ISOTOPES AND AVERAGE ATOMIC MASS

Name _____

Elements come in a variety of isotopes, meaning they are made up of atoms with the same atomic number but different atomic masses. These atoms differ in the number of neutrons.

The average atomic mass is the weighted average of all the isotopes of an element.

Example: A sample of cesium is 75% ^{133}Cs, 20% ^{132}Cs and 5% ^{134}Cs. What is its average atomic mass?

Answer: .75 x 133 = 99.75
.20 x 132 = 26.4
.05 x 134 = 6.7
Total = 132.85 amu = average atomic mass

Determine the average atomic mass of the following mixtures of isotopes.

1. 80% ^{127}I, 17% ^{126}I, 3% ^{128}I _____

2. 50% ^{197}Au, 50% ^{198}Au _____

3. 15% ^{55}Fe, 85% ^{56}Fe _____

4. 99% ^{1}H, 0.8% ^{2}H, 0.2% ^{3}H _____

5. 95% ^{14}N, 3% ^{15}N, 2% ^{16}N _____

6. 98% ^{12}C, 2% ^{14}C _____

The Structure of the Atom

1. Use the periodic table to complete the following table.

Element	Atomic Number	Protons	Electrons
a. Li			
b.			87
c.	93		
d. Hg			80
e.	81		
f.	75		
g. B			

2. Give the number of protons, electrons, and neutrons in each of the following atoms.

a. $^{108}_{47}Au$

b. $^{40}_{20}Ca$

c. $^{23}_{11}Na$

3. Name each isotope, and write it in symbolic notation.

a. atomic number 26; mass number 56

b. atomic number 29; mass number 64

c. atomic number 17; mass number 37

4. How many protons, electrons, and neutrons are in each of the following isotopes?

a. uranium-235

b. hydrogen-3

c. silicon-29

5. How many neutrons does europium-151 have? What is the isotope's mass number?

6. How many more neutrons does thorium-230 have than protons? How many electrons does thorium-230 have?

7. Show that the mass number and the number of protons are conserved in the following nuclear equation: $^{234}_{92}U \longrightarrow {}^{230}_{90}Th + {}^{4}_{2}He$.

8. Give the mass number of each isotope.

a. Be with 5 neutrons

b. Ga with 39 neutrons

c. Si with 16 neutrons

d. Ti with 26 neutrons

9. Give the atomic number of each isotope.

a. magnesium-25

b. bromine-79

c. antimony-121

10. Neon has two isotopes: neon-10 and neon-12.

a. Which isotope has the greater mass?

b. Which has more neutrons?

c. Which has more protons?

d. Which has more electrons?

11. Use the table below to calculate the atomic mass of element *X*. Then use the periodic table to identify the element. Show all your work.

Isotope	Mass (amu)	Percent Abundance
^{16}X	15.995	99.762
^{17}X	16.999	0.038
^{18}X	17.999	0.20

12. Magnesium has three isotopes. Magnesium-24 has a percent abundance of 78.99%. Magnesium-26 has a percent abundance of 11.01%. What is the percent abundance of magnesium-25? Assume that there are no other magnesium isotopes.

15. An element has three naturally occurring isotopes. Information about each isotope is summarized below.

Isotope	Mass (amu)	Percent Abundance
Isotope 1	23.985	78.10
Isotope 2	24.946	10.13
Isotope 3	25.983	11.17

a. Find the atomic mass of this element. Show all your work.

b. Identify the element, using the periodic table.

c. Write each isotope in symbolic notation.

16. The isotope carbon-14 can be used to determine the ages of objects that were once living, such as wood, bones, and fossils. While alive, living things take in all the isotopes of carbon, including carbon-14. Carbon-14 undergoes radioactive decay continuously. After an organism dies, the carbon-14 in its body continues to decay. However, its body no longer takes in new carbon-14. Thus, by measuring how much carbon-14 a once-living object contains and comparing it with the amount of carbon-14 in a currently living thing, you can determine the age of the object.

a. In terms of subatomic structure, how does carbon-14 differ from carbon-12 and carbon-13?

b. How is carbon-14 like carbon-12 and carbon-13?

c. Carbon-14 emits a beta particle as it decays. What atom does carbon-14 decay to?

d. Write an equation to represent the decay of carbon-14.

