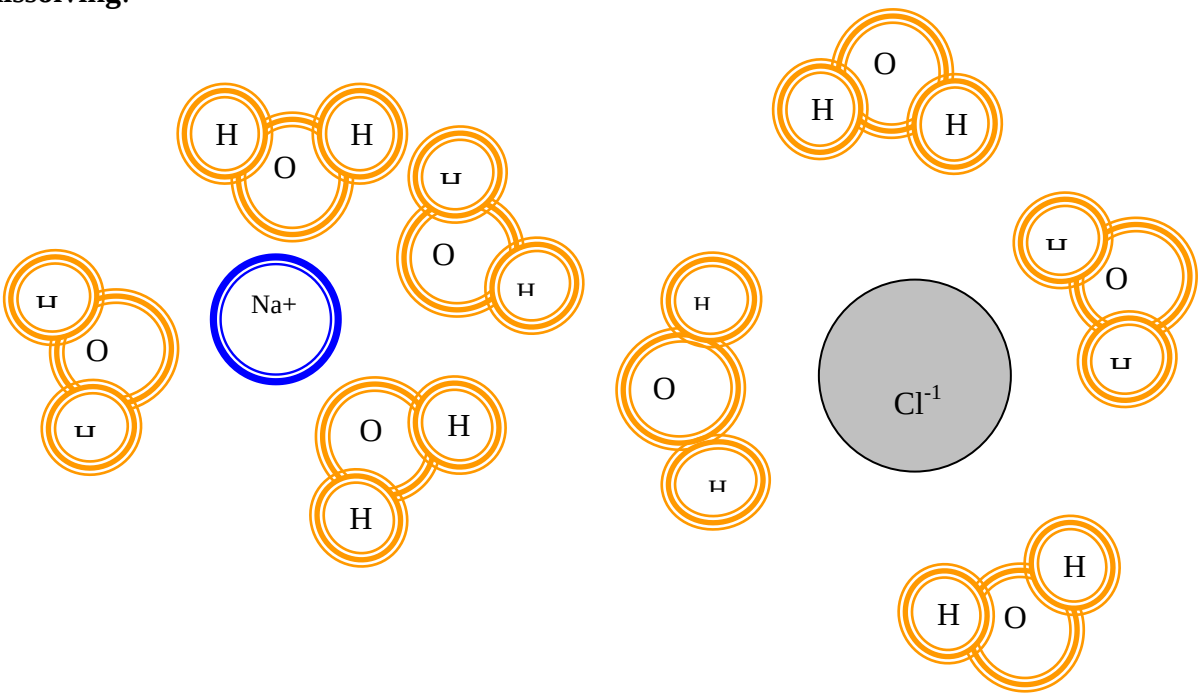
Before dissolving:





As salt's ions come apart and find themselves trapped among water molecules, we no longer see them.

After dissolving:



Example: Draw what is going on when KI dissolves.

Exercises

1.

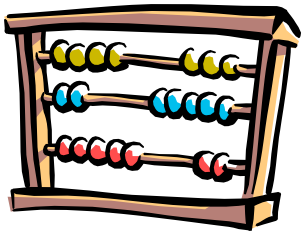
Homogeneous Mixture	***Solvent***	***Solute(s)***
a. 18 K gold (24 K is pure)		
b. Air		
c. ocean water		
d. 7up		

2. Why does salt seem to disappear as it dissolves in water?

3. What part of the water molecule faces a dissolved Mg^{+2} ion? Draw it.

4. If 4.0 grams of Na_3N dissolved in water, what mass of ions would be created in solution?

8. Concentration of Solutions



A. Mass Percent:

$$m/m\% = \frac{mass\,of\ solute}{mass\,of\ solute + mass\,of\ solvent} \times 100\%$$

Example 1 Two grams(2.0 g) of salt are mixed with 50 grams of water. Find the mass % of the solution.

Example 2 How many grams of salt must be added to 10 grams of water to create a 10% solution**?**

Example 3 How many grams of NaBr are needed to make 30 g of a 2.0% solution?

