Name ______________ Date ________ Class ________

CHAPTER 3 REVIEW

Atoms: The Building Blocks of Matter

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. Why is Democritus's view of matter considered only an idea, while Dalton's view is considered a theory?

Democritus's idea of matter does not relate atoms to a measurable property, while Dalton's theory can be tested through quantitative experimentation.

2. Give an example of a chemical or physical process that illustrates the law of conservation of mass.

A glass of ice cubes will have the same mass when the ice has completely melted into liquid water, even though its volume will change. (Accept any reasonable process.)

3. State two principles from Dalton's atomic theory that have been revised as new information has become available.

Atoms are divisible into smaller particles called subatomic particles. A given element can have atoms with different masses, called isotopes.

4. The formation of water according to the equation

$$2H_2 + O_2 \rightarrow 2H_2O$$

shows that 2 molecules (made of 4 atoms) of hydrogen and 1 molecule (made of 2 atoms) of oxygen produce 2 molecules of water. The total mass of the product, water, is equal to the sum of the masses of each of the reactants, hydrogen and oxygen. What parts of Dalton's atomic theory are illustrated by this reaction? What law does this reaction illustrate?

Atoms cannot be subdivided, created, or destroyed. Also, atoms of different elements combine in simple, whole-number ratios to form compounds. The reaction also illustrates the law of conservation of mass.

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SECTION 1 continued

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

5. **16 g** If 3 g of element C combine with 8 g of element D to form compound CD, how many grams of D are needed to form compound CD_2?

6. A sample of baking soda, $NaHCO_3$, *always* contains 27.37% by mass of sodium, 1.20% of hydrogen, 14.30% of carbon, and 57.14% of oxygen.

a. Which law do these data illustrate?

the law of definite proportions

b. State the law.

A chemical compound contains the same elements in exactly the same proportions by mass regardless of the sample or the source of the compound.

7. Nitrogen and oxygen combine to form several compounds, as shown by the following table.

Compound	Mass of nitrogen that combines with 1 g oxygen (*g*)
NO	1.70
NO_2	0.85
NO_4	0.44

Calculate the ratio of the masses of nitrogen in each of the following:

2.0 **a.** $\frac{NO}{NO_2}$ **2.0** **b.** $\frac{NO_2}{NO_4}$ **4.0** **c.** $\frac{NO}{NO_4}$

d. Which law do these data illustrate?

the law of multiple proportions

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CHAPTER 3 REVIEW

Atoms: The Building Blocks of Matter

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. In cathode-ray tubes, the cathode ray is emitted from the negative electrode, which is called the **cathode**.

2. The smallest unit of an element that can exist either alone or in molecules containing the same or different elements is the **atom**.

3. A positively charged particle found in the nucleus is called a(n) **proton**.

4. A nuclear particle that has no electrical charge is called a(n) **neutron**.

5. The subatomic particles that are least massive and most massive, respectively, are the **electron** and **neutron**.

6. A cathode ray produced in a gas-filled tube is deflected by a magnetic field. A wire carrying an electric current can be pulled by a magnetic field. A cathode ray is deflected away from a negatively charged object. What property of the cathode ray is shown by these phenomena?

The particles that compose cathode rays are negatively charged.

7. How would the electrons produced in a cathode-ray tube filled with neon gas compare with the electrons produced in a cathode-ray tube filled with chlorine gas?

The electrons produced from neon gas and chlorine gas would behave in the same way because electrons do not differ from element to element.

8. **a.** Is an atom positively charged, negatively charged, or neutral?

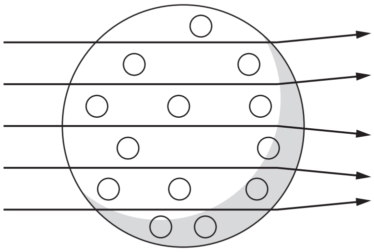
Atoms are neutral.

b. Explain how an atom can exist in this state.

Atoms consist of a positively charged nucleus, made up of protons and neutrons, that is surrounded by a negatively charged electron cloud. The positive and negative charges combine to form a net neutral charge.

