

Today's Lecture

- ✓ Announcements
- ✓ Quiz
- ✓ Atoms, Molecules, and Ions
 - The Periodic Table
 - Ions and ionic compounds



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Announcements

- Office hours
 - Mon, Wed, 11:30-12:30 am
 - Sun, Tue, Thu 12:00-1:00 pm
- Reading
 - Chapter 2, Sections **(2.6)**, and **(2.7)**
- Suggested Problems
- 2.37, 2.39, 2.43, 2.45, 2.49, 2.51, 2.53, 2.55, 2.57, 2.59



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Quiz

The density of benzene is 0.879 g/mL. Calculate the mass in grams of 1.00 qt of benzene.



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Subatomic Particles

- Protons and electrons are the only particles that have a charge.
- Protons and neutrons have essentially the same mass.
- The mass of an electron is so small we ignore it.

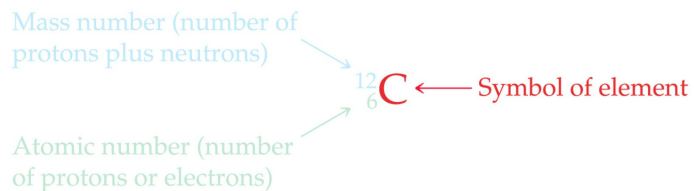
Particle	Charge	Mass (amu)
Proton	Positive (1+)	1.0073
Neutron	None (neutral)	1.0087
Electron	Negative (1-)	5.486×10^{-4}



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Symbols of Elements

Mass number (number of
protons plus neutrons)



Atomic number (number
of protons or electrons)

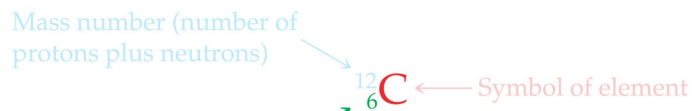
Elements are symbolized by one or two letters.

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Atomic Number

Mass number (number of
protons plus neutrons)



Atomic number (number
of protons or electrons)

All atoms of the same element have the same number of protons:

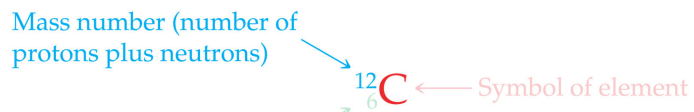
The atomic number (Z)

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Atomic Mass

Mass number (number of
protons plus neutrons)



Atomic number (number
of protons or electrons)

The mass of an atom in atomic mass units (amu) is the total number of protons and neutrons in the atom.



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Isotopes

- Isotopes are atoms of the same element with different masses.
- Isotopes have different numbers of neutrons.



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Periodic Table

1A 1 H	2A 2 He																	3A 13 B	4A 14 C	5A 15 N	6A 16 O	7A 17 F	8A 18 Ne								
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne														
11 Na	12 Mg	3B 3 Sc	4B 4 Ti	5B 5 V	6B 6 Cr	7B 7 Mn	8B 8 9 10 Fe Co Ni			1B 11 Cu	2B 12 Zn	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar														
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr														
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe														
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	113	114	115	116	117	118

Metals
Metalloids
Nonmetals

- It is a systematic catalog of the elements.
- Elements are arranged in order of atomic number.

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Periodicity

Atomic number	1	2	3	4	...	9	10	11	12	...	17	18	19	20	...
Symbol	H	He	Li	Be	...	F	Ne	Na	Mg	...	Cl	Ar	K	Ca	...
	Nonreactive gas		Soft, reactive metal	Nonreactive gas		Soft, reactive metal	Nonreactive gas		Soft, reactive metal	Nonreactive gas		Soft, reactive metal			

When one looks at the chemical properties of elements, one notices a repeating pattern of reactivities.

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Periodic Table

- The rows on the periodic chart are periods.
- Columns are groups.
- Elements in the same group have similar chemical properties.

Metals

Metalloids

Nonmetals

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Groups

Group	Name	Elements
1A	Alkali metals	Li, Na, K, Rb, Cs, Fr
2A	Alkaline earth metals	Be, Mg, Ca, Sr, Ba, Ra
6A	Chalcogens	O, S, Se, Te, Po
7A	Halogens	F, Cl, Br, I, At
8A	Noble gases (or rare gases)	He, Ne, Ar, Kr, Xe, Rn

These five groups are known by their names.

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Periodic Table

1A 1 1 H	2A 2 He											3A 13 B	4A 14 C	5A 15 N	6A 16 O	7A 17 F	8A 18 Ne														
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne														
11 Na	12 Mg	3B 3 Al	4B 4 Si	5B 5 P	6B 6 S	7B 7 Cl	8B 8 Fe		9 Co	10 Ni	11 Cu	12 Zn	13 Ga	14 Ge	15 As	16 Se	17 Br	18 Kr													
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr														
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe														
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og														

Metals	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
Metalloids	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No
Nonmetals														

Nonmetals are on the right side of the periodic table (with the exception of H).



