4.3 Distinguishing Among Atoms

Atomic Number

- Elements are different because they contain different numbers of protons

See p. 110

Table 4.2

Atoms of the First Ten Elements

Name	Symbol	Atomic number	Protons	Neutrons*	Mass number	Number of electrons
Hydrogen	H	1	1	0	1	1
Helium	He	2	2	2	4	2
Lithium	Li	3	3	4	7	3
Beryllium	Be	4	4	5	9	4
Boron	B	5	5	6	11	5
Carbon	C	6	6	6	12	6
Nitrogen	N	7	7	7	14	7
Oxygen	O	8	8	8	16	8
Fluorine	F	9	9	10	19	9
Neon	Ne	10	10	10	20	10

*Number of neutrons in the most abundant isotope. Isotopes are introduced later in Section 4.3.

See p. 111

CONCEPTUAL PROBLEM 4.1

Understanding Atomic Number

The element nitrogen (N), shown here in liquid form, has an atomic number of 7. How many protons and electrons are in a neutral nitrogen atom?

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See p. 111

Practice Problems

15. Complete the table.

Element	Atomic number	Protons	Electrons
K	19	(a)	19
(b)	(c)	(d)	5
S	16	(e)	(f)
V	(g)	23	(h)

16. How many protons and electrons are in each atom?

a. fluorine (atomic number = 9)
b. calcium (atomic number = 20)
c. aluminum (atomic number = 13)

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Mass Number

- The mass number is the sum of the number of protons and number of neutrons.

mass # = # of protons + # of neutrons

or

# of neutrons = mass number - atomic number

- Can also be written in 'shorthand'notation

mass number ⟶ 197 Au gold-197

# of protons ⟶ 79

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See p. 112

Practice Problems

17. How many neutrons are in each atom?

a. $^{16}_{8}O$ **b.** $^{32}_{16}S$ **c.** $^{108}_{47}Ag$

d. $^{80}_{35}Br$ **e.** $^{207}_{82}Pb$

18. Use Table 4.2 to express the composition of each atom in shorthand form.

a. carbon-12 **b.** fluorine-19 **c.** beryllium-9

^{12}C C-12 12C

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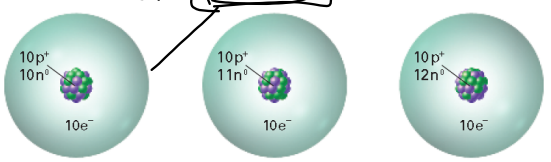
Isotopes

- Isotopes of elements have a different number of neutrons and therefore a different mass number

am = 20.17



Neon-20
10 protons
10 neutrons
10 electrons

Neon-21
10 protons
11 neutrons
10 electrons

Neon-22
10 protons
12 neutrons
10 electrons

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Atomic Mass

- all masses based on a reference mass
- by convention, 1 *atomic mass unit (amu)* is based on one-twelfth of the carbon-12 atom
- most elements occur as a mixture of two or more isotopes and therefore the atomic mass is the 'weighted average mass' of the isotopes.

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Table 4.3

Natural Percent Abundance of Stable Isotopes of Some Elements

Name	Symbol	Natural percent abundance	Mass (amu)	Average atomic mass
Hydrogen	$^{1}_{1}H$	99.985	1.0078	1.0079
	$^{2}_{1}H$	0.015	2.0141	
	$^{3}_{1}H$	negligible	3.0160	
Helium	$^{3}_{2}He$	0.0001	3.0160	4.0026
	$^{4}_{2}He$	99.9999	4.0026	
Carbon	$^{12}_{6}C$	98.89	12.000	12.011
	$^{13}_{6}C$	1.11	13.003	
Nitrogen	$^{14}_{7}N$	99.63	14.003	14.007
	$^{15}_{7}N$	0.37	15.000	
Oxygen	$^{16}_{8}O$	99.759	15.995	15.999
	$^{17}_{8}O$	0.037	16.995	
	$^{18}_{8}O$	0.204	17.999	

Sample Calculation

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SAMPLE PROBLEM 4.2

Calculating Atomic Mass

Element X has two natural isotopes. The isotope with a mass of 10.012 amu (^{10}X) has a relative abundance of 19.91%. The isotope with a mass of 11.009 amu (^{11}X) has a relative abundance of 80.09%. Calculate the atomic mass of this element.

Calculate *Solve for the unknown.*

for ^{10}X: 10.012 amu × 0.1991 = 1.993 amu
for ^{11}X: 11.009 amu × 0.8009 = 8.817 amu

Practice Problems

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23. The element copper has naturally occurring isotopes with mass numbers of 63 and 65. The relative abundance and atomic masses are 69.2% for mass = 62.93 amu, and 30.8% for mass = 64.93 amu. Calculate the average atomic mass of copper.

24. Calculate the atomic mass of bromine. The two isotopes of bromine have atomic masses and relative abundance of 78.92 amu (50.69%) and 80.92 amu (49.31%).

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$^{10}X = 10.012 \Rightarrow 19.91\%$

$^{11}X = 11.009 \Rightarrow 80.09\%$

^{10}X amu × % = 10.012 × 0.1991 = 1.993

^{11}X amu × % = 11.009 × .8009 = 8.817

10.81

Sep 17-11:19 AM

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