B. **Concentration of Solutions in Grams per Liter (g/L) = *implied:* or**

mass = CV or C = m/V

C = concentration in g/L = grams of solute per liter of solution

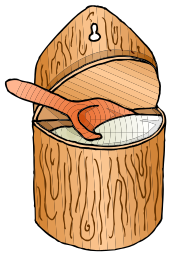
V = volume in L

Example 1 If 30 grams of NaOH are dissolved and then diluted to 2.0 L with water, what is the concentration of the solution?

Example 2 What mass of salt is needed to make 300 mL of a 2 g/L solution?

Example 3 How would ex 2 actually be done in the lab? Outline a procedure. Hint: you will need a beaker, the actual salt, a balance, a stirring rod, a graduated cylinder or volumetric flask and water.

Exercises (**Mass Percent and g/L)**



1. 5.0 grams of sugar are dissolved in 150 g of water What is the mass percent of sugar in the solution?

2. A 200-gram solution of alcohol contains 180 mL of water. What is the mass percent of alcohol? (Remember water's density.)

3. How many grams of NaBr are needed to make 50 g of a 5.0% solution?

4. You are using 150 mL of ether as a solvent. What mass of sulfanilamide crystals should be added to create a 10% m/V solution. (m/V means mass of solute in g over *mL of solution*)

5. How many grams of LiOH are needed to make 25 g of a 4.0 % solution?

6. What mass of NaF must be mixed with 25 mL = 25 g (because of water's density) of water to create a 3.5% solution.

7. An 800 g solution of Kool Aid contains 780 g of water. What is the mass percent of solute in this solution?

8. What is the mass percent of a solution created by adding 10 g of olive oil to 90 g of vegetable oil?

9. If a 4000g solution of salt contains 40g of salt, what is its mass percent?

Concentration in g/L

1. Find the concentration in g/L for each of the following:

a. 20 g of NaCl dissolved in 500 L of solution
b. 2.8 g of NaBr dissolved in 200 mL of solution
c. 200 mg of KCl dissolved in 75 mL of solution

2. How many grams of Br_2 are needed to make 250 mL of a 4.5 g/L solution?
3. How many grams of HCl are needed to make 500 mL of a 2 g/L solution?
4. How many grams of LIF are needed to make 2.0 L of a 5 g/L solution?
5. What volume is needed to create a 2.0 g/L solution from dissolving 6.0 g of salt?

C- Concentration of Solutions in ppm

ppm = parts per million = mg of solute per L or kg of solution

Example 1: A 200 ml sample of lake water contains 3.0 mg of pesticide. What is the concentration of pesticide in ppm?

Example 2: How many grams of Pb are in a 2.0 L sample of water with a Pb concentration of 0.2 ppm?

Example 3: Convert 2.0g / 300L to ppm.

Exercises

1. LD50 is a designation for the level of dosage required to kill 50% of the test subjects - usually lab rats. If it takes only .063 grams of arsenic in a 1.0 liter volume to kill 50 % of a sample of test rats, what is the LD50 for arsenic in parts per million? (A: 63 ppm)

2. A water purifier claims that it removes 95% of the lead ions from your drinking water. If your water normally carries .125 grams per liter of lead, what would be the concentration in ppm found in a glass of water you might drink from? (A: 6.2 ppm)

3. If an adrenaline rush can be experienced when your blood contains only 5.4 ppm of the hormone, what total mass of adrenaline is required in the blood of a person who has 6.5 liters of blood total for the hormone to kick in? (A: 35.1 mg)

4. A tanker of mercury (I) chloride, HgCl, carrying 150 000 kg crashes off the Washington coast. What total volume of sea water must the cargo mix with to dilute it down below the threshold of 4 ppm? (A: 3.75×10^{10} L)

Flashback (other types of concentration)

5. What volume of solution is needed to dissolve 2.0 g of salt in order to create a 0.20 g/L solution?

6. What is the concentration in g/L of a 2.0 ppm solution of Cu^{+2}?