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Periodic Table

1A 1 1 H	2A 2 He											3A 13 B	4A 14 C	5A 15 N	6A 16 O	7A 17 F	8A 18 Ne														
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne														
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Metals	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
Metalloids	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No
Nonmetals														

Metalloids border the stair-step line (with the exception of Al, Po, and At).



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Periodic Table

1A 1																	8A 18		
2 He	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He		
3 Li	4 Be	3B	4B	5B	6B	7B	8B					1B	2B	5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
19 K	20 Ca	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
37 Rb	38 Sr	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	113	114	115	116	117	118		
Metals		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb				
Metalloids		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No				
Nonmetals																			

Metals are on the left side of the chart.



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Sample Exercise 2.5 Using the Periodic Table

Which two of the following elements would you expect to show the greatest similarity in chemical and physical properties: B, Ca, F, He, Mg, P?



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Practice Exercise

Locate Na (sodium) and Br (bromine) on the periodic table. Give the atomic number of each, and label each a metal, metalloid, or nonmetal.



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Ions

1A	2A	Transition metals										3A	4A	5A	6A	7A	8A				
H ⁺																		H ⁻			
Li ⁺															Al ³⁺			N ³⁻	O ²⁻	F ⁻	
Na ⁺	Mg ²⁺																	S ²⁻		Cl ⁻	
K ⁺	Ca ²⁺																	Se ²⁻		Br ⁻	
Rb ⁺	Sr ²⁺																	Te ²⁻		I ⁻	
Cs ⁺	Ba ²⁺																				

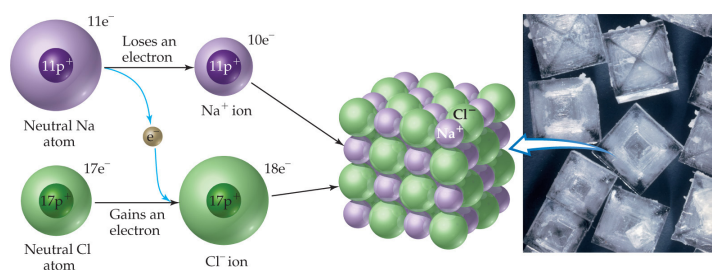
- When atoms lose or gain electrons, they become ions.
 - Cations are positive and are formed by elements on the left side of the periodic chart.
 - Anions are negative and are formed by elements on the right side of the periodic chart.



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Ionic Bonds

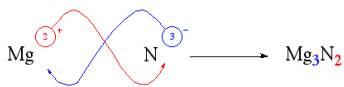
Ionic compounds (such as NaCl) are generally formed between metals and nonmetals.



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Writing Formulas



- Because compounds are electrically neutral, one can determine the formula of a compound this way:
 - The charge on the cation becomes the subscript on the anion.
 - The charge on the anion becomes the subscript on the cation.
 - If these subscripts are not in the lowest whole-number ratio, divide them by the greatest common factor.

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Sample Exercise 2.7 Writing Chemical Symbols for Ions

Give the chemical symbol, including mass number, for each of the following ions: **(a)** The ion with 22 protons, 26 neutrons, and 19 electrons; **(b)** the ion of sulfur that has 16 neutrons and 18 electrons.



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Practice Exercise

How many protons, neutrons, and electrons does the $^{79}\text{Se}^{2-}$ ion possess?



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Sample Exercise 2.8 Predicting the Charges of Ions

Predict the charge expected for the most stable ion of barium and for the most stable ion of oxygen.



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Practice Exercise

Predict the charge expected for the most stable ion of **(a)** aluminum and **(b)** fluorine.



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Sample Exercise 2.9 Identifying Ionic and Molecular Compounds

Which of the following compounds would you expect to be ionic: N_2O , Na_2O , CaCl_2 , SF_4 ?



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Practice Exercise

Which of the following compounds are molecular: CBr_4 , FeS , P_4O_6 , PbF_2 ?



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Sample Exercise 2.10 Using Ionic Charge to Write Empirical Formulas for Ionic Compounds

What are the empirical formulas of the compounds formed by (a) Al^{3+} and Cl^{-} ions, (b) Al^{3+} and O^{2-} ions, (c) Mg^{2+} and NO_3^{-} ions?



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Practice Exercise

Write the empirical formulas for the compounds formed by the following ions:

(a) Na^{+} and PO_4^{3-} , (b) Zn^{2+} and SO_4^{2-} , (c) Fe^{3+} and CO_3^{2-} .



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Next Lecture

- Avogadro's Number and the mole
 - Chapter 3
 - focus on Sections 3.4, 3.6, 3.7



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