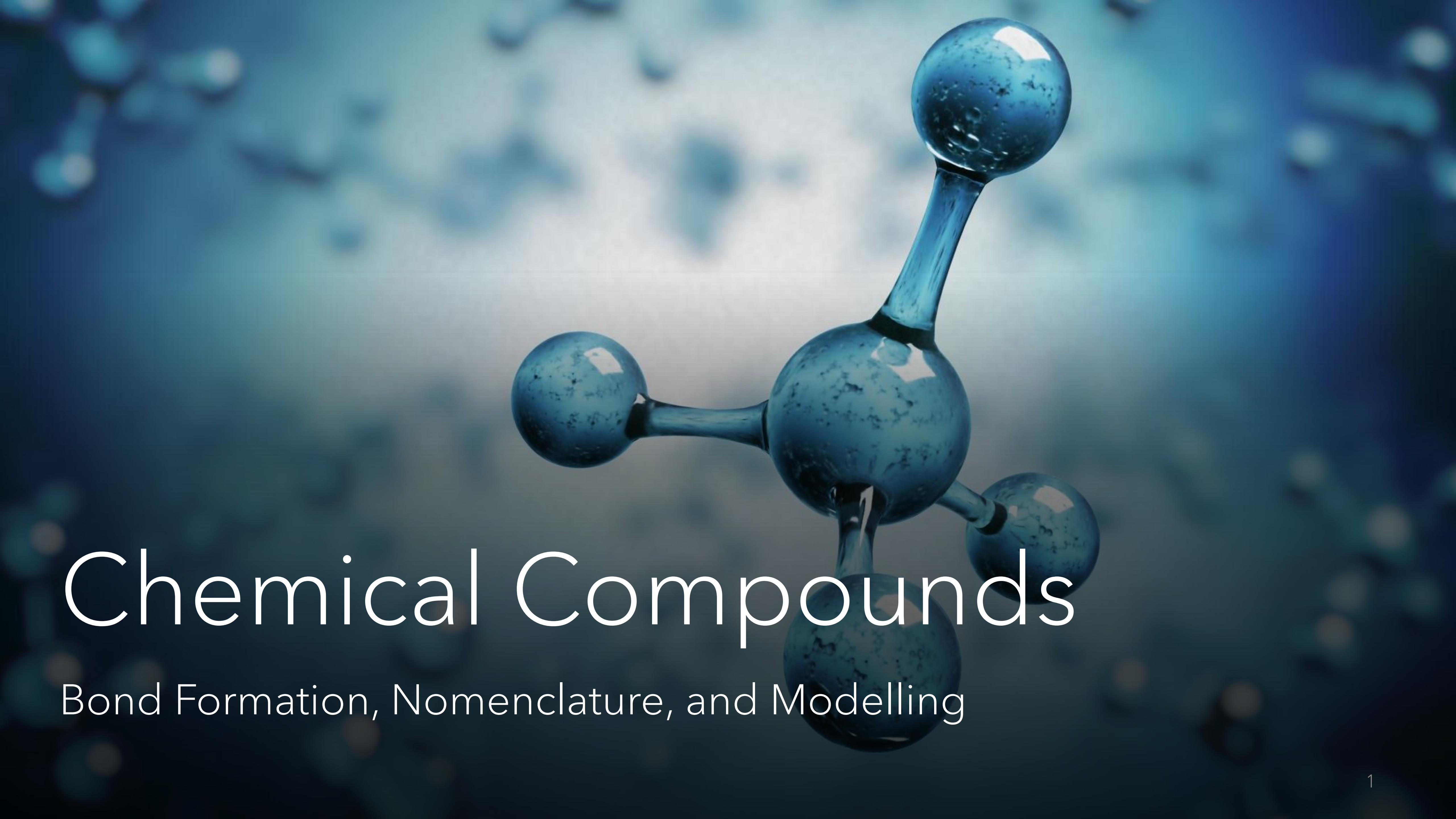


Chemical Compounds

Bond Formation, Nomenclature, and Modelling

Overview

Review: atoms and subatomic particles, ions

Modelling Atoms and Compounds

- Counting Atoms
- Bohr Models
- Lewis Diagrams

IUPAC Naming and Writing Formulas

Balanced Chemical Equations

Section 1: Review

Review

1. Why do compounds form?
2. How do you draw the Bohr model for an atom? Ion?
3. What is a valence shell? Valence electron?
4. On the periodic table, where are the metals and non-metals? What is the difference?
5. Which of these compounds are ionic? Covalent? What's the difference?
6. How do you name ionic compounds?

Review: Atoms and Subatomic Particles

Atom:

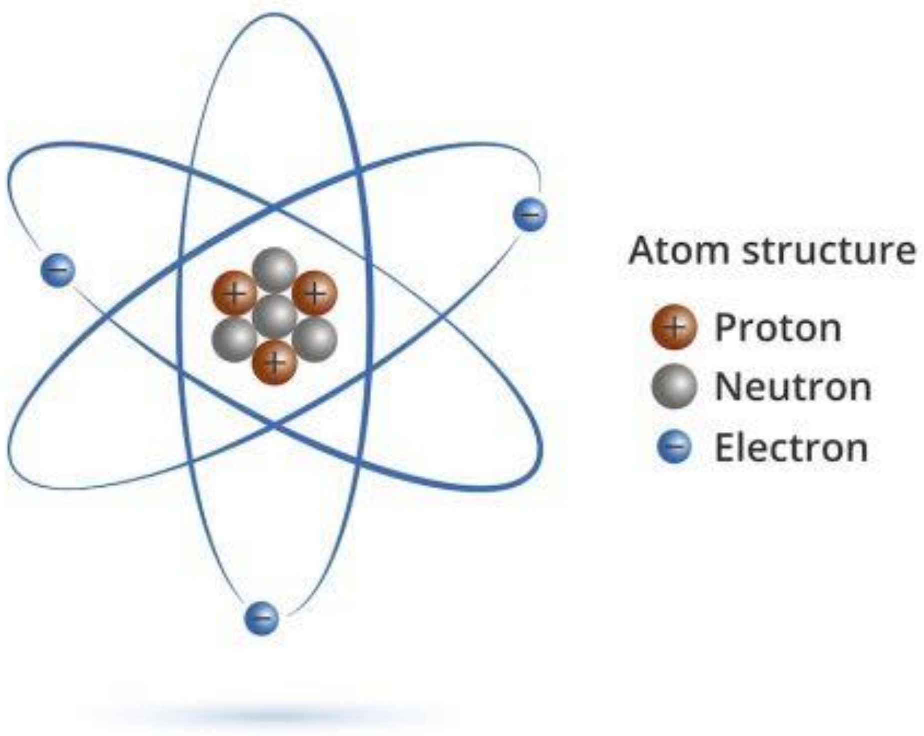
- Smallest unit of matter
- No electric charge (neutral)
- Examples:
  - Na (sodium atom)
  - O (oxygen atom)

Review: Atoms and Subatomic Particles

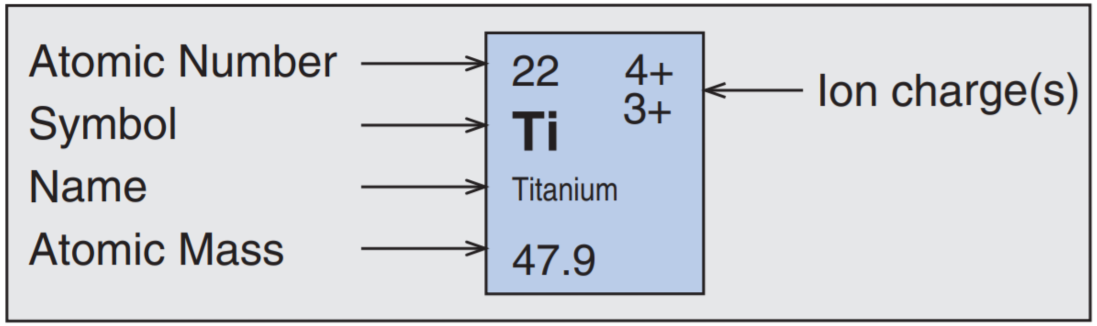
Proton: positively charged particle in the nucleus of an atom; has a mass of 1

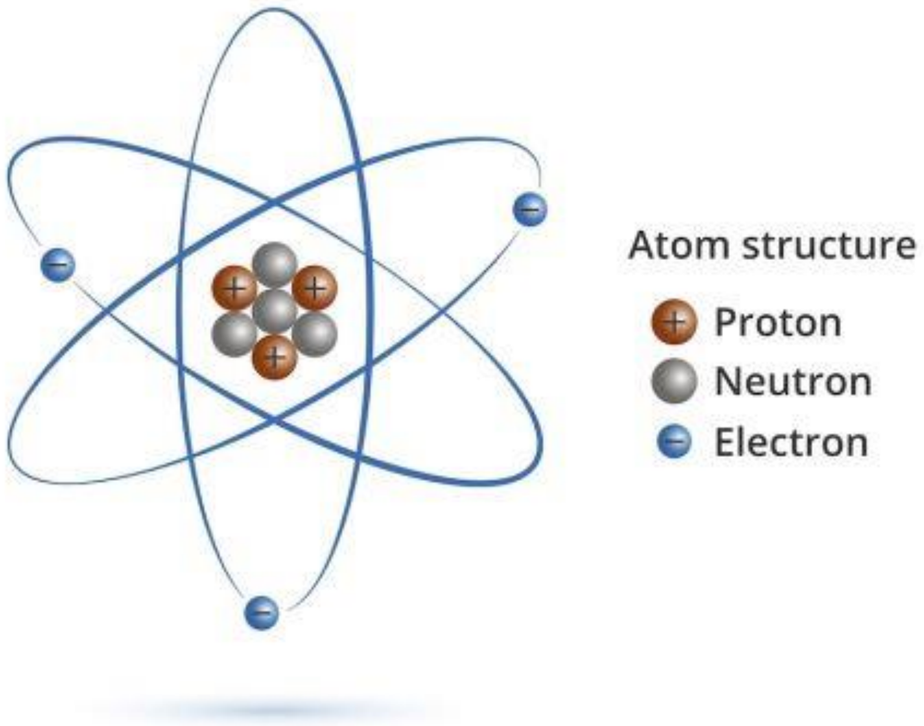
Neutron: uncharged particle in the nucleus of an atom; has a mass of 1

Electron: negatively charged particle in energy shell surrounding the nucleus of the atom; very tiny (mass of 0)



Review: Atoms and Subatomic Particles





For an ***atom***:

- # protons = atomic number
- # electrons = atomic number
- # neutrons =
  rounded atomic mass – atomic number

If the tenths place is a 4 or lower, round down.	32.1 → 32	65.4 → 65
If the tenths place is a 5 or higher, round up.	10.8 → 11	35.5 → 36

Review: Atoms and Subatomic Particles

	# protons	# neutrons	# electrons
atom (neutral)	atomic number	rounded atomic mass minus atomic number	atomic number

Practice: Atoms and Subatomic Particles

1) Why are the number of protons and electrons the same for an atom? (Hint: what is the charge on an atom?)
2) Explain why you need to subtract atomic number from atomic mass to calculate the number of neutrons in an atom.
3) Complete the following table.

atom	# protons	# neutrons	# electrons
Ca	20	20	20
F	9	10	9
Cl	17	19	17
Ar	18	22	18
Zn	30	35	30

Review: Ions

Ion: an atom or molecule with an electric charge; formed by gaining or losing electrons

Examples:

- Na^{+} (sodium ion with 1+ charge)
- O^{2-} (oxygen ion with 2- charge)

Review: Ions

The Periodic Table tells you which ion(s) an atom can form.

- **Cation**: positively charged ion (e.g. Ca^{2+}, Cr^{3+}, NH_4^+); forms when *electrons are lost*
- **Anion**: negatively charged ion (e.g. N^{3-}, S^{2-}, PO_4^{3-}); forms when *electrons are gained*

12 2+
Mg
Magnesium
24.3

magnesium atom can lose two electrons to form the Mg^{2+} ion

22 4+ 3+
Ti
Titanium
47.9

titanium is a **multivalent metal**: it can form more than one ion

16 2–
S
Sulfur
32.1

sulfur atom can gain two electrons to form the S^{2-} ion

10 0
Ne
Neon
20.2

6
C
Carbon
12.0

carbon and neon do not form ions

Review: Ions


CATIONs : positive ions, protons > electrons
Cats are HAPPY.
ANIONS : negative ions, protons < electrons
(onion)
Onions make you cry (negative).

Review: Ions

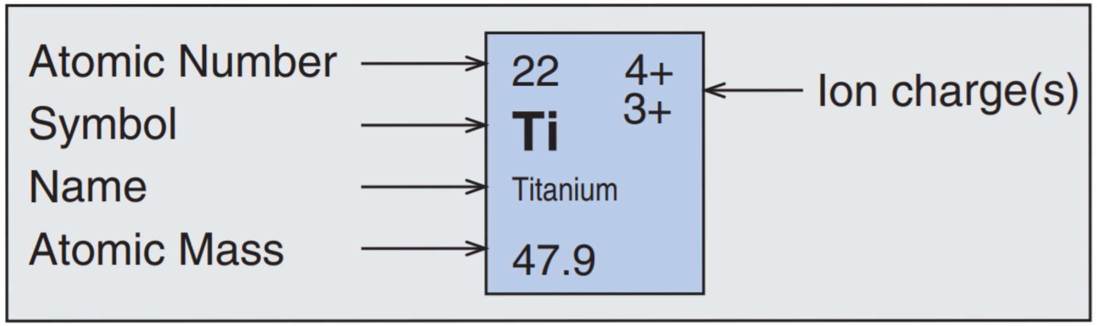
NAMES, FORMULAE AND CHARGES OF SOME POLYATOMIC IONS

Positive Ions		Negative Ions	
NH_4^+	Ammonium	CH_3COO^-	Acetate
		CO_3^{2-}	Carbonate
		ClO_3^-	Chlorate
		ClO_2^-	Chlorite
		CrO_4^{2-}	Chromate
		CN^-	Cyanide
		$Cr_2O_7^{2-}$	Dichromate
		HCO_3^-	Hydrogen carbonate, bicarbonate
		HSO_4^-	Hydrogen sulfate, bisulfate
		HS^-	Hydrogen sulfide, bisulfide

A **polyatomic ion** is a group of covalently bonded atoms with a charge.

E.g. NH_4 (nitrogen tetrahydride) can lose an electron to become NH_4^+ (ammonium ion)

Review: Ions



For an *ion:*

- # protons = atomic number
- **# electrons = atomic number – ion charge**
- # neutrons = rounded atomic mass – atomic number

Review: Atoms and Subatomic Particles

	# protons	# neutrons	# electrons
atom (neutral)	atomic number	rounded atomic mass minus atomic number	atomic number
ion (charged)	atomic number	rounded atomic mass minus atomic number	atomic number minus ion charge

Practice: Ions

	# protons	# neutrons	# electrons
Mg^{2+}	12	12	10
Ti^{3+}	22	26	19
O^{2-}	8	8	10
As^{3-}	33	42	36
phosphorus ion	15	16	18
lithium ion	3	4	2
manganese(IV) ion	25	30	21
cobalt(III) ion	27	32	24

Practice: Atoms and Ions

	# protons	# neutrons	# electrons
N	7	7	7
Br^-	35	45	36
Zn^{2+}	30	35	28
Li	3	4	3
aluminum	13	14	13
calcium ion	20	20	18
nickel(III) ion	28	31	25
potassium	19	20	19

Practice: Atoms and Ions

3. Why do atoms and ions have the same number of protons and neutrons, but different numbers of electrons?
4. Why do ions never have the same number of protons as electrons?
5. To form an anion, does an atom have to gain or lose electrons? Why?
6. When a calcium atom becomes an ion, does it have to gain or lose electrons? How many?

Practice: Atoms and Ions

7. Is the chlorine ion a cation or an anion? Does it form by gaining or losing electrons?
8. Is Cr^{3+} a cation or anion?
9. Does arsenic form an ion by gaining or losing electrons? How many? How do you know?
10. Why do we call manganese a multivalent element? List 3 other multivalent elements.

