02/27/14
Solution to the Assigned Problems of Workshop 2
Chem. 103, Spring 2014

Chapter 2: Atoms and the Periodic Table

Home-assigned problems (total of 15): 2.15, 2.17, 2.19, 2.21, 2.27, 2.29, 2.31, 2.37, 2.41, 2.45, 2.47, 2.53, 2.55, 2.65, 2.73

2.15 **Strategy:** The 243 in Pu-243 is the mass number. The mass number, (*A*), is the total number of neutrons and protons present in the nucleus of an atom of an element. The number of protons in the nucleus of an atom is the atomic number (*Z*). The atomic number of plutonium, *Z*, is 94 (see inside front cover of the text).

Setup: mass number (*A*) = number of protons (*Z*) + number of neutrons

Therefore,

number of neutrons = mass number (*A*) – number of protons (*Z*)

Solution:

number of neutrons = 243 – 94 = **149**

2.17

Strategy: The superscript denotes the mass number, (*A*). The subscript denotes the atomic number, (*Z*). Since all the atoms are neutral, the number of electrons is equal to the number of protons.

Setup: Number of protons = *Z*. Number of neutrons = *A* – *Z*. Number of electrons = number of protons.

Solution: $^{17}_{8}O$: The atomic number is 8, so there are **8 protons**. The mass number is 17, so the **number of neutrons** is 17 – 8 = **9**. The number of electrons equals the number of protons, so there are **8 electrons**.

$^{29}_{14}Si$: The atomic number is 14, so there are **14 protons**. The mass number is 29, so the **number of neutrons** is 29 – 14 = **15**. The number of electrons equals the number of protons, so there are **14 electrons**.

$^{58}_{28}Ni$: The atomic number is 28, so there are **28 protons**. The mass number is 58, so the **number of neutrons** is 58 – 28 = **30**. The number of electrons equals the number of protons, so there are **28 electrons**.

$^{89}_{39}Y$: The atomic number is 39, so there are **39 protons**. The mass number is 89, so the **number of neutrons** is 89 – 39 = **50**. The number of electrons equals the number of protons, so there are **39 electrons**.

$^{180}_{73}Ta$: The atomic number is 73, so there are **73 protons**. The mass number is 180, so the **number of neutrons** is 180 – 73 = **107**. The number of electrons equals the number of protons, so there are **73 electrons**.

$^{203}_{81}Tl$: The atomic number is 81, so there are **81 protons**. The mass number is 203, so the **number of neutrons** is 203 – 81 = **122**. The number of electrons equals the number of protons, so there are **81 electrons**.

Think About It: Verify that the sum of the number of protons and the number of neutrons for each example equals the mass number that is given.

2.19 The superscript denotes the mass number, (A), and the subscript denotes the atomic number, (Z).

a. $^{187}_{75}\mathbf{Re}$ b. $^{209}_{83}\mathbf{Bi}$ c. $^{75}_{33}\mathbf{As}$ d. $^{236}_{93}\mathbf{Np}$

2.21 **Strategy:** The mass number, (A), is the total number of neutrons and protons present in the nucleus of an atom of an element. The number of protons in the nucleus of an atom is the atomic number (Z). The atomic number, (Z), can be found on the periodic table.

Setup: mass number (A) = number of protons (Z) + number of neutrons

Solution: a. The atomic number of chlorine (Cl) is 17, so there are 17 protons. The **mass number** is 17 + 18 = **35**.

b. The atomic number of phosphorous (P) is 15, so there are 15 protons. The **mass number** is 15 + 17 = **32**.

c. The atomic number of antimony (Sb) is 51, so there are 51 protons. The **mass number** is 51 + 70 = **121**.

d. The atomic number of palladium (Pd) is 46, so there are 46 protons. The **mass number** is 46 + 59 = **105**.

2.27 $(203.973020 \text{ amu})(0.014) + (205.974440 \text{ amu})(0.241)$
$$+ (206.975872 \text{ amu})(0.221) + (207.976627 \text{ amu})(0.524) = \mathbf{207.2\ amu}$$

2.29 **Strategy:** Each isotope contributes to the average atomic mass based on its relative abundance. Multiplying the mass of an isotope by its fractional abundance (not percent) will give the contribution to the average atomic mass of that particular isotope.