4. Calculate the number of moles in each of the following quantities.

a. 6.35 g lithium

b. 346 g zinc

c. 115 g nickel

5. How many atoms are in the following samples?

a. 1.24 g cobalt

b. 0.575 g cesium

c. 65.6 g silicon

Section 12.4 Percent Yield

In your textbook, read about the yields of products.

Study the diagram and the example problem.

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

mass of product from experimental measurement

mass of product predicted from stoichiometric calculation using

a. mass of reactant

b. 4-step mass-to-mass conversion

1. Write the balanced chemical equation.
2. Calculate the number of moles of reactant, using molar mass.
3. Calculate the number of moles of product, using the appropriate mole ratio.
4. Calculate the mass of product, using the reciprocal of molar mass.

Example Problem: The following chemical equation represents the production of gallium oxide, a substance used in the manufacturing of some semiconductor devices.

$$4Ga(s) + 3O_2(g) \rightarrow 2Ga_2O_3(s)$$

In one experiment, the reaction yielded 7.42 g of the oxide from a 7.00-g sample of gallium. Determine the percent yield of this reaction. The molar masses of Ga and Ga_2O_3 are 69.72 g/mol and 187.44 g/mol, respectively.

Use the information in the diagram and example problem to evaluate each value or expression below. If the value or expression is correct, write *correct*. If it is incorrect, write the correct value or expression.

1. actual yield: unknown _____

2. mass of reactant: 7.00 g Ga _____

3. number of moles of reactant: $7.00 \text{ g Ga} \times \frac{69.72 \text{ g Ga}}{1 \text{ mol Ga}}$ _____

4. number of moles of product: $0.100 \text{ mol Ga} \times \frac{2 \text{ mol } Ga_2O_3}{1 \text{ mol Ga}}$ _____

5. theoretical yield: $0.0500 \text{ mol } Ga_2O_3 \times \frac{187.44 \text{ g } Ga_2O_3}{1 \text{ mol } Ga_2O_3}$ _____

6. percent yield: $\frac{9.37 \text{ g } Ga_2O_3}{7.42 \text{ g } Ga_2O_3} \times 100$ _____

MIXED MOLE PROBLEMS

Name _____

Solve the following problems.

1. How many grams are there in 1.5×10^{25} molecules of CO_2?

_____

2. What volume would the CO_2 in Problem 1 occupy at STP?

_____

3. A sample of NH_3 gas occupies 75.0 liters at STP. How many molecules is this?

_____

4. What is the mass of the sample of NH_3 in Problem 3?

_____

5. How many atoms are there in 1.3×10^{22} molecules of NO_2?

_____

6. A 5.0 g sample of O_2 is in a container at STP. What volume is the container?

_____

7. How many molecules of O_2 are in the container in Problem 6? How many atoms of oxygen?

_____

_____

THE MOLE AND VOLUME

Name _____

For gases at STP (273 K and 1 atm pressure), one mole occupies a volume of 22.4 L. What volume will the following quantities of gases occupy at STP?

1. 1.00 mole of H_2
2. 3.20 moles of O_2
3. 0.750 mole of N_2
4. 1.75 moles of CO_2
5. 0.50 mole of NH_3
6. 5.0 g of H_2
7. 100. g of O_2
8. 28.0 g of N_2
9. 60. g of CO_2
10. 10. g of NH_3

PERCENTAGE ERROR

Name _____

Percentage error is a way for scientists to express how far off a laboratory value is from the commonly accepted value.

The formula is:

$$\% \text{ error} = \left| \frac{\text{Accepted Value} - \text{Experimental Value}}{\text{Accepted Value}} \right| \times 100$$

→ absolute value

Determine the percentage error in the following problems.