Section 2: Modelling Atoms and Compounds

Modelling Atoms and Compounds

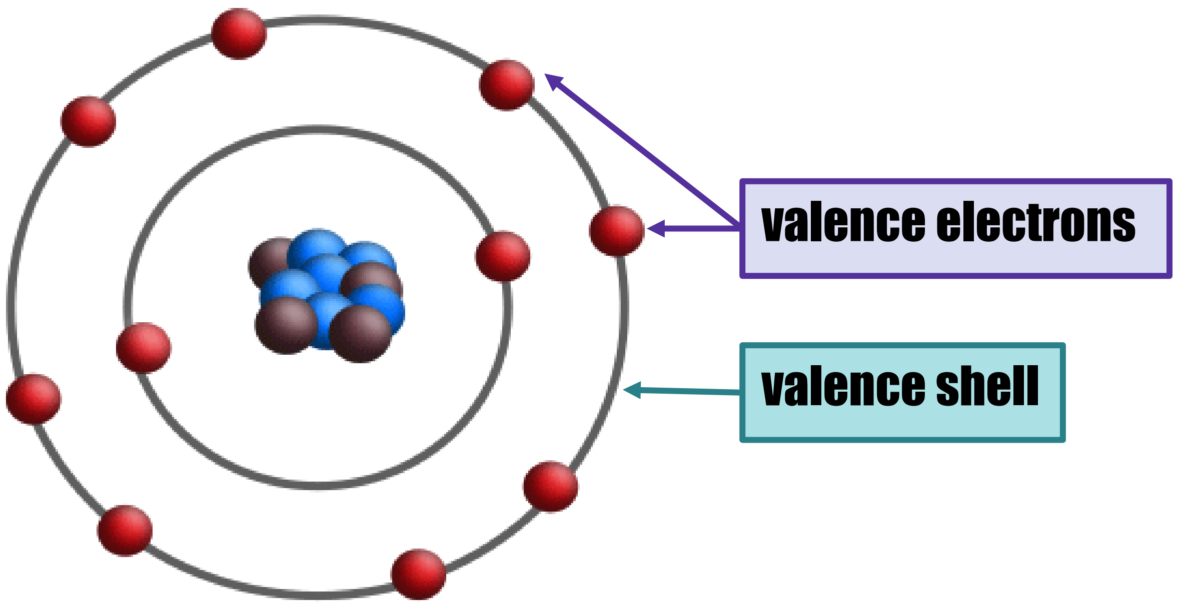
- Introduction to Chemical Compounds
- Counting Atoms
- Bohr Models of Atoms, Ionic Compounds, and Covalent Compounds
- Lewis Diagrams of Atoms, Ionic Compounds, and Covalent Compounds

Introduction to Chemical Compounds

What are compounds? Why do they form? (textbook pgs ~120-124)

Achieving Stability Through Nobility

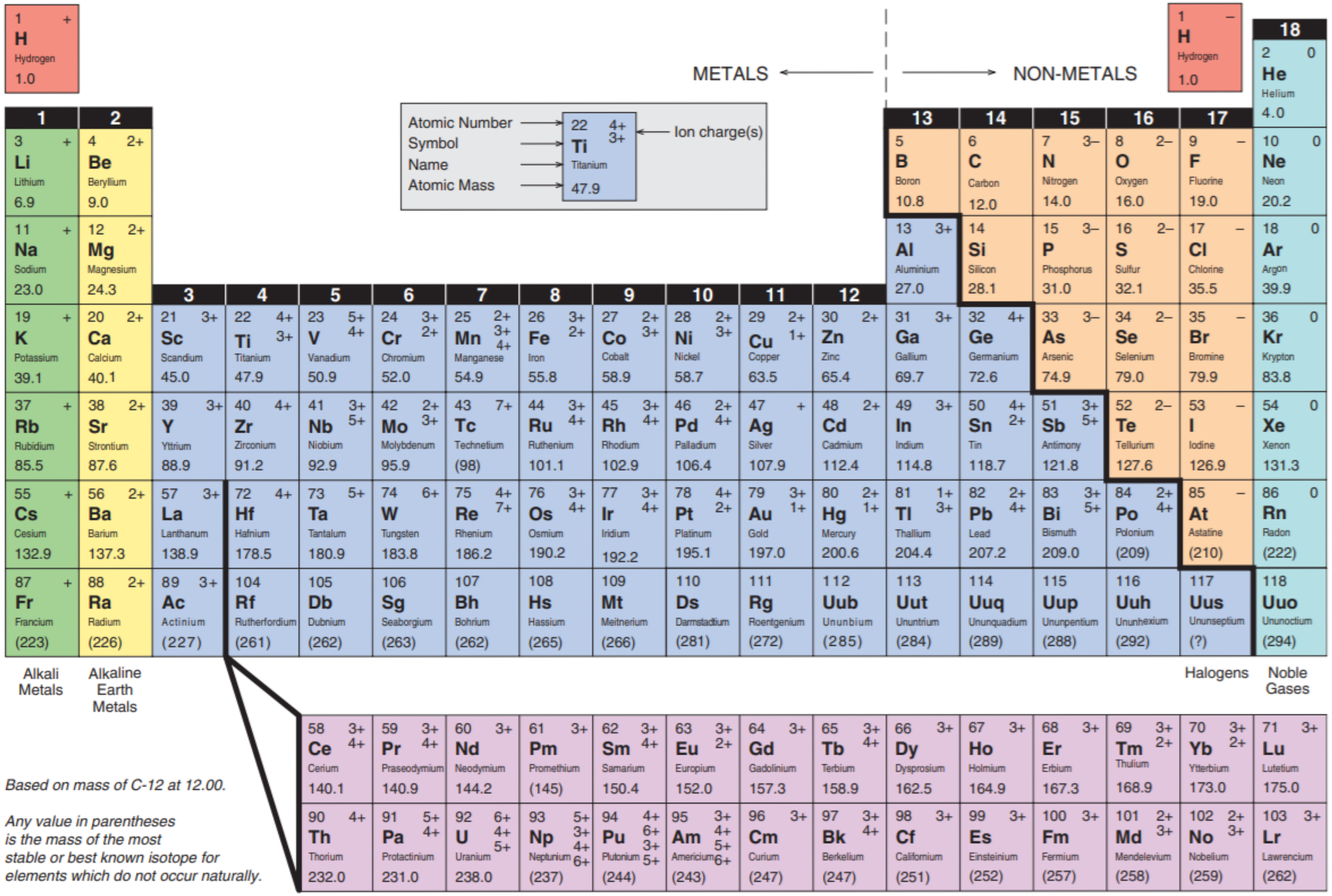
- The **valence shell** is the outermost shell containing electrons. Electrons in this shell are called **valence electrons**.
- A stable atom has a full valence shell.



Achieving Stability Through Nobility

- The **valence shell** is the outermost shell containing electrons. Electrons in this shell are called **valence electrons**.
- A stable atom has a full valence shell.
- Atoms react to form **compounds** (group of atoms bonded together) to become stable by having a full valence shell.
  - **Ionic compound**: formed when atoms *gain or lose electrons*
  - **Covalent compound**: formed when atoms *share electrons*

Achieving Stability Through Nobility



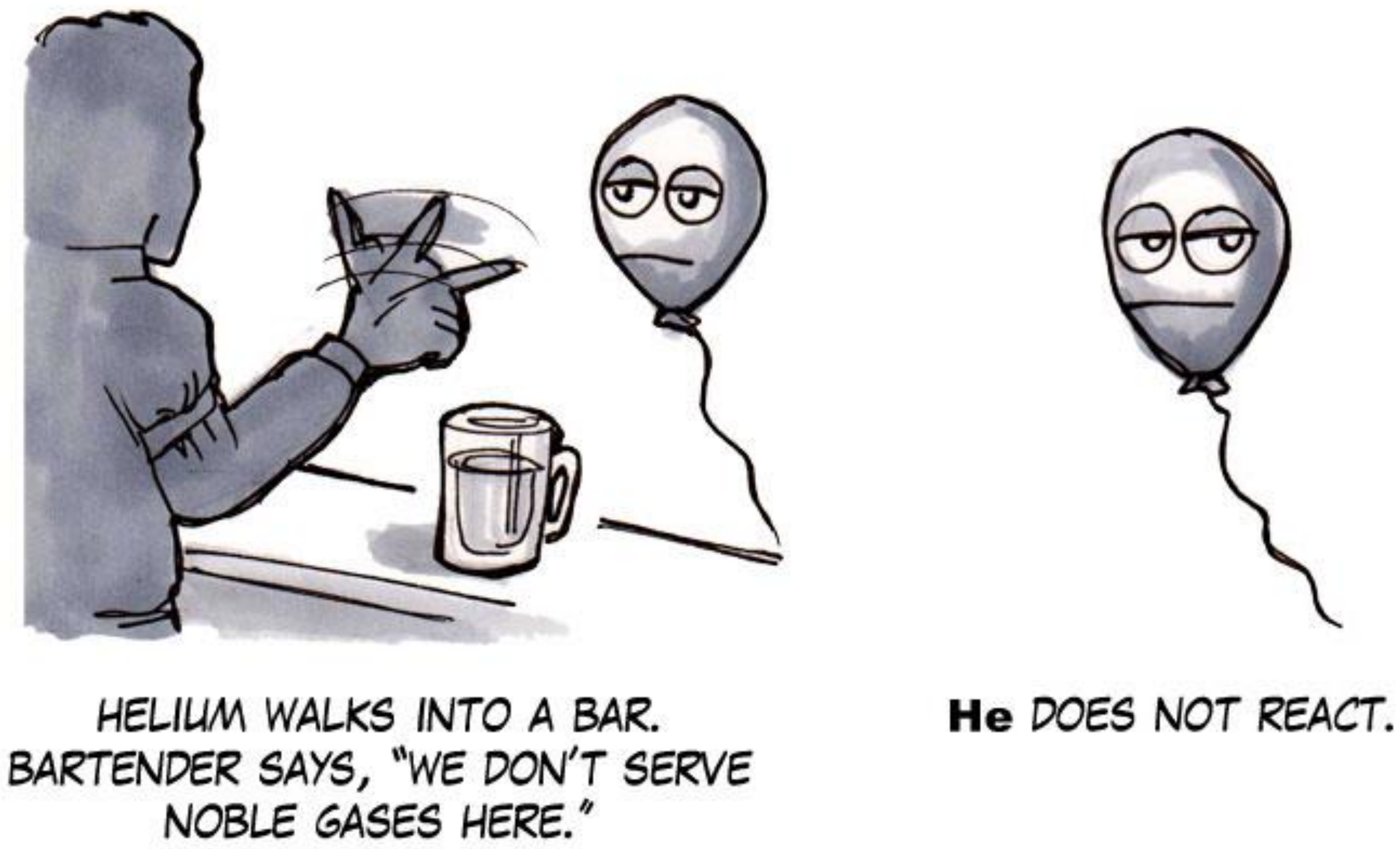
Valence electrons can explain reactivity.

The closer an atom is to a full valence shell, the more reactive it is.

Alkali metals and halogens extremely reactive.

Alkaline earth metals and Group 16 elements very reactive.

Achieving Stability Through Nobility



Valence electrons can explain reactivity.

Noble gases already have a full valence shell: they do not react with other elements.

Practice

Identify the following as **atoms** (pure elements), **ions**, or **compounds**.
BONUS: identify any cations, anions, and polyatomic ions.

1. Na
2. $TiCl_3$
3. CH_4
4. Cu
5. Fe^{3+}
6. H_2O
7. H_2
8. Fe
9. O^{2-}
10. I_2
11. $Ni(OH)_3$
12. Mg
13. $Ca(OH)_2$
14. Mn
15. HSO_4^-
16. Cu^+
17. VS_2
18. NO
19. MgO_2
20. Pt^{4+}
21. Be
22. ClO_2^-
23. CCl_4
24. Cl_2

Practice

Identify the following as **atoms** (pure elements), **ions**, or **compounds**.
BONUS: identify any cations, anions, and polyatomic ions.

1. Na
2. $TiCl_3$
3. CH_4
4. Cu
5. Fe^{3+}
6. H_2O
7. H_2
8. Fe
9. O^{2-}
10. I_2
11. $Ni(OH)_3$
12. Mg
13. $Ca(OH)_2$
14. Mn
15. HSO_4^-
16. Cu^+
17. VS_2
18. NO
19. MgO_2
20. Pt^{4+}
21. Be
22. ClO_2^-
23. CCl_4
24. Cl_2

Cations: Fe^{3+}, Cu^+, Pt^{4+}. Anions: O^{2-}, HSO_4^-, ClO_2^-. Polyatomic: HSO_4^-, ClO_2^-

Counting Atoms

See "AcCounting for Atoms" worksheet and answer key.

Bohr Models

(textbook pgs ~120-124)

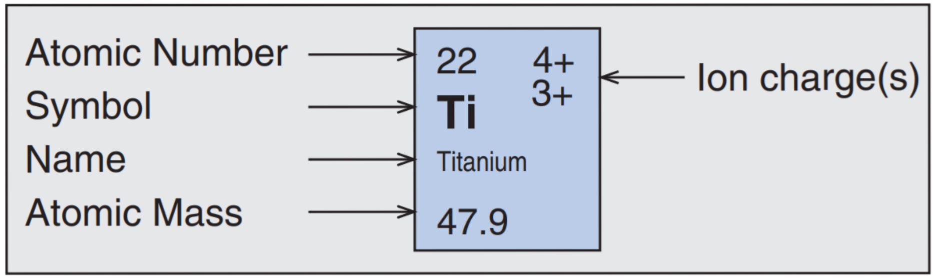
Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.
2. In the middle of diagram:
   - Element symbol (e.g. "Cl" "F" "Na")
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - Electrons drawn singly starting from top and rotating clockwise
4. Ions only:
   - Add square brackets and a charge

Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.

	protons	neutrons	electrons
Atom	atomic number	*rounded* atomic mass minus atomic number	atomic number
Ion	atomic number	*rounded* atomic mass minus atomic number	atomic number minus ionic charge

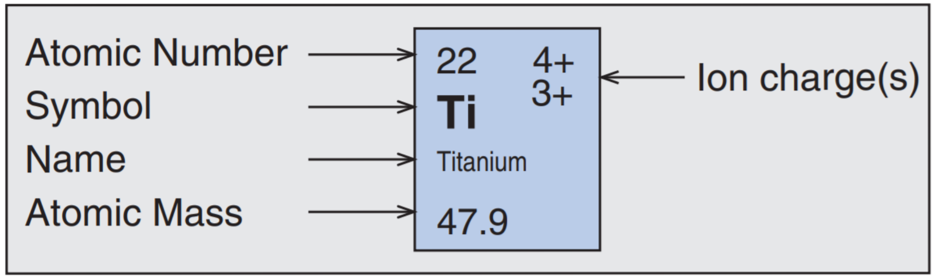


		p	n	e
11 + Na Sodium 23.0	Na			
	Na^{+}			
12 2+ Mg Magnesium 24.3	Mg			
	Mg^{2+}			
8 2– O Oxygen 16.0	O			
	O^{2-}			
17 – Cl Chlorine 35.5	Cl			
	Cl^{-}			

Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.

	protons	neutrons	electrons
Atom	atomic number	*rounded* atomic mass minus atomic number	atomic number
Ion	atomic number	*rounded* atomic mass minus atomic number	atomic number minus ionic charge



		p	n	e
11 + **Na** Sodium 23.0	Na	11	23-11=12	11
	Na^+	11	23-11=12	11-(+1)=10
12 2+ **Mg** Magnesium 24.3	Mg	12	24-12=12	12
	Mg^{2+}	12	24-12=12	12-(+2)=10
8 2– **O** Oxygen 16.0	O	8	16-8=8	8
	O^{2-}	8	16-8=8	8-(-2)=10
17 – **Cl** Chlorine 35.5	Cl	17	36-17=19	17
	Cl^-	17	36-17=19	18

Drawing Bohr Models of Atoms and Ions

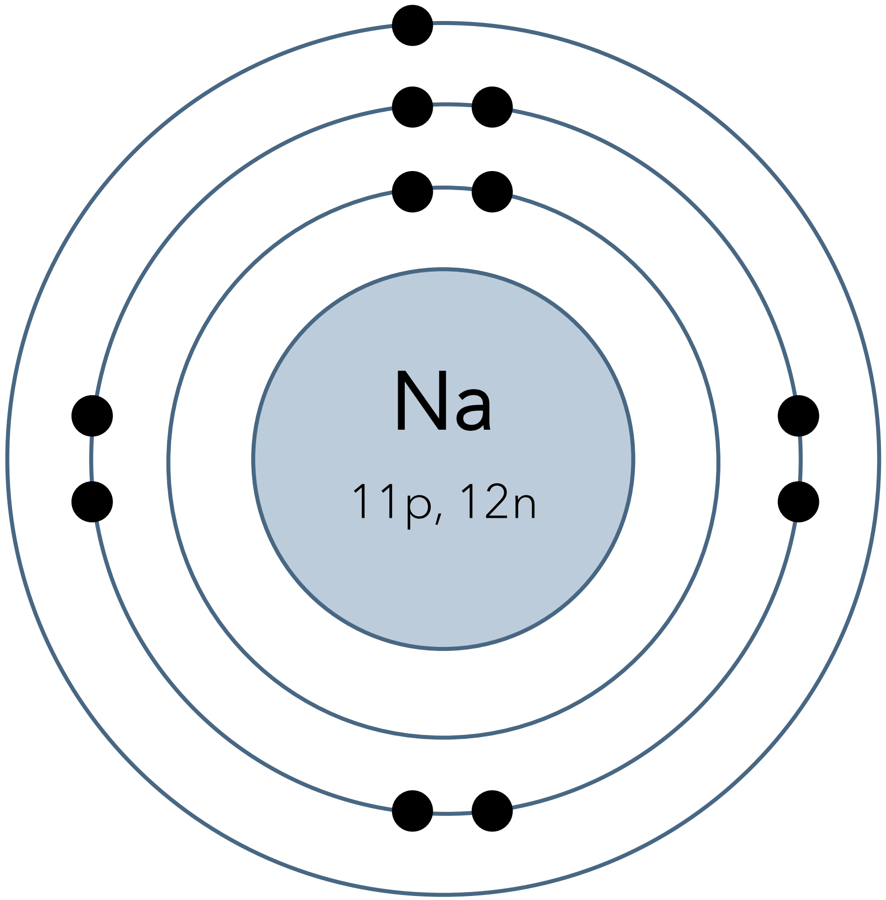
1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled ***starting at top***, going ***clockwise***, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled starting at top, going clockwise, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