It would seem that there are two unknowns in this problem, the fractional abundance of ^{6}Li and the fractional abundance of ^{7}Li. However, these two quantities are not independent of each other; they are related by the fact that they must sum to 1. Start by letting x be the fractional abundance of ^{6}Li. Since the sum of the two fractional abundances must be 1, we can write:

$$(6.0151 \text{ amu})(x) + (7.0160 \text{ amu})(1 - x) = 6.941 \text{ amu}$$

Solution: Solving for x gives 0.075, which corresponds to the fractional abundance of ^{6}Li. The fractional abundance of ^{7}Li is $(1 - x) = 0.925$. Therefore, **the natural abundances of ^{6}Li and ^{7}Li are 7.5% and 92.5%**, respectively.

2.31 **Strategy:** Each isotope contributes to the average atomic mass based on its relative abundance. Multiplying the mass of an isotope by its fractional abundance (percent value divided by 100) will give the contribution to the average atomic mass of that particular isotope.

We are asked to solve for the atomic mass of ^{24}Mg, x, given the contribution to the average atomic mass of ^{25}Mg and ^{26}Mg, and the average atomic mass of magnesium.

Setup: Each percent abundance must be converted to a fractional abundance: 10.00 percent to 10.00/100 or 0.1000, 11.01 percent to 11.01/100 or 0.1101, and 78.99 percent to 78.99/100 or 0.7899.

We can then write,

$$(0.1000)(24.9858374 \text{ amu}) + (0.1101)(25.9825937 \text{ amu}) + (0.7899)(x) = 24.3050 \text{ amu}$$

Solution: Solving for x gives:

$$(0.1000)(24.9858374 \text{ amu}) + (0.1101)(25.9825937 \text{ amu}) + (0.7899)(x) = 24.3050 \text{ amu}$$

$$2.4986 + 2.8607 + 0.7899x = 24.3050$$

$$0.7899x = 18.9457$$

$$x = 23.98 \text{ amu}$$

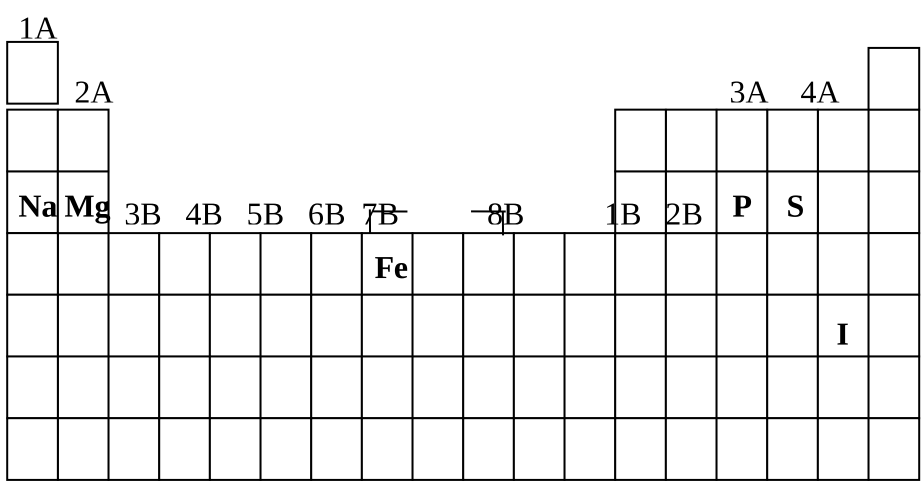
Think About It: Verify that the mass of each isotope multiplied by its fractional abundance sum to the average atomic mass of Mg (24.3050 amu).

2.37 a. **Metallic character increases as you progress down a group of the periodic table. For example, moving down Group 4A, the nonmetal carbon is at the top and the metal lead is at the bottom of the group.**

b. **Metallic character decreases from the left side of the table (where the metals are located) to the right side of the table (where the nonmetals are located).**

2.39 **Na and K are both Group 1A elements; they should have similar chemical properties. N and P are both Group 5A elements; they should have similar chemical properties. F and Cl are Group 7A elements; they should have similar chemical properties.**

2.41



Atomic number 26, iron, Fe, (present in hemoglobin for transporting oxygen)
Atomic number 53, iodine, I, (present in the thyroid gland)
Atomic number 11, sodium, Na, (present in intra- and extra-cellular fluids)
Atomic number 15, phosphorus, P, (present in bones and teeth)
Atomic number 16, sulfur, S, (present in proteins)

Atomic number 12, magnesium, Mg, (present in chlorophyll molecules)

2.45 **Strategy:** Determine the diameter of the atoms in micrograms. Then divide the diameter of a human hair by the diameter of the atoms.

