

Workbook



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Atomic Theory and Structure

Atomic Theory and Structure

Questions

- 1) When a solid mixture consisting of 10.75 g calcium hydroxide and, 11.20 g ammoniumchloride is strongly heated, gaseous products are evolved and, 15.15 g of a solid residue remains.

The gasses are passed into 60.35 g water and the mass of the resulting solution, is 67.15 g.

Show that these data conform to the law of conservation of mass.

- 2) In one experiment, 2.05 g sodium was allowed to react with 10 g chlorine. All the sodium was used up and 5.65 g sodium chloride was produced. In a second experiment, 2.27 g chlorine was allowed to react with 10 g sodium.

All the chlorine was used up and 3.56 g sodium chloride was produced.

Show that these results are consistent with the law of constant composition.

- 3) In one experiment, the burning of 0.336 g sulfur produced 0.645 g sulfur dioxide, as the sole product of the reaction. In a second experiment, 0.856 g sulfur dioxide was obtained.

What mass of sulfur was burned in the second experiment?

- 4) The following data were obtained for compounds of sulfur and oxygen.

Compound	Mass S, g	Mass O, g
A	2	1.996
B	0.5	0.7485

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- a. Show that these results are consistent with Dalton's law of multiple proportions.
- b. If the formula of compound A is SO_2 , what is the formula of compound B?
- 5) Write the following isotopes in the form ${}^A_Z\text{E}$
- Bromine – 79
 - Silver – 107
 - Lead – 204
- 6) Determine the numbers of protons, neutrons and electrons in the following atoms:
- ${}^{90}_{38}\text{Sr}$
 - ${}^{109}_{47}\text{Ag}$
 - ${}^{47}_{24}\text{Cr}$
 - ${}^{81}_{35}\text{Br}$
- 7) Determine the numbers of protons, neutrons and electrons in the following ions:
- ${}^{124}\text{Sn}^{2+}$
 - ${}^{228}\text{Ra}^{2+}$
 - ${}^{131}\text{I}^-$
- 8) Determine the numbers of protons, neutrons and electrons, in the following atoms or ions: ${}^{123}\text{I}^-$, ${}^{120}\text{Cd}$, ${}^{37}\text{Cl}$, ${}^{196}\text{Hg}$
- Which of these species:
- has protons, neutrons and electrons in the ratio of 2:3:2?
 - has more electrons than protons?
 - has about 50% more neutrons than protons?

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- 9) Arrange the following: ${}_{80}^{200}\text{Hg}$, ${}_{9}^{19}\text{F}$, ${}_{86}^{222}\text{Rn}$ in order of increasing:
- Mass.
 - increasing number of neutrons.
 - increasing number of electrons.
- 10) For the isotope ${}^{107}\text{Ag}$, express the percentage of the fundamental particles, in the nucleus that are neutrons.
- 11) Identify the isotope that has 7 more neutrons than protons, and a mass number of 59.
- 12) For the atom ${}^{16}\text{O}$ with mass $15.9949u$, determine:
- The numbers of protons, neutrons and electrons in the atom.
 - The ratio of the mass of this atom to that of the atom ${}^{12}\text{C}$.
- 13) An isotope of silver has a mass that is 8.9088 times that of carbon-12. What is the mass in u of this isotope?
- 14) There are two naturally occurring isotopes of carbon, carbon-12 and carbon-13. Their masses are $12u$ and $13.00335u$, respectively. Which of these two isotopes occurs in greater abundance?
- 15) Carbon has two naturally occurring isotopes. Their masses and percent natural abundances are $12u$ 98.892%, and $13.00335u$ 1.108%. What is the weighted average atomic mass of carbon?

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- 16) There are two naturally occurring isotopes of bromine.
They have the following abundances: ^{79}Br , 50.69% and ^{81}Br , 49.31%.
The mass of ^{79}Br is $78.918336u$. What is the mass of ^{81}Br ?
- 17) Silver has two naturally occurring isotopes.
 ^{107}Ag has a mass of $106.905092u$ and a natural abundance of 51.84%.
Calculate the mass and natural abundance of the other isotope, ^{109}Ag .