	p	n	e
Na	11	23-11=12	11

Example: sodium atom



Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
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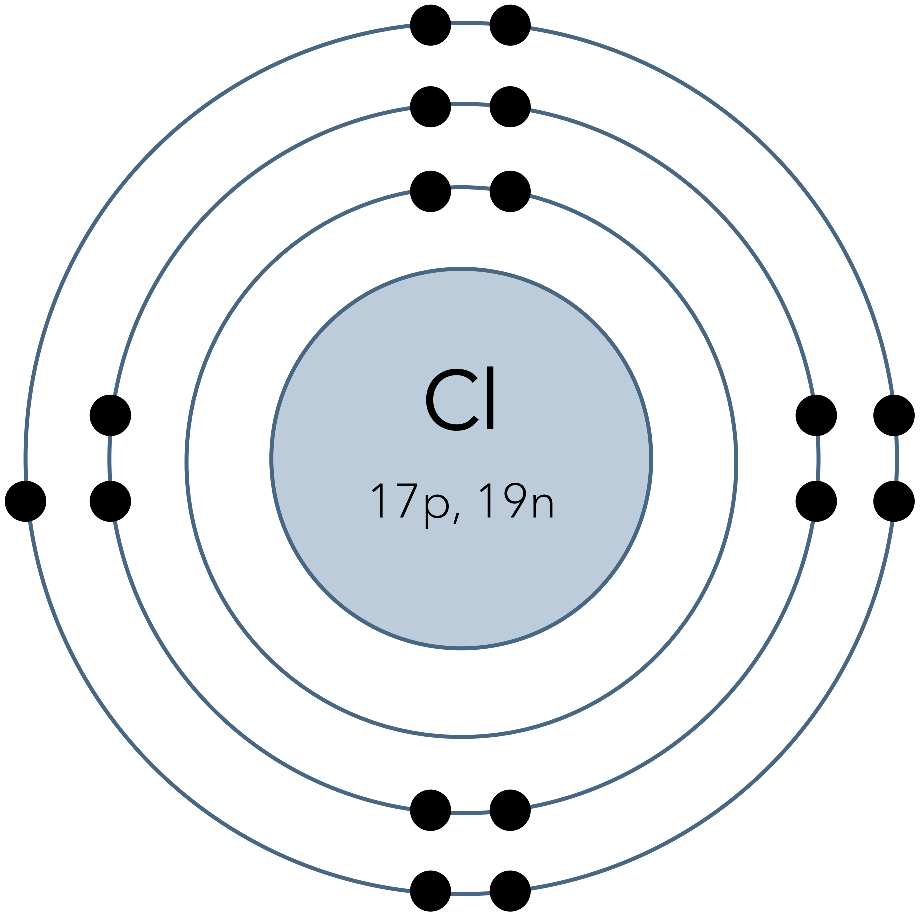
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled starting at top, going clockwise, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

	p	n	e
Cl	17	36-17=19	17

Example: chlorine atom

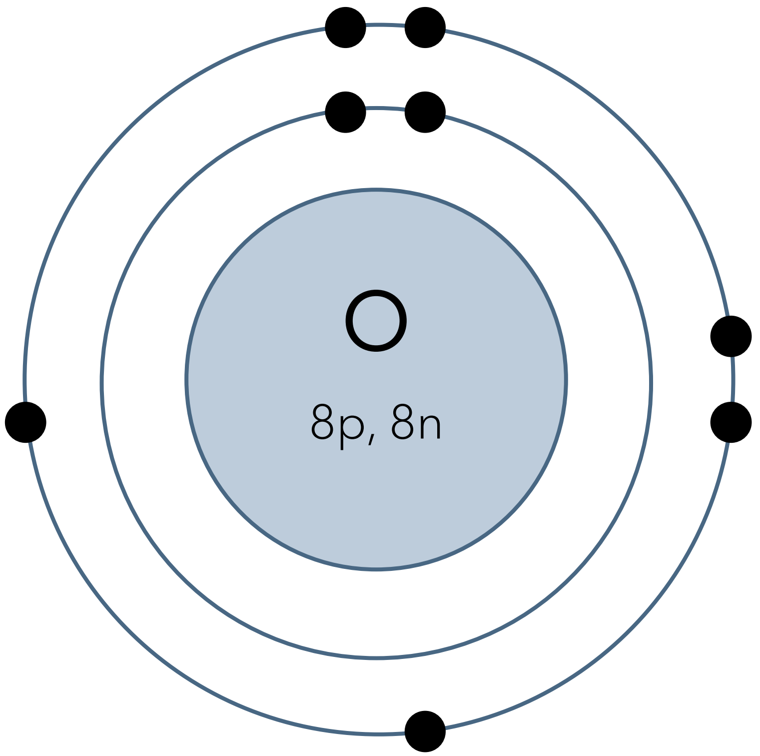


Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled starting at top, going clockwise, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

	p	n	e
O	8	16-8=8	8

Example: oxygen atom



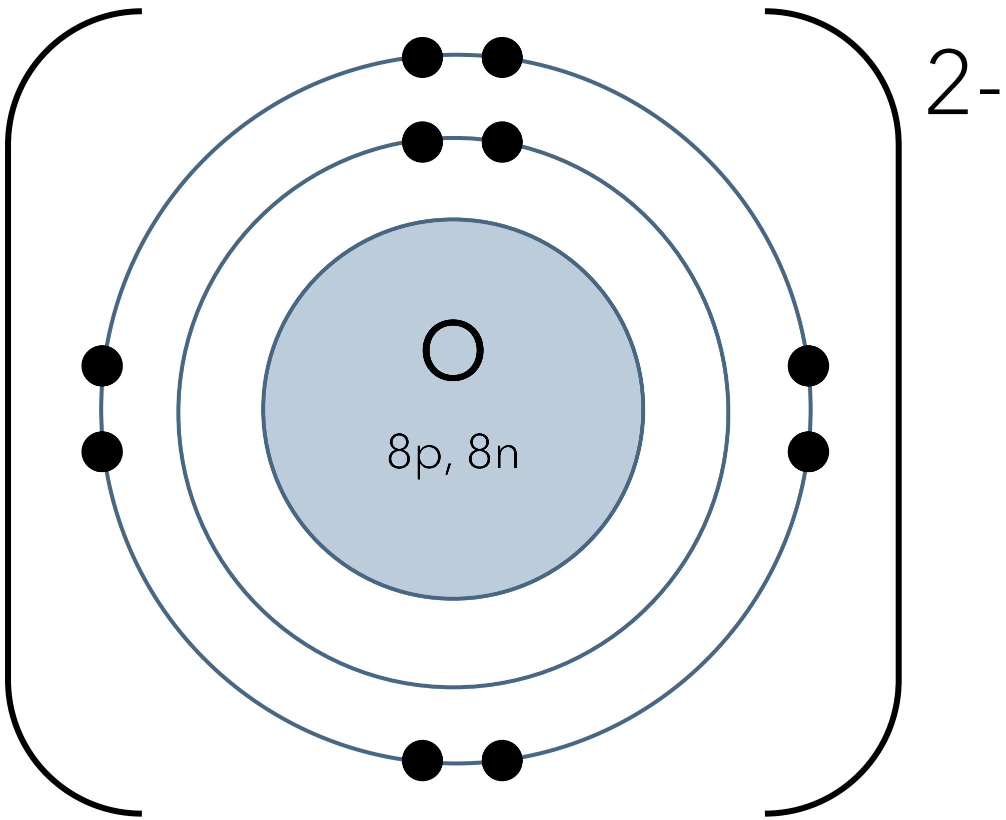
Drawing Bohr Models of Atoms and Ions

1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled starting at top, going clockwise, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

	p	n	e
O^{2-}	8	16-8=8	8-(-2)=10

Note: subtracting a negative is the same as adding.

Example: oxygen ion

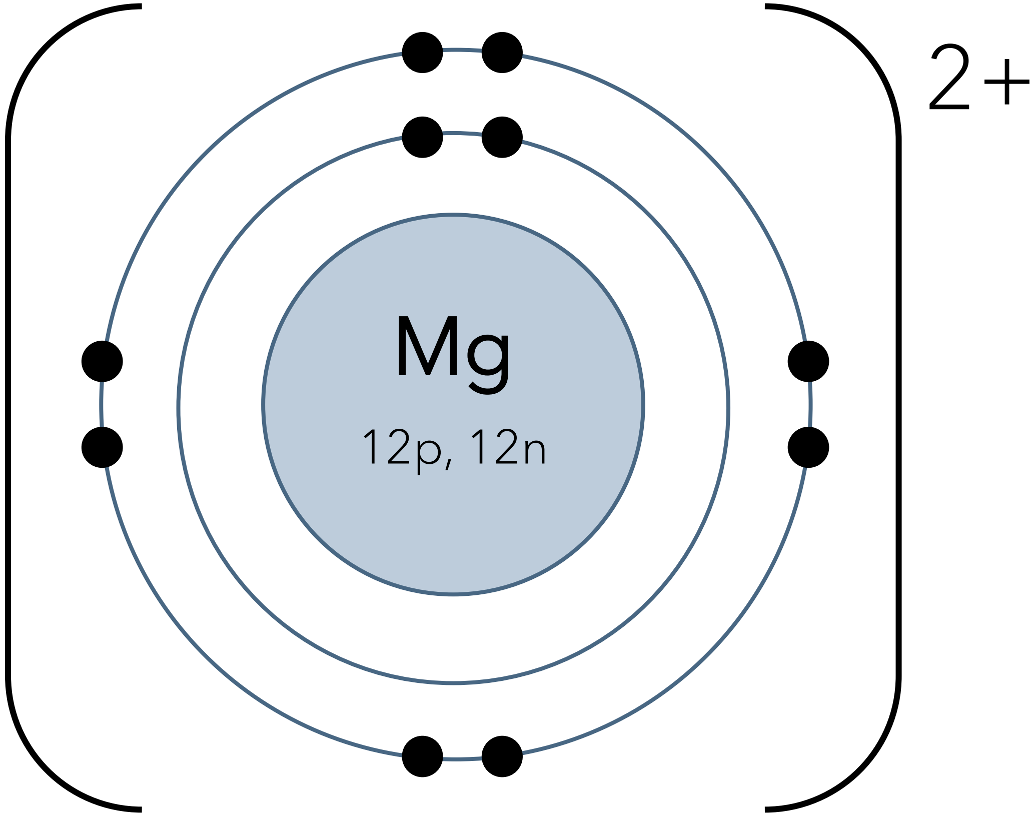


Drawing Bohr Models of Atoms and Ions

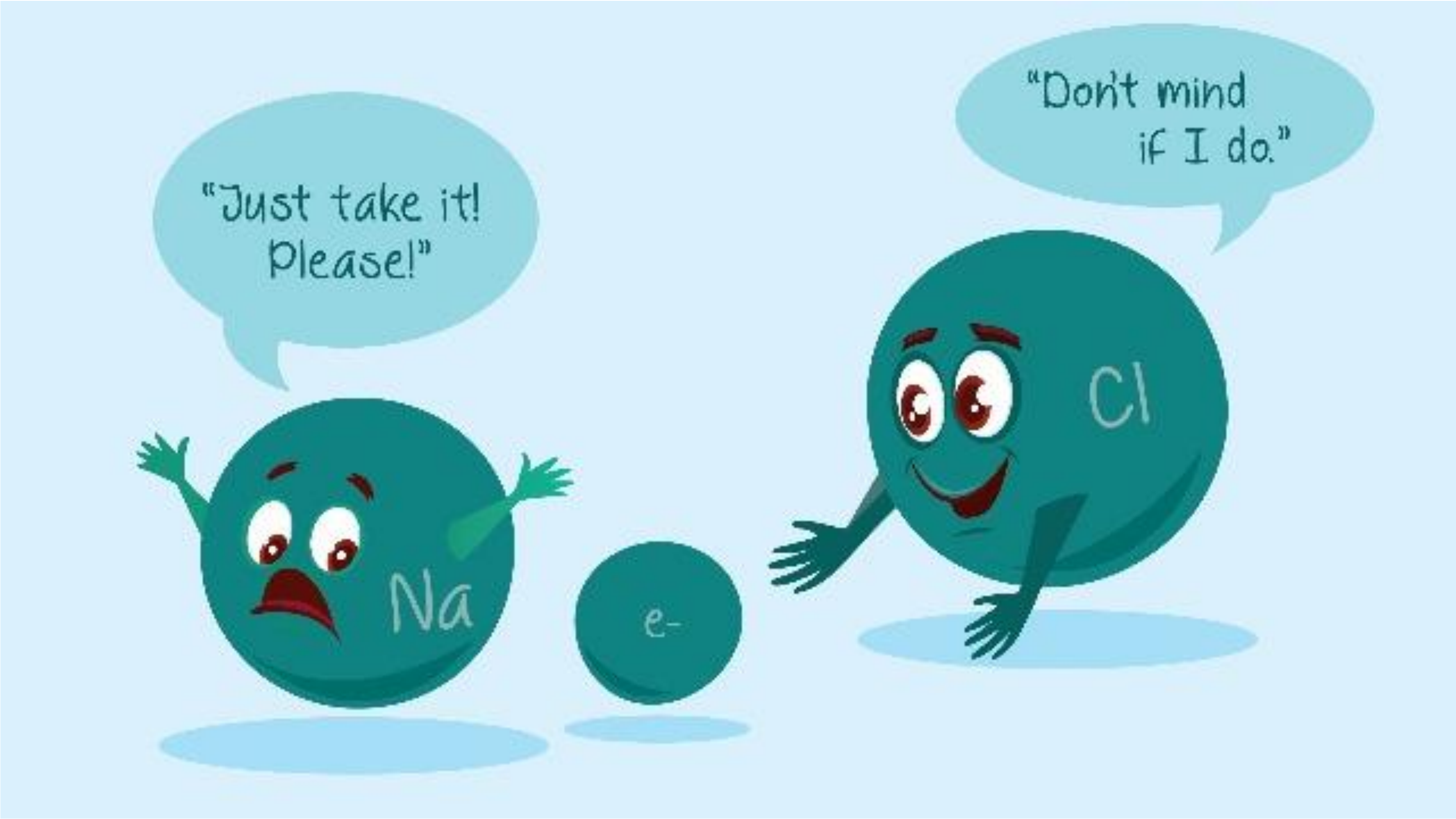
1. Calculate the number of protons, neutrons, electrons.
2. In the nucleus:
   - Element symbol
   - # protons, # neutrons
3. Draw the electrons in energy shells:
   - Max electrons per shell from inside to outside: 2, 8, 8, 18
   - (Except in first shell), electrons are filled starting at top, going clockwise, singly at first then paired
4. Ions only:
   - Add square brackets and ion charge from periodic table

	p	n	e
Mg^{2+}	12	24-12=12	12-(+2)=10

Example: magnesium ion



Ionic Compound Formation



https://www.technologynetworks.com/analysis/articles/cation-vs-anion-definition-chart-and-the-periodic-table-322863

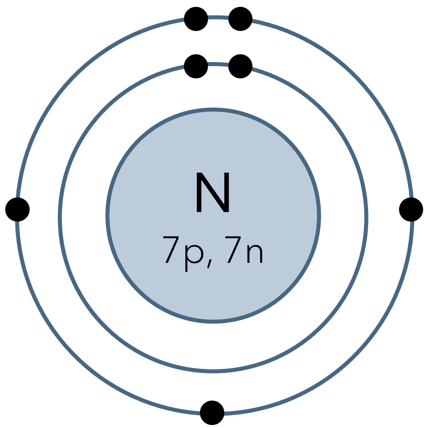
Ionic Compound Formation (Review)

- Atoms form ions to have a **full valence shell**, just like the noble gases have.
- Electrons are negatively charged. When electrons are added or taken away, atoms become positively or negatively charged ions.
  - **Cation**: positively charged ion (e.g. Ca^{2+}, Cr^{3+}, NH_4^+); forms when *electrons are lost* from an atom
  - **Anion**: negatively charged ion (e.g. N^{3-}, S^{2-}, PO_4^{3-}); forms when *electrons are gained* by an atom

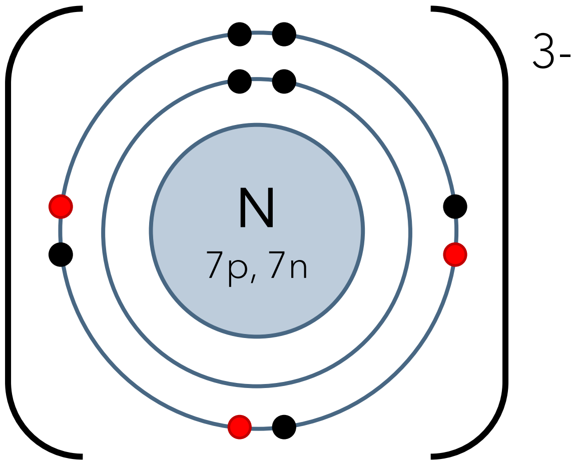
Ionic Compound Formation

- Atoms are neutral because #protons = #electrons.
- Nitrogen atom becomes an ion when it gains 3 electrons.

nitrogen atom (neutral)



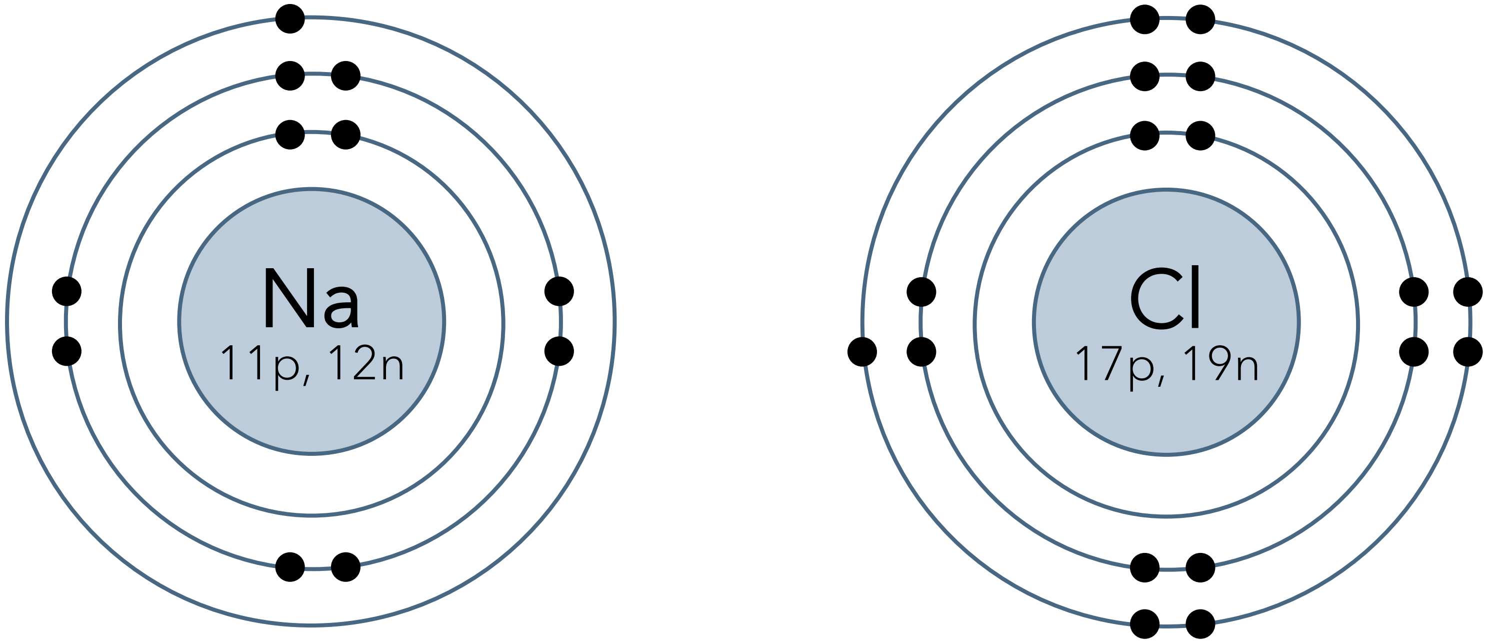
nitrogen ion (3- charge)



Where do these electrons come from?