Setup: Use the conversion factor (see Table 1.2):

$$\frac{1\times 10^{-6}\ \mu\text{m}}{1\ \text{pm}}$$

Solution: First, convert picograms to micrograms:

$$121\ \text{pm}\times\frac{1\times 10^{-6}\ \mu\text{m}}{1\ \text{pm}} = 1.21\times 10^{-4}\ \mu\text{m}$$

Then, divide the diameter of the human hair by the diameter of the atoms:

$$(25.4\ \mu\text{m})\times\frac{1\ \text{atom}}{1.21\times 10^{-4}\ \mu\text{m}} = \mathbf{2.10\times 10^{5}\ atoms}$$

2.47 $$(5.00\times 10^{9}\ \text{Ni atoms})\times\frac{1\ \text{mol Ni}}{6.022\times 10^{23}\ \text{Ni atoms}} = \mathbf{8.30\times 10^{-15}\ mol\ Ni}$$

2.53 **Strategy:** The question asks for atoms of Sc. We cannot convert directly from grams to atoms of scandium. What unit do we need to convert grams of Sc to moles of Sc in order to convert to atoms? What does Avogadro's number represent?

Setup: To calculate the number of Sc atoms, we first must convert grams of Sc to moles of Sc. We use the molar mass of scandium as a conversion factor. Once moles of Sc are obtained, we can use Avogadro's number to convert from moles of scandium to atoms of scandium.

$$1\ \text{mol Sc} = 44.96\ \text{g Sc}$$

The conversion factor needed is:

$$\frac{1\ \text{mol Sc}}{44.96\ \text{g Sc}}$$

Avogadro's number is the key to the second conversion. We have:

$$1 \text{ mol} = 6.022 \times 10^{23} \text{ particles (atoms)}$$

From this equality, we can write two conversion factors.

$$\frac{1 \text{ mol Sc}}{6.022 \times 10^{23} \text{ Sc atoms}} \quad \text{and} \quad \frac{6.022 \times 10^{23} \text{ Sc atoms}}{1 \text{ mol Sc}}$$

The conversion factor on the right is the one we need because it has number of Sc atoms in the numerator, which is the unit we want for the answer.

Solution: Let's complete the two conversions in one step.

$$\text{grams of Sc} \rightarrow \text{moles of Sc} \rightarrow \text{number of Sc atoms}$$

$$\textbf{? atoms of Sc} = 4.09 \text{ g Sc} \times \frac{1 \text{ mol Sc}}{44.96 \text{ g Sc}} \times \frac{6.022 \times 10^{23} \text{ Sc atoms}}{1 \text{ mol Sc}} = \mathbf{5.48 \times 10^{22} \textbf{ Sc atoms}}$$

Think About It: Should 4.09 g of Sc contain fewer than Avogadro's number of atoms? What mass of Sc would contain Avogadro's number of atoms?

2.55

$$173 \text{ Au atoms} \times \frac{1 \text{ mol Au}}{6.022 \times 10^{23} \text{ Au atoms}} \times \frac{197.0 \text{ g Au}}{1 \text{ mol Au}} = 5.66 \times 10^{-20} \text{ g Au}$$

$$(7.5 \times 10^{-22} \text{ mol Ag}) \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}} = 8.1 \times 10^{-20} \text{ g Ag}$$

7.5×10^{-22} mole of silver has a greater mass than 173 atoms of gold.

2.65 a.

Isotope	$^{4}_{2}He$	$^{20}_{10}Ne$	$^{40}_{18}Ar$	$^{84}_{36}Kr$	$^{132}_{54}Xe$
No. Protons	**2**	**10**	**18**	**36**	**54**
No. Neutrons	**2**	**10**	**22**	**48**	**78**

b.

neutron/proton ratio	**1.00**	**1.00**	**1.22**	**1.33**	**1.44**

The neutron/proton ratio increases with increasing atomic number.

2.73 The mass number, (A), is the total number of neutrons and protons present in the nucleus of an atom of an element. The number of protons in the nucleus of an atom is the atomic number (Z). The atomic number, (Z), can be found on the periodic table. The superscript denotes the mass number, (A), and the subscript denotes the atomic number, (Z).

mass number (A) = number of protons (Z) + number of neutrons

Symbol	^{101}Ru	^{181}**Ta**	^{150}**Sm**
Protons	**44**	**73**	62
Neutrons	**57**	108	88
Electrons	**44**	73	**62**