1. Experimental Value = 1.24 g
   Accepted Value = 1.30 g

   Answer: _____

2. Experimental Value = 1.24×10^{-2} g
   Accepted Value = 9.98×10^{-3} g

   Answer: _____

3. Experimental Value = 252 mL
   Accepted Value = 225 mL

   Answer: _____

4. Experimental Value = 22.2 L
   Accepted Value = 22.4 L

   Answer: _____

5. Experimental Value = 125.2 mg
   Accepted Value = 124.8 mg

   Answer: _____

TEMPERATURE AND ITS MEASUREMENT

Name _____ FR PC

Temperature (which measures average kinetic energy of the molecules) can be measured using three common scales: Celsius, Kelvin and Fahrenheit. We use the following formulas to convert from one scale to another. Celsius is the scale most desirable for laboratory work. Kelvin represents the absolute scale. Fahrenheit is the old English scale which is never used in lab.

$°C = K - 273$	$K = °C + 273$
$°F = {}^{9}/_{5}°C + 32$	$°C = {}^{5}/_{9}(°F - 32)$

Complete the following chart. All measurements are good to 1° C or better.

	°C	K	°F
1	0° C		
2			212° F
3		450 K	
4			98.6° F
5	-273° C		
6		294 K	
7			77° F
8		225 K	
9	-40° C		

Answ

2.

3.

4.

5.

6.

7.

8.

9.

10.

12.

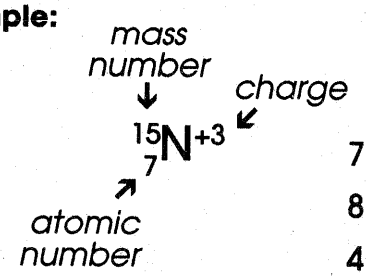
ATOMIC STRUCTURE

Name _____

An atom is made up of protons and neutrons (both found in the nucleus) and electrons (in the surrounding electron cloud). The atomic number is equal to the number of protons. The mass number is equal to the number of protons plus neutrons. In a neutral atom, the number of protons equals the number of electrons. The charge on an ion indicates an imbalance between protons and electrons. Too many electrons produces a negative charge, too few, a positive charge.

This structure can be written as part of a chemical symbol.

Example:



7 protons

8 neutrons (15 – 7)

4 electrons

Complete the following chart.

Element/ Ion	Atomic Number	Atomic Mass	Mass Number	Protons	Neutrons	Electrons
H						
H^+						
$^{12}_{6}C$						
$^{7}_{3}Li^+$						
$^{35}_{17}Cl^-$						
$^{39}_{19}K$						
$^{24}_{12}Mg^{2+}$						
As^{3-}						
Ag						
Ag^{+1}						
S^{-2}						
U						

Percentage Composition

Name _____

Date _____

Find the percentage composition of each of the following compounds.

1. $NaCl$
2. HBr
3. KI
4. CO
5. SO_2
6. H_2Te
7. K_2S
8. AlI_3
9. NH_3
10. NH_4Br
11. $NaNO_3$
12. H_2SO_4
13. $Ca(NO_3)_2$
14. $Sc(OH)_3$
15. K_3PO_4
16. $Zn_3(PO_4)_2$
17. Fe_3O_4
18. $(NH_4)_2SO_4$
19. $CuSO_4 \cdot 5H_2O$
20. $(NH_4)_2Cr_2O_7$
21. potassium bromide
22. cesium chloride
23. nitric oxide
24. hydriodic acid
25. carbon dioxide
26. water
27. sodium oxide
28. phosphorus tribromide
29. arsine
30. potassium nitrite
31. ammonium chloride
32. phosphoric acid
33. barium hydroxide
34. aluminum nitrate

(continued)