Ionic Compound Formation (NaCl)

- Ionic compounds form when **electrons are transferred** and ions are formed. Usually involves a **metal and a non-metal**.



sodium atom (neutral)

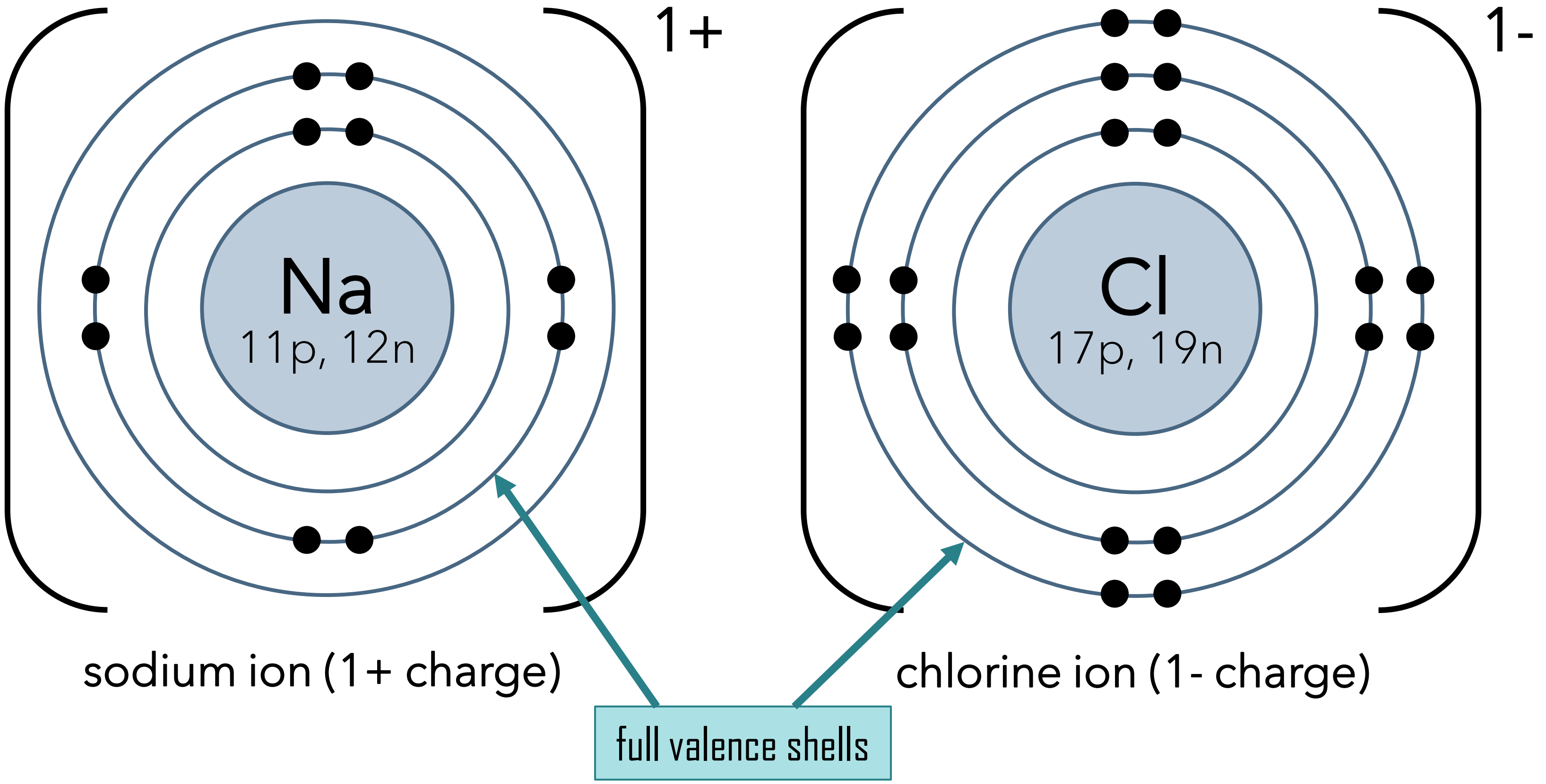
chlorine atom (neutral)

In order to get full valence shells:

- Na needs to **lose 1** electron.
- Cl needs to **gain 1** electron.

Ionic Compound Formation (NaCl)

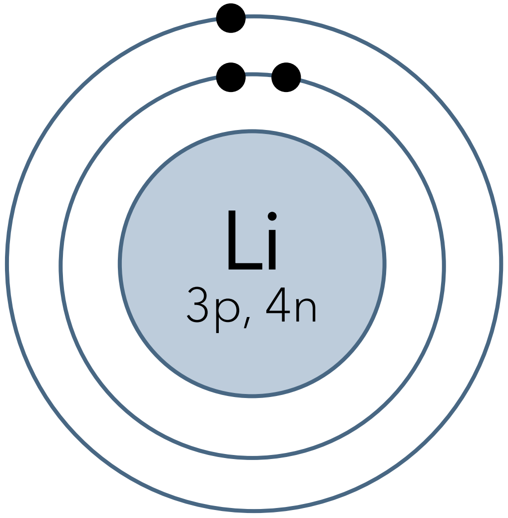
- Ionic compounds form when **electrons are transferred** and ions are formed. Usually involves a **metal and a non-metal**.



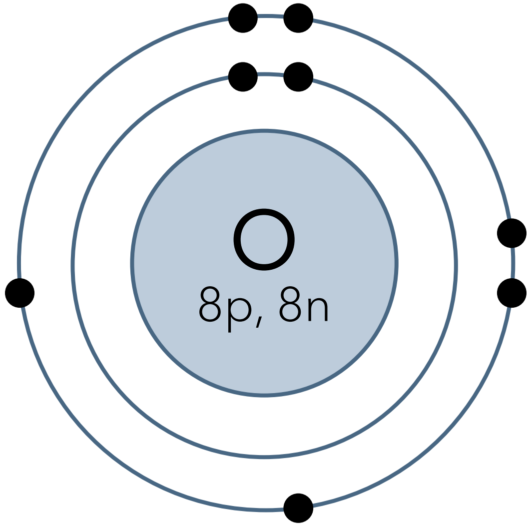
This ionic compound is NaCl (sodium chloride). It has one Na^{+} ion and one Cl^{-} ion.

Ionic Compound Formation (Li_2O)

- Ionic compounds form when **electrons are transferred** and ions are formed. Usually involves a **metal and a non-metal**.



lithium atom (neutral)



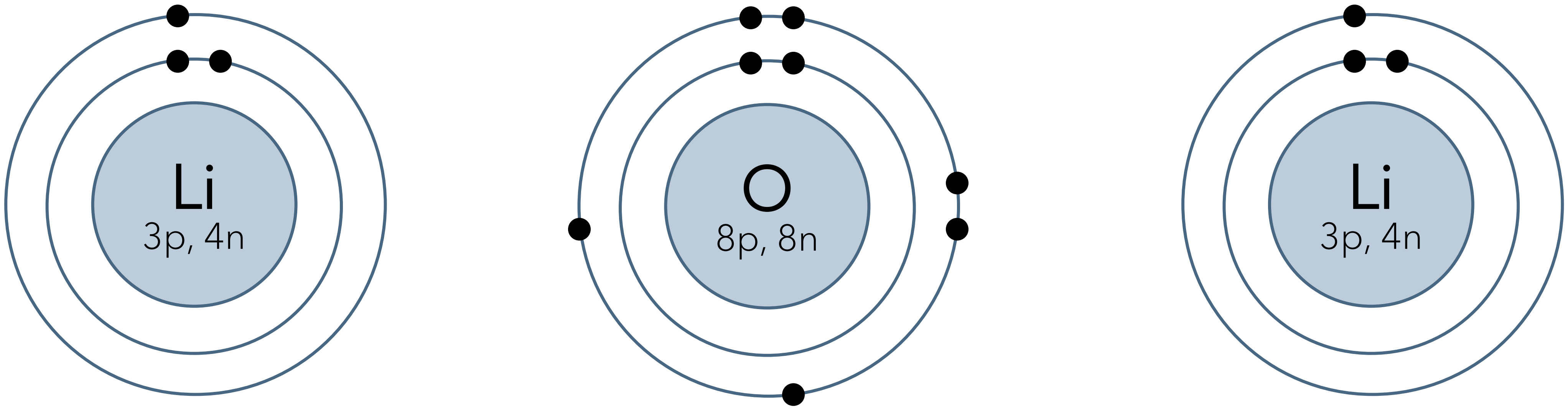
oxygen atom (neutral)

- Li needs to **lose 1** electron.
- O needs to **gain 2** electrons.

<u>Problem</u>: Electron numbers not balanced.

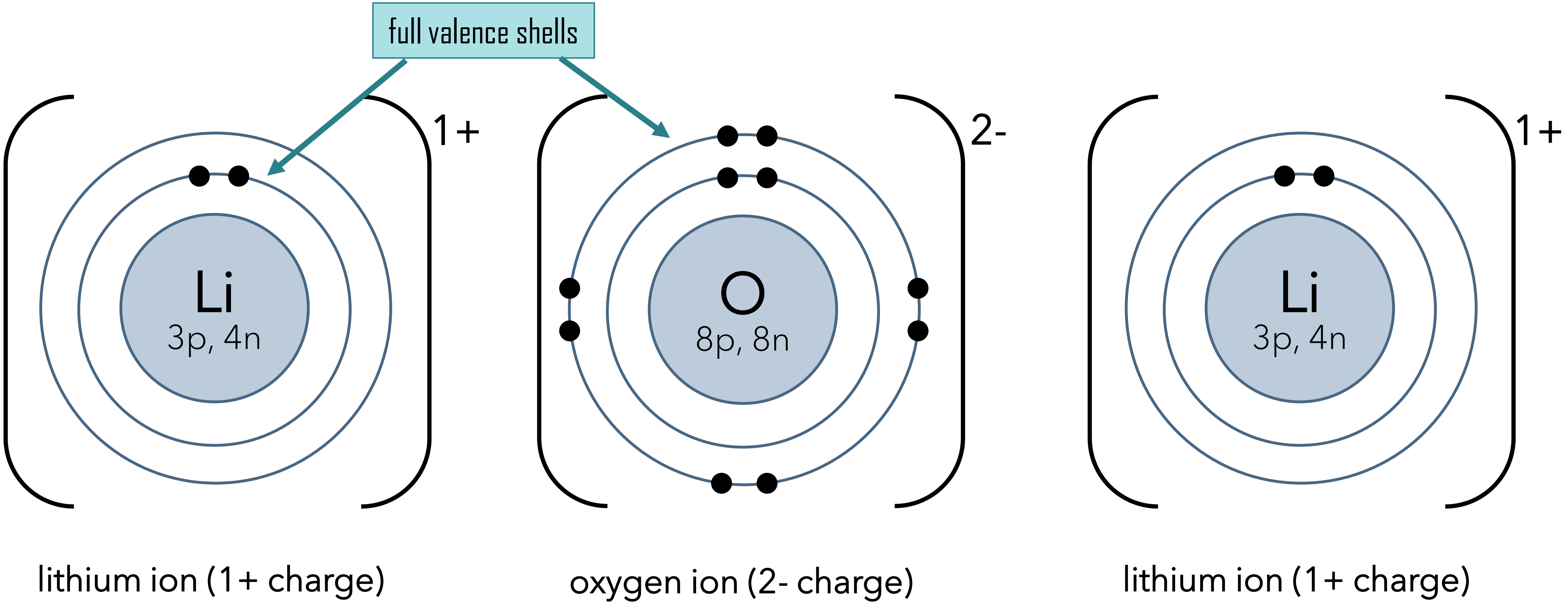
<u>Solution</u>: The compound needs two lithium ions!

Ionic Compound Formation (Li_2O)



lithium atom (neutral) | oxygen atom (neutral) | lithium atom (neutral)

Ionic Compound Formation (Li_2O)



This ionic compound is **Li_2O** (lithium oxide). It has two Li^+ ions and one O^{2-} ion.

Bohr Models of Compounds

(textbook pgs ~120-124)

Bohr Models of Ionic Compounds

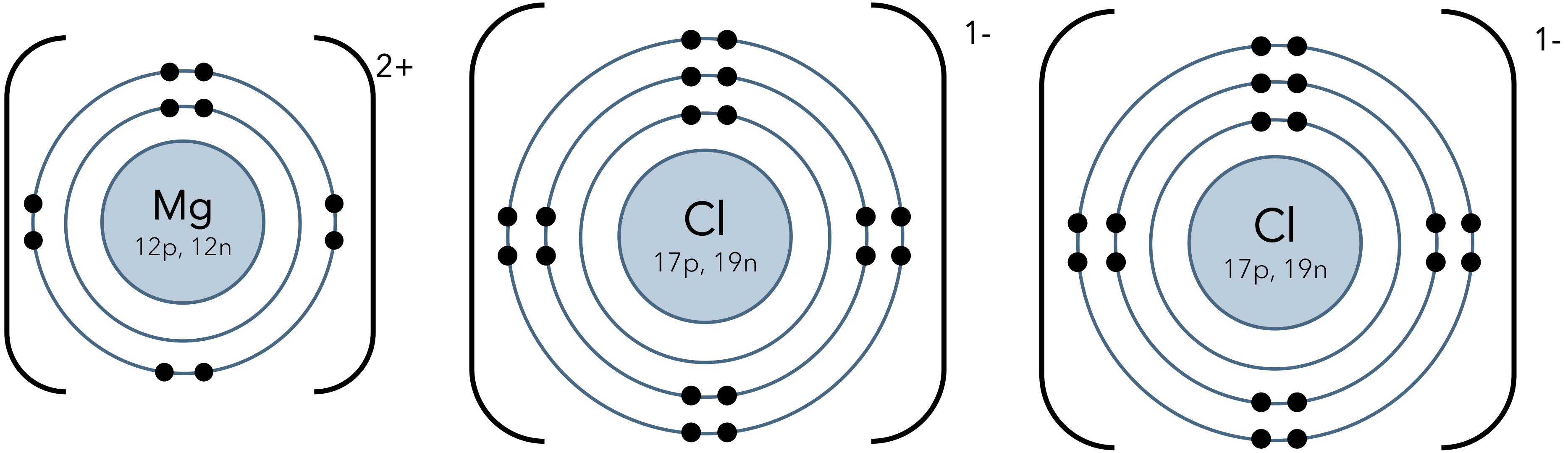
1. Determine how many of each ion is in the compound, from the subscripts.
2. Use the periodic table to find the ionic charge of each ion.
3. Draw the Bohr models of all the ions in the compound. (They should all have full valence shells.)

Practice:

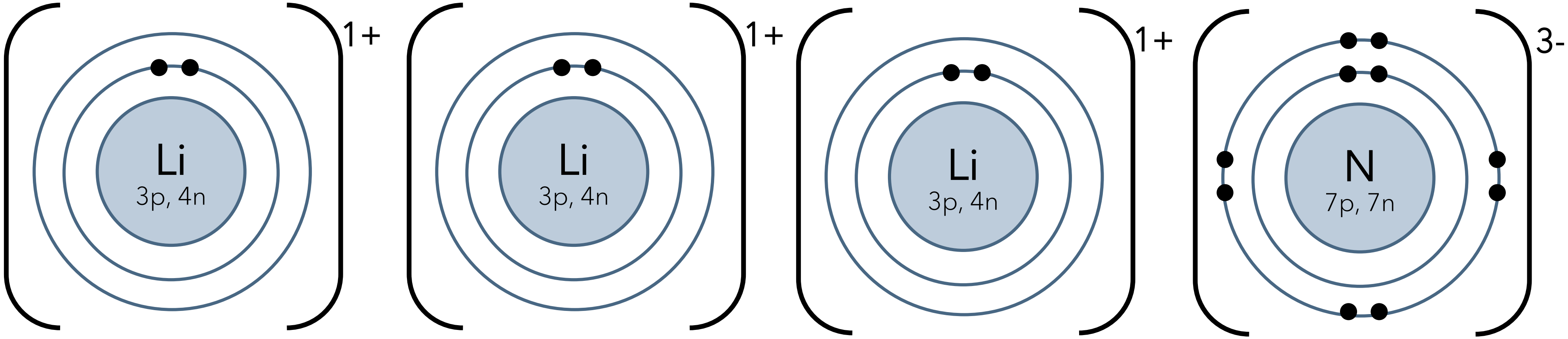
a) $MgCl_2$
b) Li_3N

Bohr Models of Ionic Compounds

$MgCl_2$



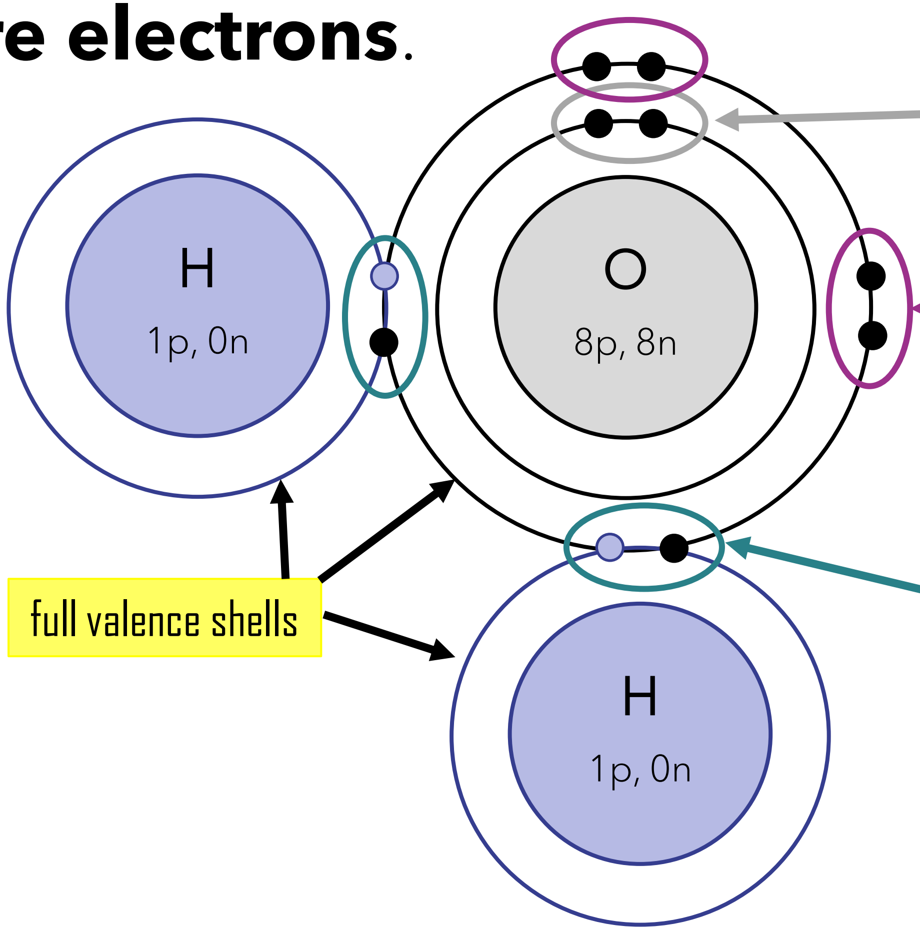
Li_3N



Covalent Compound Formation

- Covalent compounds form when two (or more) **non-metal** atoms **share electrons**.