Answer Key

- 1) The law of conservation of mass states that the total mass of substances present, after a chemical reaction is the same as the total mass of substances, before the reaction.

$$10.75\text{g} + 11.20\text{g} = 15.15\text{g} + 67.15\text{g} - 60.35\text{g}$$

- 2) The law of constant composition states that all of the samples of a compound have the same composition – the same proportions by mass of the constituent elements.

$$\text{Experiment 1) } m_{\text{Na}} = 2.05 \text{ g, } m_{\text{Cl}} = 5.65\text{g} - 2.05\text{g} = 3.6\text{g} \left(\frac{2.05\text{g}}{5.65\text{g}} \right) \times 100\% = 36\%.$$

$$\text{Experiment 2) } m_{\text{Na}} = 3.56\text{g} - 2.27\text{g} = 1.29\text{g g, } m_{\text{Cl}} = 2.27\text{g} \left(\frac{1.29\text{g}}{3.56\text{g}} \right) \times 100\% = 36\%.$$

- 3) 0.446 g
- 4) a. The law of multiple proportions states that if two elements form more than, a single compound, the masses of one element combined with a fixed mass, of the second are in the ratio of small whole numbers.

Compound	Mass S, g	Mass O, g
A	2	1.996
B	0.5	0.7485

$$\frac{2.994\text{g}}{1.996\text{g}} = 1.5 = \frac{3}{2}$$

b. SO_3

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- 5) a. ${}^{79}_{35}\text{Br}$
b. ${}^{107}_{47}\text{Ag}$
c. ${}^{204}_{82}\text{Pb}$
- 6) a. ${}^{90}_{38}\text{Sr}$ protons = 38, neutrons = 52, electrons = 38.
b. ${}^{109}_{47}\text{Ag}$ protons = 47, neutrons = 62, electrons = 47.
c. ${}^{47}_{24}\text{Cr}$ protons = 24, neutrons = 23, electrons = 24.
d. ${}^{81}_{35}\text{Br}$ protons = 35, neutrons = 46, electrons = 35.
- 7) a. ${}^{124}\text{Sn}^{2+}$ protons = 50, neutrons = 74, electrons = 48.
b. Ra^{2+} protons = 88, neutrons = 140, electrons = 86.
c. ${}^{131}\text{I}^{-}$ protons = 53, neutrons = 78, electrons = 5
- 8) ${}^{123}\text{I}^{-}$, protons = 53, neutrons = 70, electrons = 54.
 ${}^{120}\text{Cd}$, protons = 48, neutrons = 72, electrons = 48.
 ${}^{37}\text{Cl}$, protons = 17, neutrons = 20, electrons = 17.
 ${}^{196}\text{Hg}$, protons = 80, neutrons = 116, electrons = 80.
- a. ${}^{120}\text{Cd}$ b. ${}^{123}\text{I}^{-}$ c. ${}^{120}\text{Cd}$.
- 9) a. ${}^{19}_9\text{F} < {}^{200}_{80}\text{Hg} < {}^{222}_{86}\text{Rn}$ b. ${}^{19}_9\text{F} < {}^{200}_{80}\text{Hg} < {}^{222}_{86}\text{Rn}$ c. ${}^{19}_9\text{F} < {}^{200}_{80}\text{Hg} < {}^{222}_{86}\text{Rn}$.
- 10) 56.07%
- 11) Iron - 59
- 12) a. protons = 8, neutrons = 8, electrons = 8 b. 1.33.
- 13) 106.91 u
- 14) Carbon-12
- 15) 12.011 u
- 16) 80.92 u
- 17) 108.9 u, 48.16%

Calculations involving moles

- 1) What is the total number of atoms in
 - a. 17 mol Feq
 - b. 0.00065 mol Ag
 - c. 6×10^{-12} mol Na

- 2) Determine
 - a. The number of moles of Zn in a 365 g sample of zinc metal.
 - b. The number of Cr atoms in 235 kg chromium.
 - c. The mass of a one million atom sample of metallic gold.

- 3) How many Ag atoms are present in a sample that contains 22.4% Ag by mass? The sample weighs 80 g.

- 4) Determine
 - a. The number of Kr atoms in a 7.5 mg sample of krypton.
 - b. The molar mass and the identity of an element if the mass of a 4.3×10^{22} atom sample of the element is 3.35 g.

- 5) How many ^{41}K atoms are present in a piece of lead weighing 320 mg? The percent natural abundance of ^{41}K is 6.7%.

Answer Key

- 1) a. $1.02 \cdot 10^{25}$ atoms b. $3.91 \cdot 10^{20}$ atoms c. $3.61 \cdot 10^{12}$ atoms
- 2) a. 5.58 mol b. $2.72 \cdot 10^{27}$ atoms c. $3.27 \cdot 10^{-16}$ g
- 3) $1 \cdot 10^{23}$ atoms
- 4) a. $5.39 \cdot 10^{19}$ atoms b. $M_w = 47.86 \frac{\text{g}}{\text{mol}}, \text{Ti}$
 $3.3 \cdot 10^{20}$ atoms