35. lithium phosphate
36. calcium phosphate
37. aluminum oxide
38. ammonium carbonate
39. ammonium phosphate
40. barium chloride dihydrate
41. What is the percentage of strontium in $SrCl_2$?
42. What is the percentage of carbon in calcium carbonate?
43. What is the percentage of water in copper(II) sulfate pentahydrate?
44. What is the percentage of hydrogen in $Ca(C_2H_3O_2)_2$?
45. What is the percentage of oxygen in $KMnO_4$?
46. What is the percentage of cobalt in cobalt(II) nitrate?
47. What is the percentage of carbon in sucrose, $C_{12}H_{22}O_{11}$?
48. What is the percentage of bismuth in sodium bismuthate, $NaBiO_3$?
49. What is the percentage of aluminum in $NaAl(SO_4)_2 \cdot 12H_2O$?
50. What is the percentage of chromium in potassium dichromate?
51. How much iron can be obtained from 100.0 g of Fe_3O_4?
52. How much phosphorus is there in 500.0 g of calcium phosphate?
53. How many kilograms of aluminum can be obtained from 2000 kg of aluminum chloride?
54. How many grams of hydrogen can be obtained from 35 cm^3 of water?
55. How much anhydrous copper(II) sulfate can be obtained from 15.0 g of hydrated copper(II) sulfate?
56. How many grams of silver can be recovered from 10.0 g of silver sulfide?

(continued)

Empirical Formula

Name _____

Date _____

Find the empirical formula for each of the following substances. The percentage composition is given.

1. 88.8% copper; 11.2% oxygen
2. 40.0% carbon; 6.7% hydrogen; 53.3% oxygen
3. 92.3% carbon; 7.7% hydrogen
4. 70.0% iron; 30.0% oxygen
5. 5.88% hydrogen; 94.12% oxygen
6. 79.90% copper; 20.10% oxygen
7. 56.4% potassium; 8.7% carbon; 34.9% oxygen
8. 10.04% carbon; 0.84% hydrogen; 89.12% chlorine
9. 42.50% chromium; 57.50% chlorine
10. 15.8% carbon; 84.2% sulfur
11. 30.43% nitrogen; 69.57% oxygen
12. 82.40% nitrogen; 17.60% hydrogen
13. 12.5% hydrogen; 37.5% carbon; 50.0% oxygen
14. 75.0% carbon; 25.0% hydrogen
15. 29.40% calcium; 23.56% sulfur; 47.04% oxygen
16. 38.67% potassium; 13.85% nitrogen; 47.48% oxygen
17. 60.0% magnesium; 40.0% oxygen
18. 52.94% aluminum; 47.06% oxygen
19. 72.40% iron; 27.60% oxygen

(continued)

Empirical Formula *(continued)*

Name _____

Date _____

20. 52.0% zinc; 9.6% carbon; 38.4% oxygen

21. 60.98% arsenic; 39.02% sulfur

22. 74.17% mercury; 25.83% chlorine

23. 60.0% terbium; 40.0% chlorine

24. 65.1% scandium; 34.9% oxygen

25. 34.6% gallium; 17.8% carbon; 47.6% oxygen

26. A sample of potassium sulfate has the following composition: 17.96 g of potassium, 7.35 g of sulfur, 14.70 g of oxygen. What is its simplest formula?

27. A pure sample of mercury oxide produced 20.3 g of mercury and 1.7 g of oxygen. What oxide of mercury is this?

28. 11.00 g of a certain compound contain 2.82 g of magnesium of 8.18 g of chlorine. What is its simplest formula?

29. A certain sample of a barium salt contains 8.57 g of barium and 4.43 g of chlorine. What is its simplest formula?

30. 50.0 g of sulfur are mixed with 100.0 g of iron and the mixture is heated. When the reaction is completed, 12.7 g of iron remain. What is the formula of the compound formed?

31. 0.916 g of iron is heated in air. The resulting product has a mass of 1.178 g. What is the formula of the compound?

32. 21.42 g of calcium combine with 8.58 g of oxygen in a combustion reaction. What is the formula of the product?

33. 0.238 g of carbon is burned in 1.00 dm^3 of oxygen. The oxide of carbon which is formed has a mass of 0.872 g. What is the formula of this oxide?

34. Analysis of 100.0 g of a compound produces the following result: 26.6 g of potassium; 35.4 g of chromium; 38.0 g of oxygen. What is the formula of this compound?

35. When 0.982 g of mercuric oxide are heated until all oxygen is expelled, 0.909 g of mercury remain. What is the formula of this oxide?