This covalent compound is H_2O (water or dihydrogen monoxide). It has two hydrogen atoms and one oxygen atom.



(These electrons are not in the valence shell. This is *not* a lone pair.)

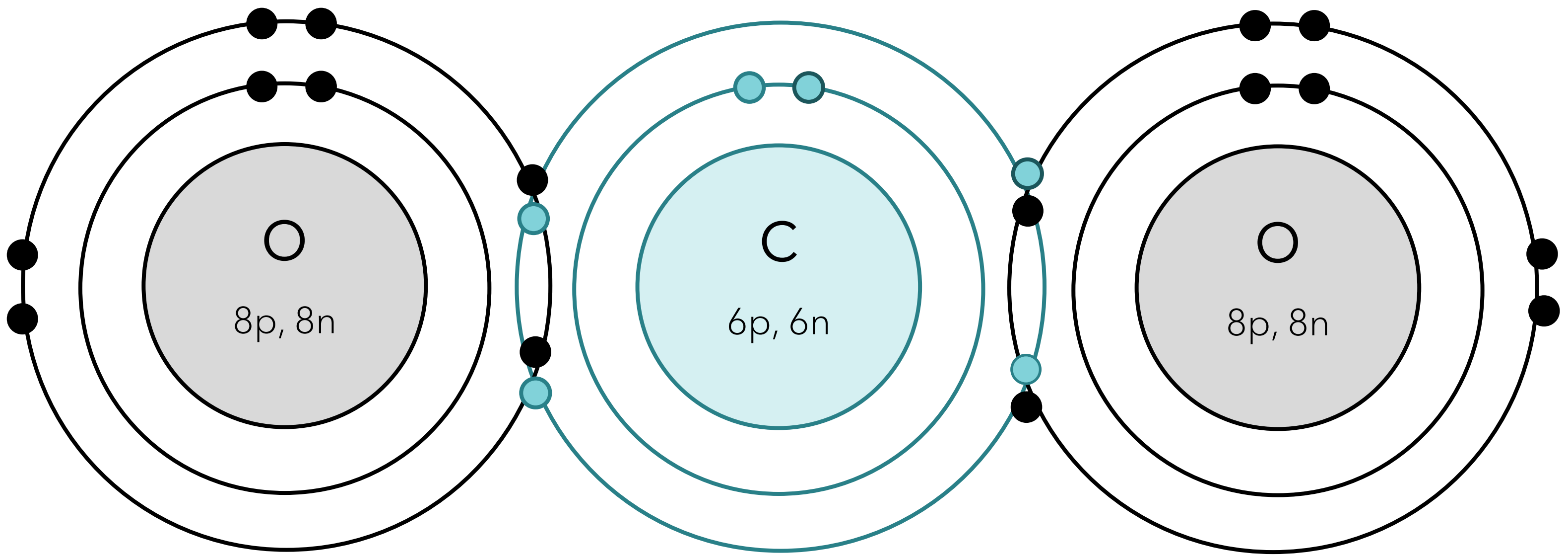
Lone pair: pair of valence electrons that is not shared between atoms

Bonding pair: shared pair of valence electrons in a covalent compound

Total: 2 bonding pairs, 2 lone pairs

Covalent Compound Formation

- Covalent compounds form when two (or more) **non-metal** atoms **share electrons**.



This covalent compound is CO_2 (carbon dioxide).
It has one carbon atom and two oxygen atoms.

Total: 4 bonding pairs, 4 lone pairs

Bohr Models of Covalent Compounds

1. Determine how many of each atom is in the compound, from the subscripts.
2. Draw the Bohr models of the atoms. 'Guess and check' what covalent bonds between valence electrons will cause all atoms to have a full valence shell.
3. Redraw the Bohr model, showing the covalent bonds.

Practice:

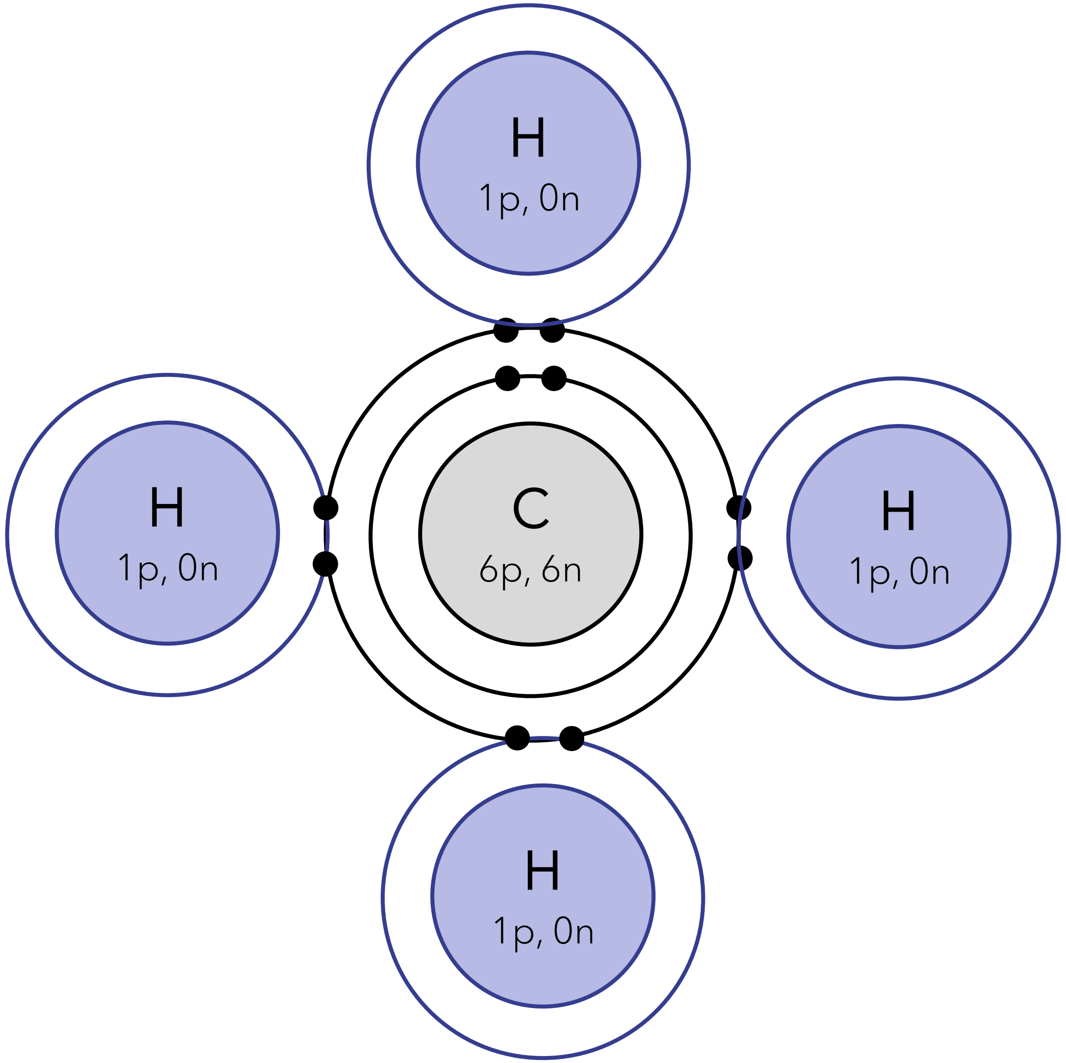
a) CH_4

b) N_2

Bohr Models of Covalent Compounds

Practice:

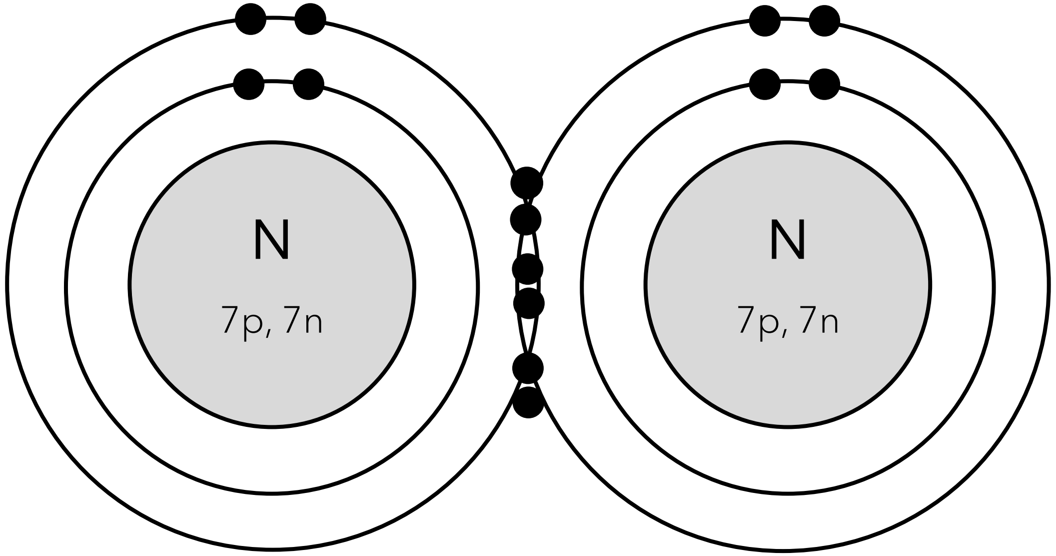
a) CH_4



Bohr Models of Covalent Compounds

Practice:

b) N_2

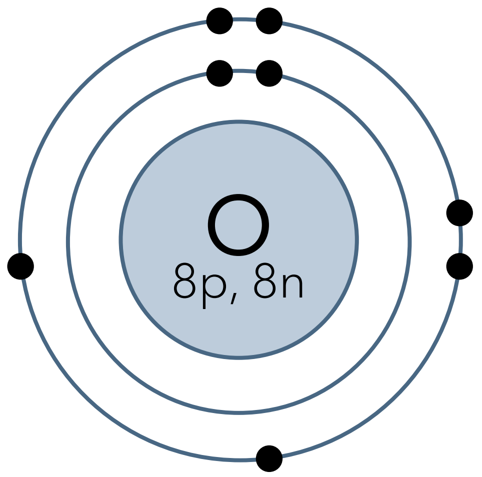


c) CO_2H_4 ???

Introducing Lewis Structures

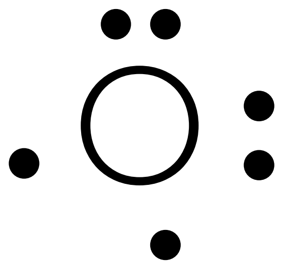
Bohr Model

- All electrons
- All energy shells
- Shows protons and neutrons
- Shows a lot of information, but is clunky and time-consuming

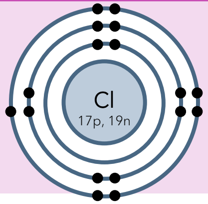
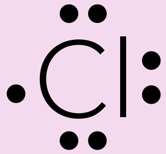
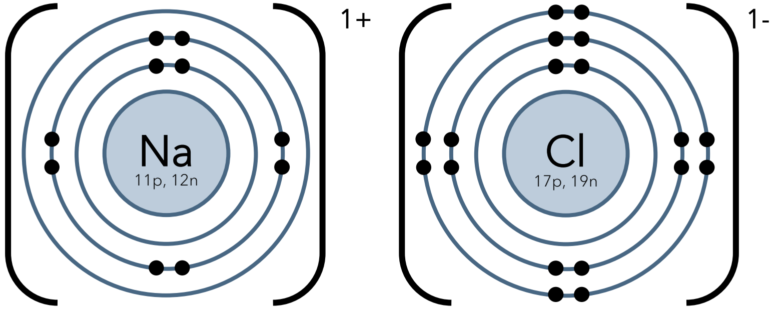
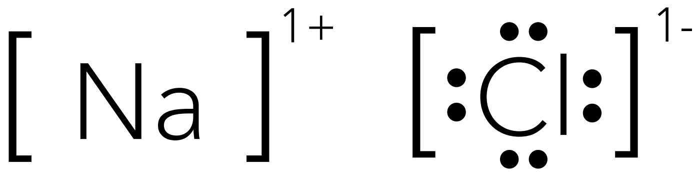
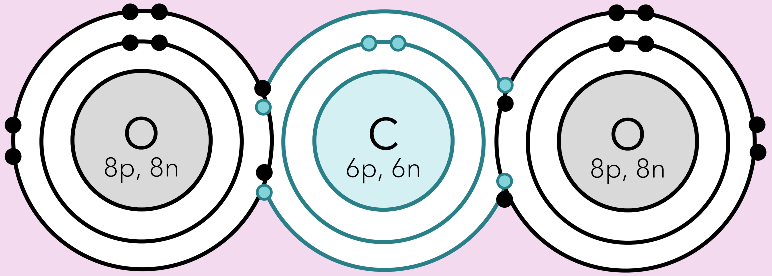
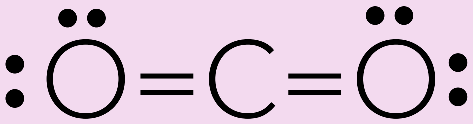


Lewis Structure

- Only **valence** electrons (except cations)
- Outermost shell only
- Protons and neutrons ignored
- Good at determining bonding in a **covalent** compound



Introducing Lewis Structures

	Bohr Model	Lewis Structure
Atom		
Ionic Compound		
Covalent Compound		

Lewis Structures of Atoms

Valence Electrons in Each Group

1																	2
1	2											3	4	5	6	7	8
1	2											3	4	5	6	7	8
1	2											3	4	5	6	7	8
1	2											3	4	5	6	7	8
1	2											3	4	5	6	7	8
1	2											3	4	5	6		

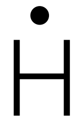
Look at the last digit of the group #. Exception: hydrogen and helium.

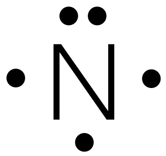
Lewis Structures of Atoms

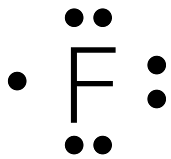
1. Write element symbol (capitalization matters!)
2. Draw valence electrons around, using the same positions as the Bohr model (i.e. clockwise, unpaired at first then paired)

Practice: Draw the Lewis structures of:

a) Mg atom 

c) H atom 

b) N atom 

d) F atom 

Lewis Structures of Ions and Ionic Compounds

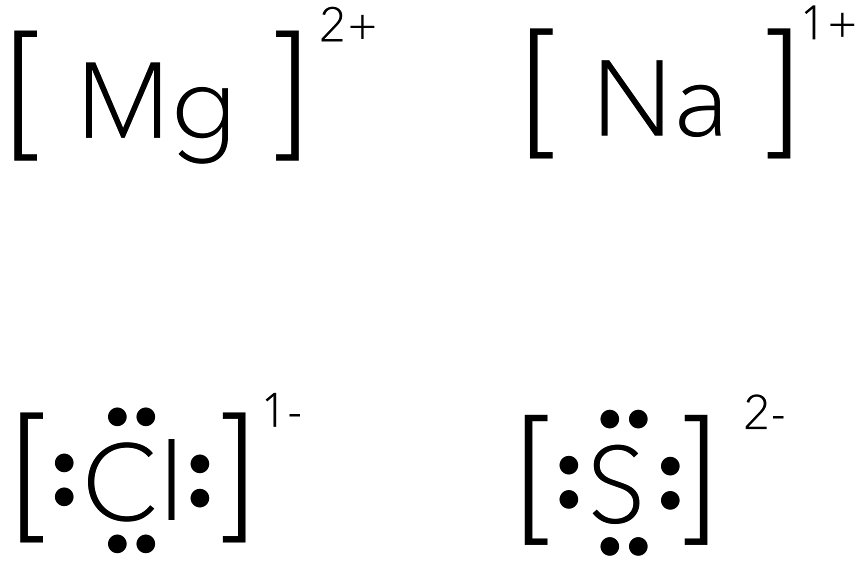
Lewis structures for ions are very similar to atoms.

Cation:

- Element symbol
- No electrons
- Square brackets and charge

Anion:

- Element symbol
- Full valence shell
- Square brackets and charge



Lewis Structures of Ions and Ionic Compounds

Practice. Draw the Lewis structures for the following:

a) NaCl $\quad [\mathrm{Na}]^{1+}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^{1-}$

b) $MgCl_2$ $\quad [\mathrm{Mg}]^{2+}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^{1-}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}:]^{1-}$

c) CaH_2 $\quad [\mathrm{Ca}]^{2+}\ [\ddot{\mathrm{H}}]^{1-}\ [\ddot{\mathrm{H}}]^{1-}$

d) AlF_3 $\quad [\mathrm{Al}]^{3+}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{F}}}:]^{1-}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{F}}}:]^{1-}\ [:\ddot{\underset{\cdot\cdot}{\mathrm{F}}}:]^{1-}$

Lewis Structures of Covalent Compounds

Rule 1: All valence electrons must be used.

Rule 2: All atoms must have a full valence shell.

1. Draw the Lewis structure of each atom.
2. Determine how many bonds each atom "needs" to complete its valence shell.
3. Guess and check with single, double, and triple bonds until your structure satisfies Rule 1 AND Rule 2.

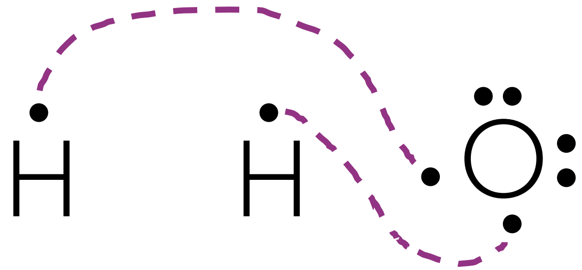
Lewis Structures of Covalent Compounds

Rule 1: All valence electrons must be used.

Rule 2: All atoms must have a full valence shell.

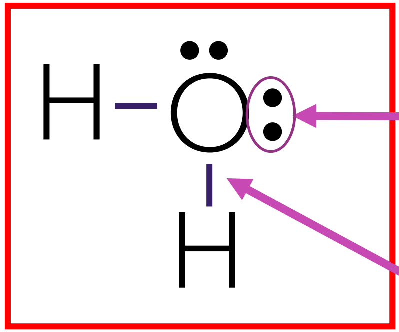
Example: H_2O

1. Draw the Lewis structure of each atom. (Count how many electrons you have in total; write this down.)
2. Determine how many bonds each atom "needs" to complete its valence shell.
3. Guess and check with single, double, and triple bonds until your structure satisfies Rule 1 AND Rule 2.



Each H needs 1 bond; O needs 2 bonds.

Total e = 8



This is a lone pair.

This is a single bond. It represents a bonding pair of electrons.

2 lone pairs;
2 bonding pairs

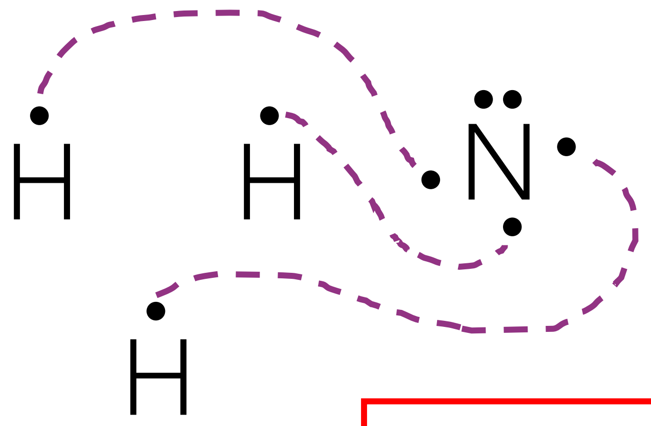
Lewis Structures of Covalent Compounds

Rule 1: All valence electrons must be used.

Rule 2: All atoms must have a full valence shell.

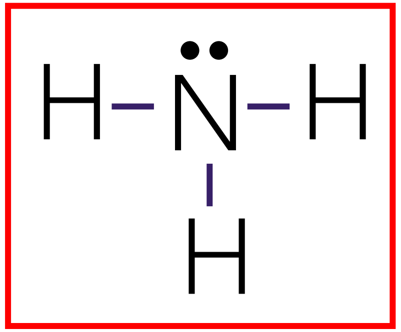
Example: NH_3

1. Draw the Lewis structure of each atom. (Count how many electrons you have in total; write this down.)
2. Determine how many bonds each atom "needs" to complete its valence shell.
3. Guess and check with single, double, and triple bonds until your structure satisfies Rule 1 AND Rule 2.



Each H needs 1 bond; N needs 3 bonds.

Total e = 8



1 lone pair;
3 bonding pairs

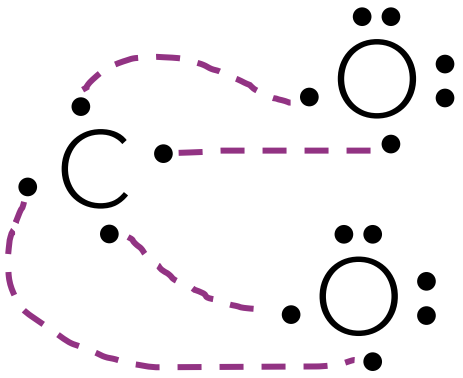
Lewis Structures of Covalent Compounds

Rule 1: All valence electrons must be used.

Rule 2: All atoms must have a full valence shell.

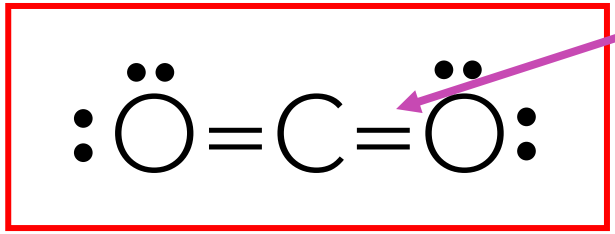
Example: CO_2

1. Draw the Lewis structure of each atom. (Count how many electrons you have in total; write this down.)
2. Determine how many bonds each atom "needs" to complete its valence shell.
3. Guess and check with single, double, and triple bonds until your structure satisfies Rule 1 AND Rule 2.



C needs 4 bonds; each O needs 2 bonds.

Total e = 16



This is a double bond. It represents two bonding pairs of electrons.

4 lone pairs;
4 bonding pairs

Lewis Structures of Covalent Compounds

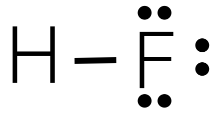
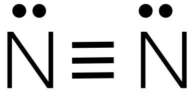
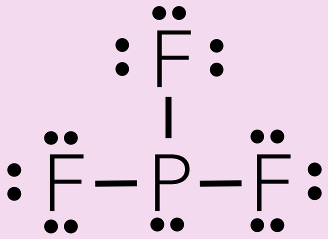
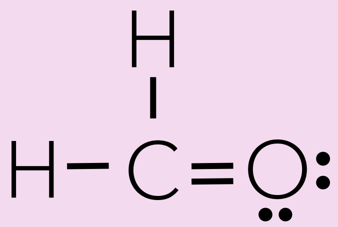
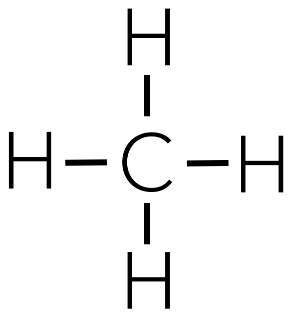
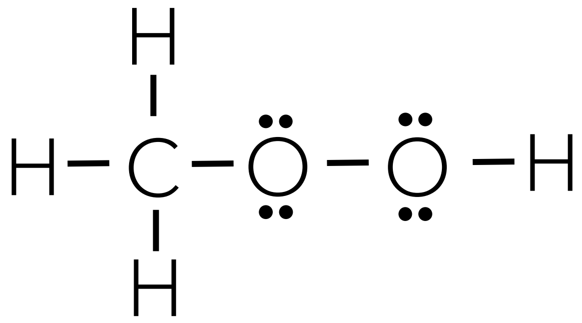
Try drawing the following covalent compounds!

- HF
- PF_3
- CH_4
- N_2 *
- CH_2O
- CO_2H_4 *(challenge)*

*Technically, N_2 is not a compound because it is only made of one element. But, the bonds between the atoms are covalent so we can still draw its Lewis structure.

Lewis Structures of Covalent Compounds

Try drawing the following covalent compounds!

	HF (3 lone pairs; 1 bonding pair)		N_2 * (2 lone pairs; 3 bonding pairs)
	PF_3 (10 lone pairs; 3 bonding pairs)		CH_2O (2 lone pairs; 4 bonding pairs)
	CH_4 (0 lone pairs; 4 bonding pairs)		CO_2H_4 (challenge) (4 lone pairs; 6 bonding pairs)

*Technically, N_2 is not a compound because it is only made of one element. But, the bonds between the atoms are covalent so we can still draw its Lewis structure.

Section 3: IUPAC Nomenclature

(not covered in textbook)

Chemical Nomenclature (Naming)

It is important to have *one* system to name chemical compounds. Why?

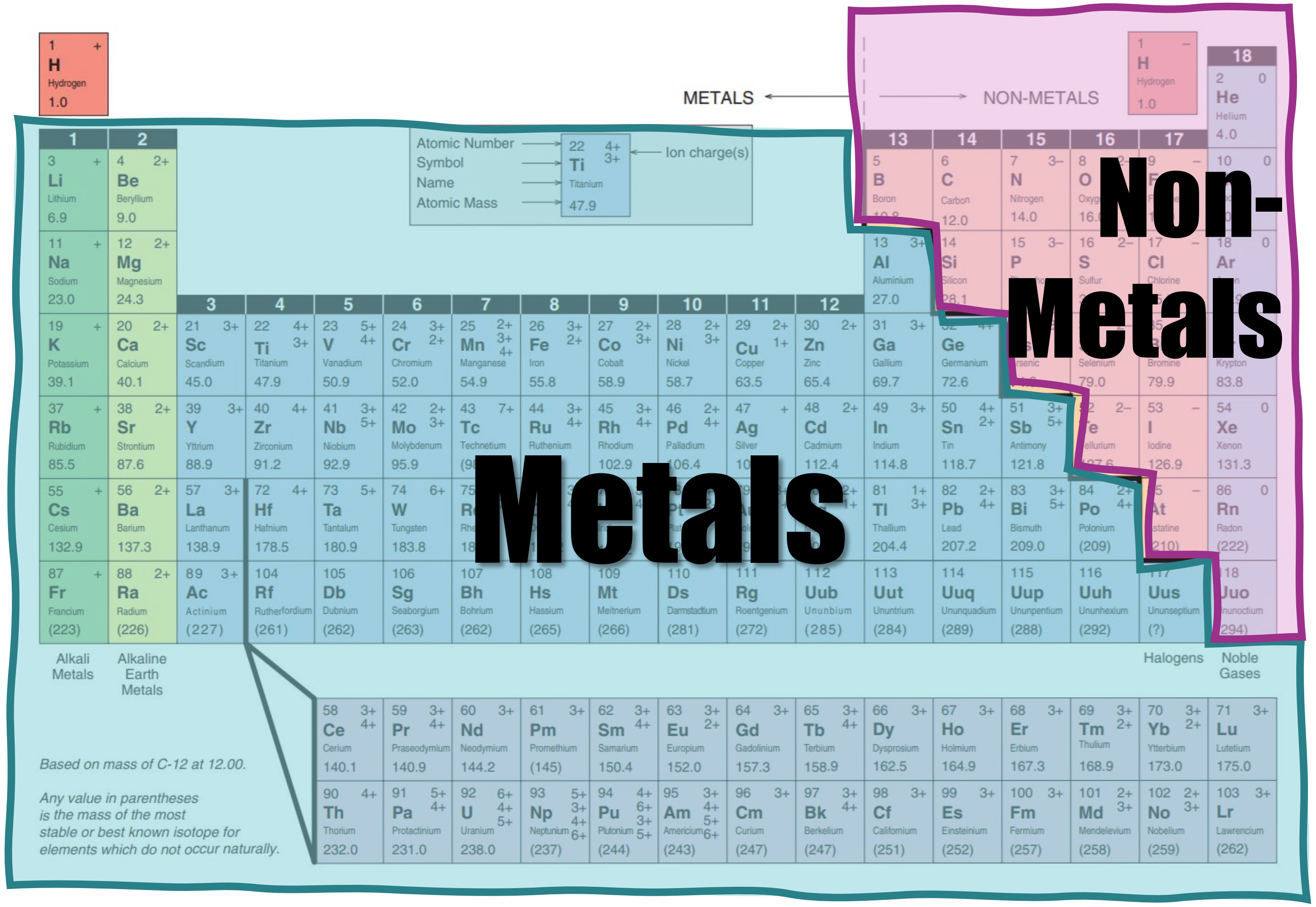
- Scientists can communicate with each other and the public, even in different languages
- Every compound has a unique name
- Information/records are accurate and consistent

IUPAC (International Union of Pure and Applied Chemistry) came up with a naming scheme that is used around the world.

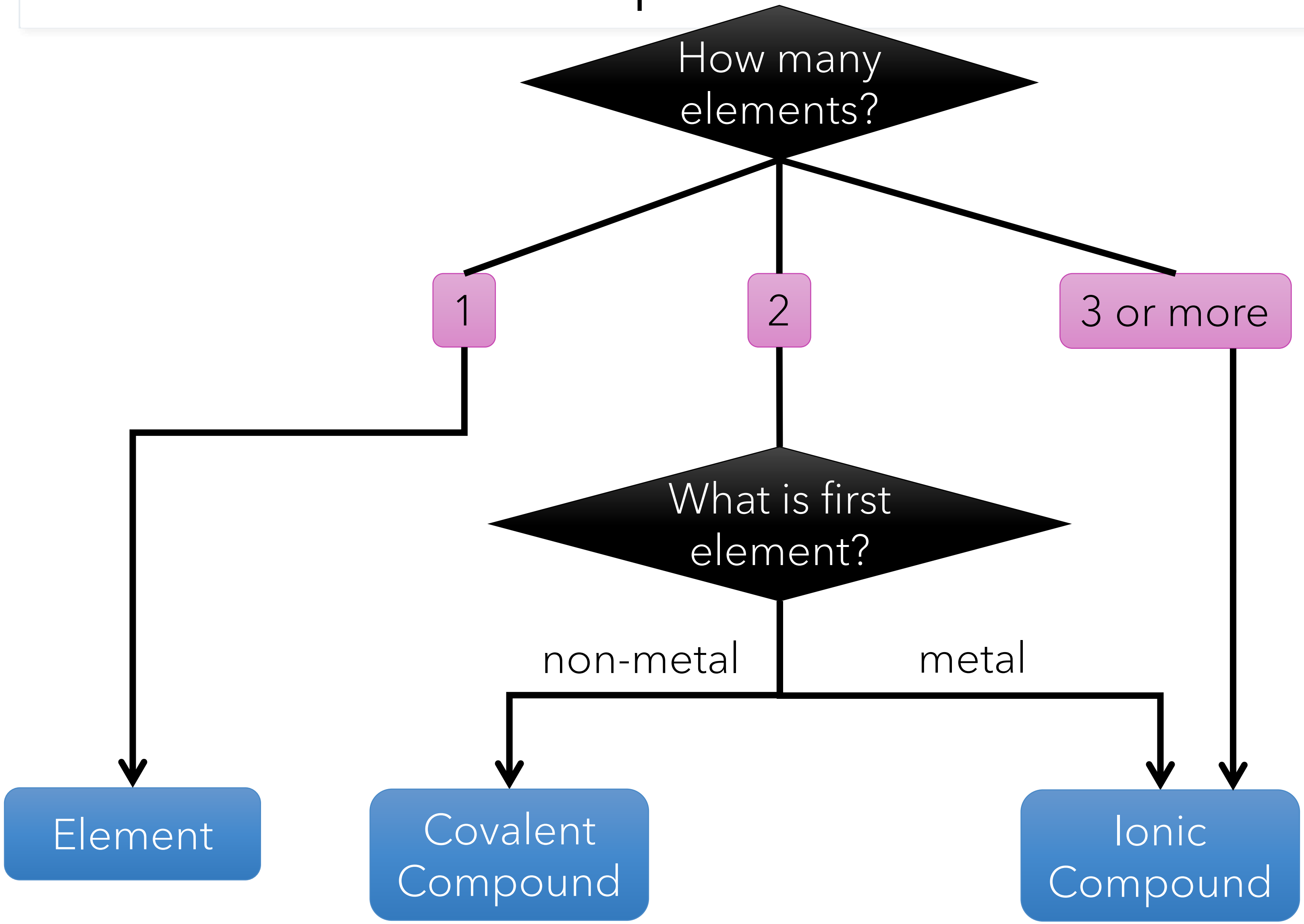
Identifying Elements, Ionic Compounds, and Covalent Compounds

Identifying Elements, Ionic Compounds, Covalent Compounds

- **Ionic compounds** form when **electrons are transferred** and ions are formed. Usually involves a **metal** and a **non-metal**.
- **Covalent compounds** form when two (or more) **non-metal** atoms **share electrons**.



Identifying Elements, Ionic Compounds, Covalent Compounds



In Science 9 and 10, you can use the following flowchart to tell apart elements and compounds based on their formulas.

(Note: in nature, many covalent compounds with 3+ elements exist; but we will not learn how to name them.)

The Cl Conundrum

Sometimes, Cl and CI can look alike. Usually, it will refer to chlorine. Rarely, it will refer to carbon and iodine. When in doubt, ask!

$NaCl$

$MgClO_4$

Cl_2

CI_4

Identifying Elements, Ionic Compounds, Covalent Compounds

Chemical	What is it?	Chemical	What is it?
PF_3		Mg	
$CaCl_2$		$NaOH$	
Cl_2		CCl_4	
NO_2		$MgBr_2$	
Br_2			

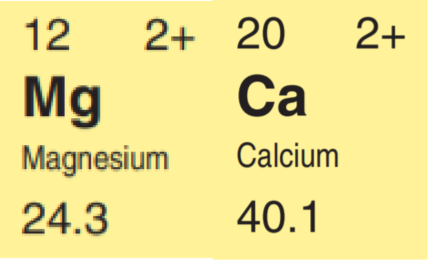
Naming Elements

Naming Elements

An **element** is a pure substance containing **only one kind of atom**.

Examples:

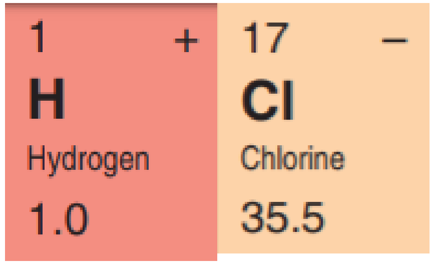
- Mg (magnesium)
- Ca (calcium)



Names of elements are found on the **periodic table**.

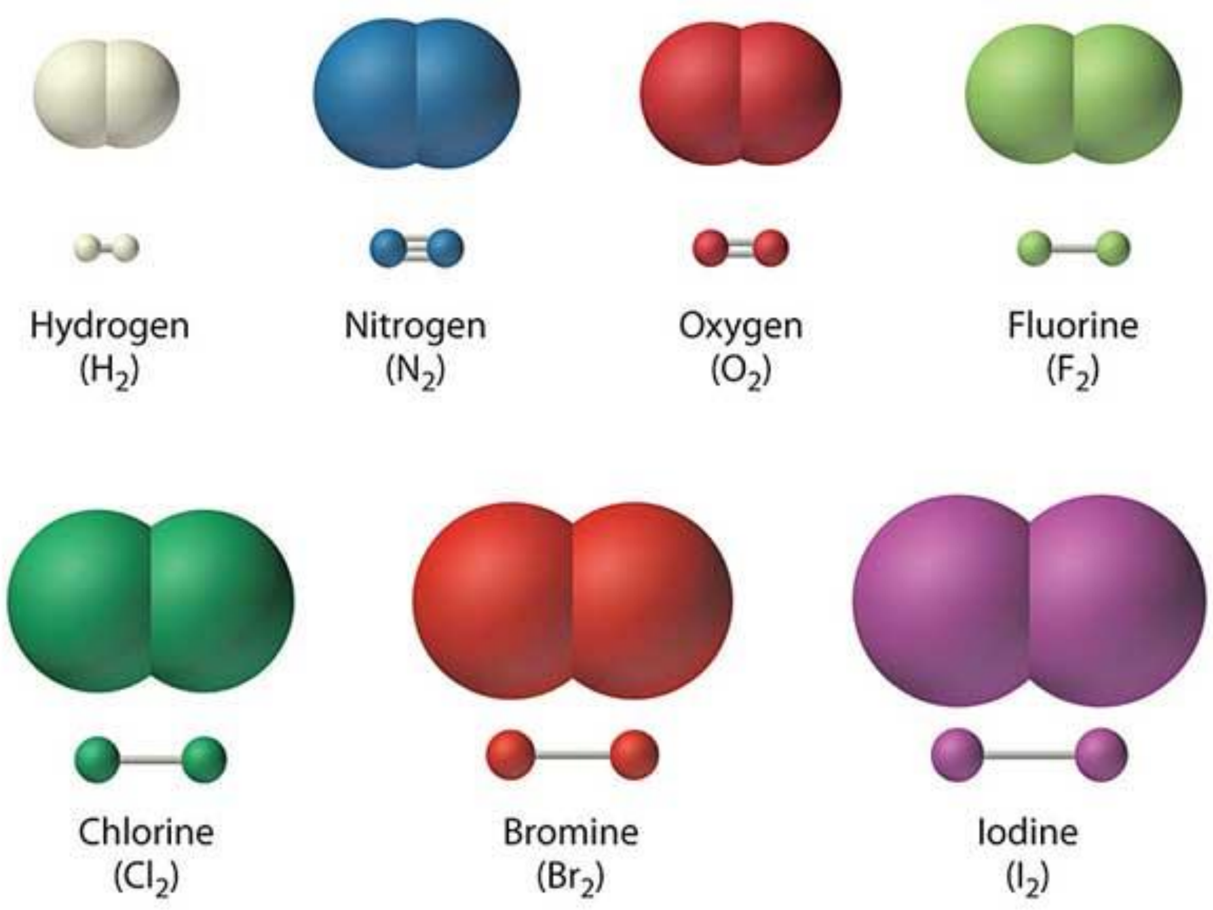
Ignore subscripts when naming.

- H_2 (hydrogen)
- Cl_2 (chlorine)



Revisiting Diatomic Elements

- When in their elemental (i.e. not in a compound) form, these elements exist as **diatomic molecules**: two atoms bonding covalently to fill their valence shells.
- Must memorize!



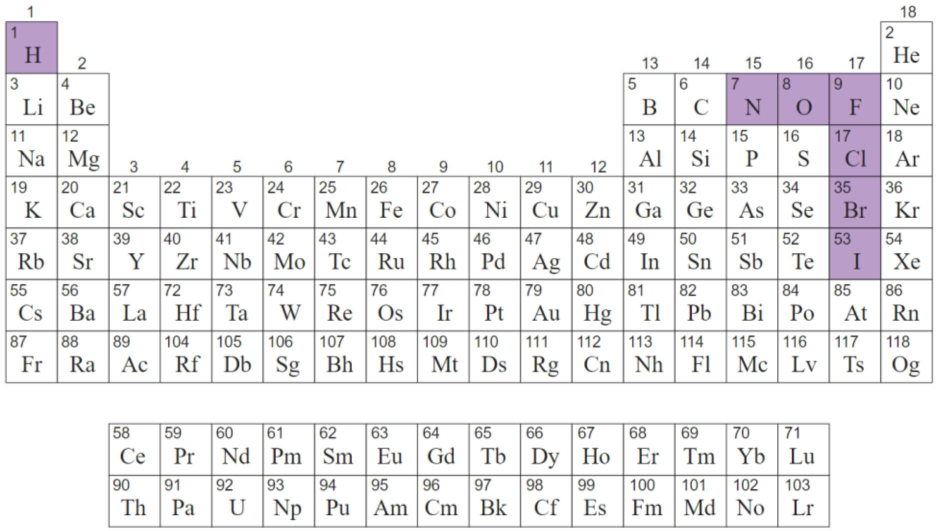
https://fl-pda.org/independent/courses/elementary/science/section4/4c6.htm

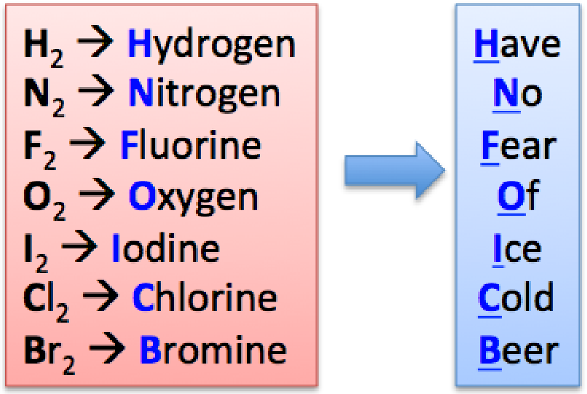
Revisiting Diatomic Elements

Memory aids:

- **HIBrONClF**
- **HOFBrINCl**
- **I Have No Bright Or Clever Friends**
- **Have No Fear Of Ice Cold Beer**
- **I Bring Cookies For Our New Home**

…or make your own!





https://study.com/academy/lesson/diatomic-molecule-definition-example.html https://mccord.cm.utexas.edu/chembook/page-nonav.php?chnum=1&sect=12

Naming Ions

(not covered in textbook)

Reference

Non-metal Element	"-ide" Ending
N, nitrogen	Nitride
O, oxygen	Oxide
F, fluorine	Fluoride
P, phosphorus	Phosphide
S, sulfur	Sulfide

Non-metal Element	"-ide" Ending
Cl, chlorine	Chloride
Se, selenium	Selenide
Br, bromine	Bromide
I, iodine	Iodide
H, hydrogen	Hydride

Non-metal Element	"-ide" Ending
As, arsenic *	Arsenide
Te, tellurium *	Telluride
At, astatine *	Astatide

* uncommon

Different Types of Ions

<u>Monovalent ion</u>:

- Can only make one ion (see periodic table)
- Cations: write name of element
- Anions: write name of element with "–ide" ending

Examples:

- Sodium ion = Na^{+}
- Yttrium ion = Y^{3+}
- Bromide ion = Br^{-}
- Oxide ion = O^{2-}

Different Types of Ions

<u>Multivalent Ion</u>:

- An element that can make *<u>multiple possible ions</u>* (see periodic table)
- Metals only
- Must specify charge with Roman numerals

Examples:

- manganese(III) = Mn^{3+}
- manganese(IV) = Mn^{4+}
- copper(I) = Cu^{+}
- vanadium(V) = V^{5+}

Note: manganese and magnesium are *different* elements!

Different Types of Ions

<u>Polyatomic ion</u>:

- Group of non-metal atoms *covalently* bonded with an ionic charge
- Spelling counts!!! (Copy from table)

Examples:

- NH_4^+ = ammonium ion
- PO_4^{3-} = phosphate ion
- PO_3^{3-} = phosphite ion

Polyatomic Ions

Note: Become familiar with these names so you can recognize them quickly in the future.

NAMES, FORMULAE AND CHARGES OF SOME POLYATOMIC IONS

Positive Ions		Negative Ions	
NH_4^+	Ammonium	CH_3COO^-	Acetate
		CO_3^{2-}	Carbonate
		ClO_3^-	Chlorate
		ClO_2^-	Chlorite
		CrO_4^{2-}	Chromate
		CN^-	Cyanide
		$Cr_2O_7^{2-}$	Dichromate
		HCO_3^-	Hydrogen carbonate, bicarbonate
		HSO_4^-	Hydrogen sulfate, bisulfate
		HS^-	Hydrogen sulfide, bisulfide

Positive Ions	Negative Ions	
	HSO_3^-	Hydrogen sulfite, bisulfite
	OH^-	Hydroxide
	ClO^-	Hypochlorite
	NO_3^-	Nitrate
	NO_2^-	Nitrite
	ClO_4^-	Perchlorate
	MnO_4^-	Permanganate
	PO_4^{3-}	Phosphate
	PO_3^{3-}	Phosphite
	SO_4^{2-}	Sulfate
	SO_3^{2-}	Sulfite

Ionic Compound Nomenclature

(not covered in textbook)

Intro to Ionic Compound Nomenclature

Cation comes first; anion comes second.

Names of ionic compounds tell you *which ions* are in the compound.

e.g. "sodium chloride" has Na^+ and Cl^- ions.

e.g. "titanium(IV) dichromate" has Ti^{4+} and $Cr_2O_7^{2-}$ ions.

Chemical formulae tell you *how many of each ion* are in the compound, using subscripts.

e.g. "$CaCl_2$" has 1 Ca^{2+} ion and 2 Cl^- ions.

e.g. "$Mn(OH)_2$" has 1 Mn^{4+} ion and 2 OH^- ions.

Naming Ionic Compounds

1. Write the **cation**, first.

   For metals that can only form one ion (monovalent metals), do not write the ion charge.

   For multivalent metals, determine the ion charge through **charge balancing**. Then, put the ion charge in **Roman numerals**, in brackets.

   If the cation is polyatomic, write it exactly the way it is written in the table.

2. Write the anion with **"–ide" ending** (unless it is polyatomic).

Naming Ionic Compounds

1. Write the ***cation, first***.
2. Write the ***anion with "–ide" ending***.

Chemical Formula	Periodic Table		Name
NaCl	11 + **Na** Sodium 23.0	17 – **Cl** Chlorine 35.5	
$MgBr_2$	12 2+ **Mg** Magnesium 24.3	35 – **Br** Bromine 79.9	

Naming Ionic Compounds

Oh no! Chromium is multivalent. Charge balancing is used to find the charge of a **multivalent metal ion.**

1. Write the ***cation, first***.
2. Write the ***anion with "–ide" ending***.

Chemical Formula	Periodic Table	Name
Cr_2O_3	24 Cr Chromium 52.0 ($3+$, $2+$); 8 O Oxygen 16.0 ($2-$)	???
CrO		???

Naming Ionic Compounds

1. Write the cation, first.

    For metals that can only form one ion (monovalent metals), do not write the ion charge.

    For multivalent metals, determine the ion charge through ***charge balancing***. Then, put the ion charge in ***Roman numerals***, in brackets.

2. Write the anion with "–ide" ending.

Charge Balancing (to find the charge of a **multivalent** metal ion)

1) Write out all the ions you have. Leave the charge blank on the multivalent metal.
2) Rule: *The total number of* ***positive*** *charges in an ionic compound must equal the total number of* ***negative*** *charges. Determine the charge on the metal ion.*
3) Write the compound name. Specify the ion charge on the multivalent metal using brackets and Roman numerals.

Charge Balancing Part 1: Determining Charges of Multivalent Metals

24 3+ 2+
Cr
Chromium
52.0

8 2–
O
Oxygen
16.0

Cr_2O_3:	
1) Write out all the ions you have. Leave the charge blank on the multivalent metal.	$Cr^?$ $Cr^?$ O^{2-} O^{2-} O^{2-} We know there are 2 chromium ions and 3 oxygen ions from the subscripts in the formula.
2) *The total number of positive charges in an ionic compound must equal the total number of negative charges.* Determine the charge on the metal ion.	Total: 6 negative charges. Must have 6 positive to balance the charges. Divide by # of chromium ions (2). Therefore, each Cr ion must have a 3+ charge.
3) Write the compound name. Specify the ion charge on the multivalent metal using brackets and Roman numerals.	chromium(III) oxide

Charge Balancing Part 1: Determining Charges of Multivalent Metals

24 3+ 2+
Cr
Chromium
52.0

8 2–
O
Oxygen
16.0

CrO:	
1) Write out all the ions you have. Leave the charge blank on the multivalent metal.	$Cr^{?}$ O^{2-} We know there is 1 chromium ion and 1 oxygen ion from the subscripts in the formula.
2) *The total number of positive charges in an ionic compound must equal the total number of negative charges.* Determine the charge on the metal ion.	Total: 2 negative charges. Must have 2 positive to balance the charges. Divide by # of chromium ions (1). Therefore, each Cr ion must have a 2+ charge.
3) Write the compound name. Specify the ion charge on the multivalent metal using brackets and Roman numerals.	chromium(II) oxide

Naming Ionic Compounds

1. Write the cation, first.

   For metals that can only form one ion (monovalent metals), do not write the ion charge.

   For multivalent metals, determine the ion charge through charge balancing. Then, put the ion charge in Roman numerals, in brackets.

   If the cation is polyatomic, write it exactly the way it is written in the table.

2. Write the anion with “–ide” ending *(unless it is polyatomic.)*

Polyatomic Ions

Note: Become familiar with these names so you can recognize them quickly in the future.

NAMES, FORMULAE AND CHARGES OF SOME POLYATOMIC IONS

Positive Ions		Negative Ions	
NH_4^+	Ammonium	CH_3COO^-	Acetate
		CO_3^{2-}	Carbonate
		ClO_3^-	Chlorate
		ClO_2^-	Chlorite
		CrO_4^{2-}	Chromate
		CN^-	Cyanide
		$Cr_2O_7^{2-}$	Dichromate
		HCO_3^-	Hydrogen carbonate, bicarbonate
		HSO_4^-	Hydrogen sulfate, bisulfate
		HS^-	Hydrogen sulfide, bisulfide

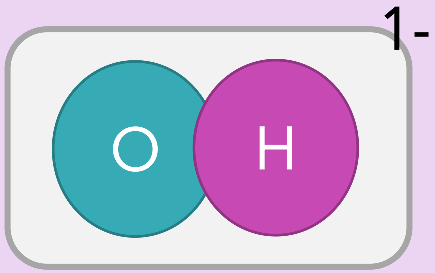
Positive Ions	Negative Ions	
	HSO_3^-	Hydrogen sulfite, bisulfite
	OH^-	Hydroxide
	ClO^-	Hypochlorite
	NO_3^-	Nitrate
	NO_2^-	Nitrite
	ClO_4^-	Perchlorate
	MnO_4^-	Permanganate
	PO_4^{3-}	Phosphate
	PO_3^{3-}	Phosphite
	SO_4^{2-}	Sulfate
	SO_3^{2-}	Sulfite

Polyatomic Ions

Polyatomic ions: ions made of multiple atoms bonded covalently together. They have special names.

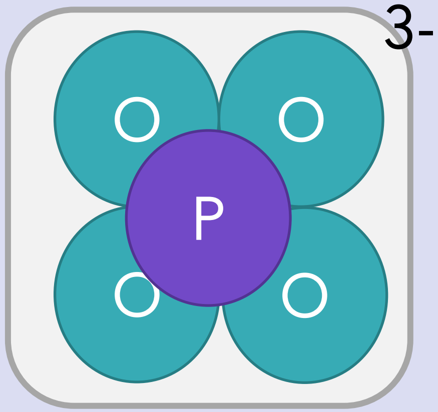
"hydroxide" or "OH^-" is made of an oxygen and hydrogen atom bonded together. Altogether, the structure has a charge of 1-.

e.g. sodium hydroxide: $NaOH$



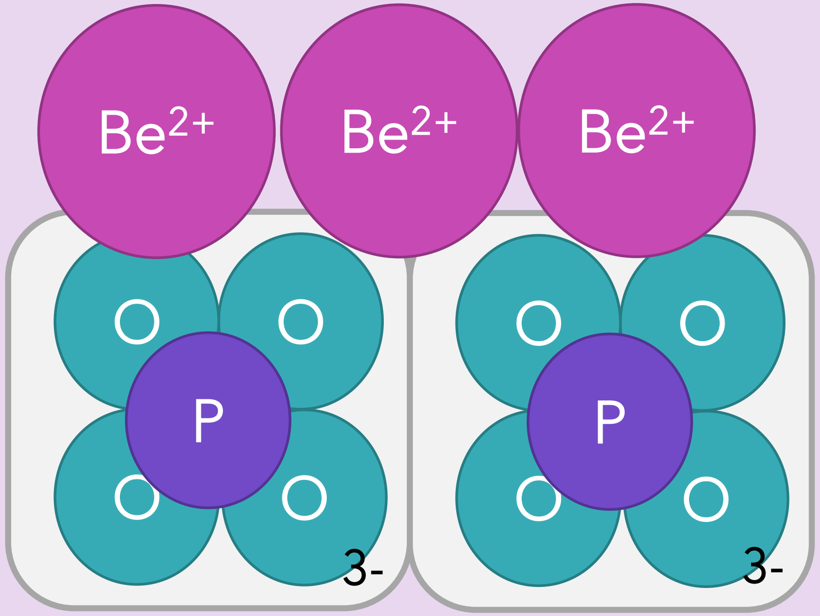
"phosphate" or "PO_4^{3-}" is made of one phosphorus atom and four oxygen atoms bonded together. Altogether, the structure has a charge of 3-.

e.g. sodium phosphate: Na_3PO_4
chromium(II) phosphate: $Cr_3(PO_4)_2$



Polyatomic Ions

To indicate more than one of a polyatomic ion in a compound, use brackets and subscripts.

Chemical Formula	Simplified Model
A subscript outside a bracket applies to the entire polyatomic ion inside the bracket. $Be_3(PO_4)_2$	

Polyatomic Ions

To indicate more than one of a polyatomic ion in a compound, use brackets and subscripts. Treat polyatomic ions as single entities when naming, incl. counting atoms.

Chemical Formula	Cation	Anion	Atom Count
NaOH	Na^+	OH^-	Na:1 O:1 H:1

Rules for Naming Ionic Compounds (FINAL)

1. Write the ***cation, first***.

    For metals that can only form one ion (monovalent metals), do not write the ion charge.

    For multivalent metals, determine the ion charge through ***charge balancing***. Then, put the ion charge in ***Roman numerals***, in brackets.

    If the cation is polyatomic, write it exactly the way it is written in the table.

2. Write the anion with ***"–ide" ending*** (unless it is polyatomic.)

Naming with Polyatomic Ions: Examples

Chemical Formula	Periodic Table	Name
$Mg(OH)_2$	12 2+ Mg Magnesium 24.3 HSO_3^- Hydrogen sulfite, bisulfite OH^- Hydroxide ClO^- Hypochlorite	magnesium hydroxide
$(NH_4)_2S$	**Positive Ions** NH_4^+ Ammonium 16 2– S Sulfur 32.1	ammonium sulfide

Naming with Polyatomic Ions: Examples

<table>
<tr><th>Chemical Formula</th><th>Periodic Table</th><th>Name</th></tr>
<tr>
<td>$Sc(HSO_3)_3$</td>
<td>21 3+
Sc
Scandium
45.0

HSO_4^- Hydrogen sulfate, bisulfate
HS^- Hydrogen sulfide, bisulfide
HSO_3^- Hydrogen sulfite, bisulfite</td>
<td>1. scandium hydrogen sulfite *OR*
2. scandium bisulfite

~~scandium hydrogen sulfite, bisulfite~~</td>
</tr>
</table>

Naming with Polyatomic Ions: Examples

22	4+
Ti	3+
Titanium	
47.9	

ClO_2^-	Chlorite
CrO_4^{2-}	Chromate
CN^-	Cyanide

$Ti_2(CrO_4)_3$:	
1) Write out all the ions you have. Leave the charge blank on the multivalent metal.	$Ti^?$ $Ti^?$ CrO_4^{2-} CrO_4^{2-} CrO_4^{2-}
2) *The total number of positive charges in an ionic compound must equal the total number of negative charges.* Determine the charge on the metal ion.	Total: 6 negative charges. Must have 6 positive to balance the charges. Divide by # of titanium ions (2). Therefore, each Ti ion must have a 3+ charge.
3) Write the compound name. Specify the ion charge on the multivalent metal using brackets and Roman numerals. Spell the polyatomic ion exactly as it is spelled in the reference sheet.	titanium(III) chromate

Writing Formulas of Ionic Compounds

(not covered in textbook)

Intro to Ionic Compound Nomenclature

Names of ionic compounds tell you *which ions* are in the compound. The cation comes first; the anion comes second.

To write a chemical formula of an ionic compound, you must find out how many of each ion is involved, through **charge balancing.**

Rule: The total number of positive charges in an ionic compound must equal the total number of negative charges.

Writing Formulas of Ionic Compounds (v1)

1. Write down each ion with its charge.
2. Add more of the ions to balance the charges: the total number of positive and negative charges must be equal.
3. Write your formula with subscripts.

   To indicate more than one of a polyatomic ion, use brackets with the subscript outside.

Writing Chemical Formulas: Examples (v1)

20 2+
Ca
Calcium
40.1

15 3–
P
Phosphorus
31.0

calcium phosphide	
1) Write down each ion with its charge.	Ca^{2+} P^{3-} Ca^{2+} P^{3-} Ca^{2+}
2) Add more of the ions to balance the charges: the total number of positive and negative charges must be equal.	
3) Write your formula with subscripts.	Ca_3P_2

Writing Chemical Formulas: Examples (v1)

24	3+	
Cr	2+	
Chromium		
52.0		

HSO_3^-	Hydrogen sulf
OH^-	Hydroxide
ClO^-	Hypochlorite

chromium(II) hydroxide	
1) Write down each ion with its charge.	Cr^{2+} OH^- OH^-
2) Add more of the ions to balance the charges: the total number of positive and negative charges must be equal.	
3) Write your formula with subscripts.	$Cr(OH)_2$

Writing Formulas of Ionic Compounds (v2)

1. Write down each ion with its charge.
2. Write the chemical formula by writing the cation first and the anion second. Then, “criss-cross” the charges to become the subscripts.
3. Reduce the subscripts if both divisible by the same number.

Writing Chemical Formulas: Examples (v2)

20 2+
Ca
Calcium
40.1

15 3–
P
Phosphorus
31.0

calcium phosphide	
1) Write down each ion with its charge.	Ca^{2+} P^{3-}
2) Write the chemical formula by writing the cation first and the anion second. Then, "criss-cross" the charges to become the subscripts.	Ca_3P_2
3) Reduce the subscripts if both divisible by the same number.	2 and 3 do not have a common factor. Therefore, Ca_3P_2 is our final answer.

Writing Chemical Formulas: Examples (v2)

24 3+
Cr 2+
Chromium
52.0

HSO_3^-	Hydrogen sulf
OH^-	Hydroxide
ClO^-	Hypochlorite

chromium(II) hydroxide	
1) Write down each ion with its charge.	Cr^{2+} OH^- $Cr(OH)_2$
2) Write the chemical formula by writing the cation first and the anion second. Then, "criss-cross" the charges to become the subscripts.	
3) Reduce the subscripts if both divisible by the same number.	1 and 2 do not have a common factor. Therefore, $Cr(OH)_2$ is our final answer.

Writing Chemical Formulas: Examples (v2)

12	2+
Mg	
Magnesium	
24.3	

CH_3COO^-	Acetate
CO_3^{2-}	Carbonate
ClO_3^-	Chlorate

magnesium carbonate	
1) Write down each ion with its charge.	Mg^{2+} CO_3^{2-}
2) Write the chemical formula by writing the cation first and the anion second. Then, "criss-cross" the charges to become the subscripts.	$Mg_2(CO_3)_2$
3) Reduce the subscripts if both divisible by the same number.	2 and 2 are both divisible by 2. Rewrite formula as **$MgCO_3$**.

Writing Chemical Formulas: Examples (v2)

25
Mn
2+
3+
4+
Manganese
54.9

PO_3^{3-}	Phosphite
SO_4^{2-}	Sulfate
SO_3^{2-}	Sulfite

manganese(IV) sulfate	
1) Write down each ion with its charge.	Mn^{4+} SO_4^{2-}
2) Write the chemical formula by writing the cation first and the anion second. Then, "criss-cross" the charges to become the subscripts.	$Mn_2(SO_4)_4$
3) Reduce the subscripts if both divisible by the same number.	4 and 2 are both divisible by 2. Rewrite formula as $Mn(SO_4)_2$.

Naming and Writing Formulas: Covalent Compounds

(not covered in textbook)

Naming Binary Covalent Compounds

- Binary covalent compound: a covalent compound containing only two element
- Names and formulas of covalent compounds *both* tell you:
  - Which elements
  - How many atoms of each element

Naming Binary Covalent Compounds

1. Write the first element.
2. Write the second element with "–ide" ending.
3. Add **prefixes** to show how many of each element there is.
   - *Do not add "mono-" to first element.*
   - *If adding "mono-" to "-oxide", write "monoxide" instead.*

e.g. O_2F_2 di oxygen difluoride

e.g. PF_3 phosphorus trifluoride

e.g. N_2O di nitrogen mon oxide

Note: All compound names (covalent *and* ionic) are lowercase.

Naming Binary Covalent Compounds

Covalent compounds with special names (must memorize):

NH_3 = ammonia

H_2O = water

CH_4 = methane

NH_4^+ (ammonium ion) and NH_3 (ammonia) are ***not the same!!!***

Chemical Formulas of Binary Covalent Compounds

1. Identify the elements involved. Write their symbols.
2. Use the prefixes to determine the number of each element in the compound. Write as subscripts.

e.g. tetraphosphorus pentaoxide

P_4O_5

e.g. nitrogen triiodide

NI_3

e.g. xenon hexafluoride

XeF_6

More Practice: Binary Covalent Compounds

Chemical Formula	Compound Name
CO_2	
CO	
CCl_4	
P_4O_5	
	diphosphorus pentaoxide
	xenon hexafluoride

Section 4: Balancing Chemical Equations

(textbook pgs 125-133)

Chemical Equation Vocabulary

Reactants: what goes into the reaction; on the left side of reaction arrow

Products: what comes out of the reaction; on the right side of reaction arrow

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

Chemical Equation Vocabulary

Word equation: uses words to describe reactants and products

$$\text{zinc} + \text{hydrogen chloride} \rightarrow \text{zinc chloride} + \text{hydrogen}$$

Skeleton equation: uses chemical formulas to describe reactants and products

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

Tip: When converting between word and skeleton equations, remember your diatomic elements!

Chemical Reaction Vocabulary

Balanced chemical equation: uses coefficients and chemical formulas to describe reactants and products in their correct proportions

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Chemical Reaction Vocabulary (FYI only)

In chemical equations, you will sometimes see information about the state that a chemical substance is in.

E.g. $\mathbf{2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}}$

(g): Gas

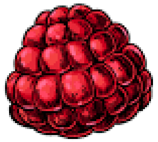
(l): Liquid

(s): Solid

(aq): Aqueous solution (substance is dissolved in water)

Fruit Tart Case Study

You are making fruit tarts for a party. You have a certain number of each ingredient. How many tarts can you make? What is left over?



12

raspberries

+

8

blackberries

+

4

fruitless tarts

→

??

https://www.mypetitejoys.com/no-bake-blackberry-mini-tarts/ https://leaf.nutrisystem.com/recipes/skinny-mini-fruit-tart/ https://www.youtube.com/watch?v=mfGNSkXOUHo

Fruit Tart Case Study

You are making fruit tarts for a party. Unfortunately, after you are finished, you see an Instagram picture that makes you want to rearrange your fruit tarts. You need 3 finished raspberry/blackberry tarts in total. How many of each tart will you start with? What will you be left with?

6 raspberries each

+

1 blackberry each

→

2 raspberries +
1 blackberry each

https://www.mypetitejoys.com/no-bake-blackberry-mini-tarts/ https://leaf.nutrisystem.com/recipes/skinny-mini-fruit-tart/ https://www.youtube.com/watch?v=mfGNSkXOUHo

Fruit Tart Case Study

You are making fruit tarts for a party. Unfortunately, after you are finished, you see an Instagram picture that makes you want to rearrange your fruit tarts. You need 3 finished raspberry/blackberry tarts in total. How many of each tart will you start with? What will you be left with?

6 raspberries each

+

1 blackberry each

→

2 raspberries +
1 blackberry each

+

fruitless tart

Discuss: approaches and strategies in completing this problem

https://www.mypetitejoys.com/no-bake-blackberry-mini-tarts/

https://leaf.nutrisystem.com/recipes/skinny-mini-fruit-tart/

https://veenaazmanov.com/homemade-mini-tart-shells/

https://www.youtube.com/watch?v=mfGNSkXOUHo

Fruit Tart Case Study

 +  →  + 

6 raspberries each | 1 blackberry each | 2 raspberries + 1 blackberry each | fruitless tart

$$\underline{\ 1\ }\,Rb_6T + \underline{\ 3\ }\,BbT \rightarrow \underline{\ 3\ }\,Rb_2BbT + \underline{\ 1\ }\,T$$

Legend

Rb = “raspberry” element
Bb = “blackberry” element
T = “tart” element

Follow-up: Now, suppose that you need 12 tarts instead of 3. How many raspberry and blackberry tarts do you start with?

https://veenaazmanov.com/homemade-mini-tart-shells/

https://www.mypetitejoys.com/no-bake-blackberry-mini-tarts/
https://leaf.nutrisystem.com/recipes/skinny-mini-fruit-tart/
https://www.youtube.com/watch?v=mfGNSkXOUHo

Balancing Chemical Equations

Why balance?

- Chemical "recipes": how much do you put in? how much do you expect to yield?
- **Conservation of mass**: no atoms are ever created or destroyed

https://www.budgetbytes.com/

Balancing Chemical Equations: Vocabulary

Balancing chemical formulas involves adding **coefficients** in front of elements and compounds until ***the total number of atoms of each element in the reactants equals the products***.

coefficients
(balancing numbers)

$$2H_2 + O_2 \rightarrow 2H_2O$$

subscripts (don't
mess with these)

Balancing Chemical Equations: Vocabulary

Balancing chemical formulas involves adding **coefficients** in front of elements and compounds until ***the total number of atoms of each element in the reactants equals the products***.

Reactants: what goes into the reaction

Products: what comes out of the reaction

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

PhET Simulation

- https://phet.colorado.edu/sims/html/balancing-chemical-equations/1.1.0/balancing-chemical-equations_en.html

Balancing Chemical Equations: Tips

- **Goal: the number of atoms of each element in the reactants equals the products.**
- Change coefficients only. Never add or change subscripts.
- Balance atoms in compounds first. Save elements for last.
- If the same **polyatomic ion** appears in the reactants *and* products, you can often treat it as a **group of atoms** instead of splitting it up.
- At the end, reduce all coefficients to lowest whole-number terms.
- Note: **Do not write a coefficient** if there is only **"1"** of that element or compound.

Balancing can be frustrating at first. Practice, practice, practice!

Balancing Examples (easy)

Note: Do not write a coefficient if there is only "1" of that element or compound.

1. ____ N_2 + _3_ H_2 → _2_ NH_3

2. _2_ NaCl + ____ F_2 → _2_ NaF + ____ Cl_2

3. _2_ Ag_2O → _4_ Ag + ____ O_2

4. _4_ P + _5_ O_2 → _2_ P_2O_5

Balancing Examples (medium)

Treat polyatomic ions as groups if they appear in reactants and products (e.g. #2 & #3 but not #5)

5. $\underline{\ 2\ }$ NaBr + ___ CaF_2 → $\underline{\ 2\ }$ NaF + ___ $CaBr_2$

6. ___ $FeCl_3$ + $\underline{\ 3\ }$ NaOH → ___ $Fe(OH)_3$ + $\underline{\ 3\ }$ NaCl

7. ___ H_2SO_4 + $\underline{\ 2\ }$ $NaNO_2$ → $\underline{\ 2\ }$ HNO_2 + ___ Na_2SO_4

8. $\underline{\ 6\ }$ CO_2 + $\underline{\ 6\ }$ H_2O → ___ $C_6H_{12}O_6$ + $\underline{\ 6\ }$ O_2

9. $\underline{\ 2\ }$ HCl + ___ $CaCO_3$ → ___ $CaCl_2$ + ___ H_2O + ___ CO_2

Balancing Examples (hard)

10. ___ C_3H_8 + 5 O_2 → 3 CO_2 + 4 H_2O

11. 2 C_6H_{14} + 19 O_2 → 12 CO_2 + 14 H_2O

Make sure to balance the element (O_2) last!

12. 2 C_8H_{18} + 25 O_2 → 16 CO_2 + 18 H_2O

Trick for Combustion Reactions (e.g. #10-12)

1. Balance every atom except oxygen.

$$\_\_\_ C_6H_{14} + \_\_\_ O_2 \rightarrow \underline{\;6\;} CO_2 + \underline{\;7\;} H_2O$$

2. Find out how many oxygen atoms you need the __O_2 to contribute. Divide that number by 2. This is your *temporary* coefficient for O_2.

$$\_\_\_ C_6H_{14} + \underline{\tfrac{19}{2}} O_2 \rightarrow \underline{\;6\;} CO_2 + \underline{\;7\;} H_2O$$

$6CO_2$ has 12 oxygen atoms. $7H_2O$ has 7 oxygen atoms. In total, there are 19 oxygen atoms in the products.

3. You are not allowed to have fractional coefficients in your final answer. Multiply all the coefficients by 2.

$$\underline{\;2\;} C_6H_{14} + \underline{\;19\;} O_2 \rightarrow \underline{\;12\;} CO_2 + \underline{\;14\;} H_2O$$

Resources

- Naming and Writing Chemical Formulas
  - Tyler DeWitt Videos https://www.youtube.com/user/tdewitt451/videos
  - Mr. Carman's Blog (generates quizzes) https://www.kentschools.net/ccarman/cp-chemistry/practice-quizzes/compound-naming/
  - Mr. Eisley (list of other resources to practice http://www.mreisley.com/nomenclature-practice.html
  - ChemFiesta (worksheets with answers) https://chemfiesta.org/2015/01/13/naming-worksheets/
- Balancing Chemical Equations
  - TemplateLAB (explanations and many worksheets with answers) https://templatelab.com/balancing-equations-worksheet/