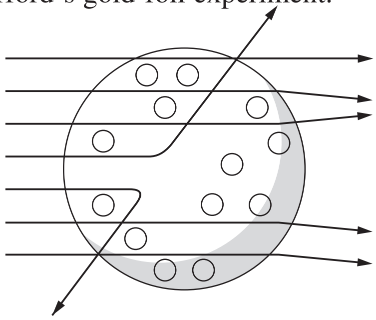
SECTION 2 continued

9. Below are illustrations of two scientists' conceptions of the atom. Label the electrons in both illustrations with a − sign and the nucleus in the illustration to the right with a + sign. On the lines below the figures, identify which illustration was believed to be correct before Rutherford's gold-foil experiment and which was believed to be correct after Rutherford's gold-foil experiment.



(Students should place a − sign inside all circles.)

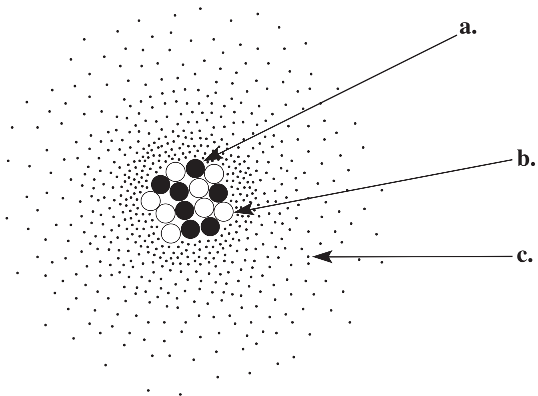
a. **before Rutherford's experiment**



(Students should place a + sign in the center and a − sign inside all circles.)

b. **after Rutherford's experiment**

10. In the space provided, describe the locations of the subatomic particles in the labeled model of an atom of nitrogen below, and give the charge and relative mass of each particle.



a. proton

The proton, a positive and relatively massive particle, should be located in the nucleus.

b. neutron

The neutron, a neutral and relatively massive particle, should be located in the nucleus.

c. electron (a possible location of this particle)

The electron, a negative particle with a low mass, should be located in the cloud surrounding the nucleus.

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CHAPTER 3 REVIEW

Atoms: The Building Blocks of Matter

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. Explain the difference between the *mass number* and the *atomic number* of a nuclide.

Mass number is the total number of protons and neutrons in the nucleus of an isotope. Atomic number is the total number of protons in the nucleus of each atom of an element.

2. Why is it necessary to use the average atomic mass of all isotopes, rather than the mass of the most commonly occurring isotope, when referring to the atomic mass of an element?

Elements rarely occur as only one isotope; rather, they exist as mixtures of different isotopes of various masses. Using a weighted average atomic mass, you can account for the less common isotopes.

3. How many particles are in 1 mol of carbon? 1 mol of lithium? 1 mol of eggs? Will 1 mol of each of these substances have the same mass?

There are 6.022×10^{23} particles in 1 mol of each of these substances. One mole of one substance will not necessarily have the same mass as one mole of another substance.

4. Explain what happens to each of the following as the atomic masses of the elements in the periodic table increase:

a. the number of protons

increases

b. the number of electrons

increases

c. the number of atoms in 1 mol of each element

stays the same

5. Use a periodic table to complete the following chart:

Element	Symbol	Atomic number	Mass number
Europium-151	$^{151}_{63}Eu$	63	151
Silver-109	$^{109}_{47}Ag$	47	109
Tellurium-128	$^{128}_{52}Te$	52	128

6. List the number of protons, neutrons, and electrons found in zinc-66.

__30__ protons

__36__ neutrons

__30__ electrons

PROBLEMS Write the answer on the line to the left. Show all your work in the space provided.

7. __32.00 g__ What is the mass in grams of 2.000 mol of oxygen atoms?

8. __3.706 mol__ How many moles of aluminum exist in 100.0 g of aluminum?

9. __1.994×10^{24} atoms__ How many atoms are in 80.45 g of magnesium?

10. __1.993×10^{-21} g__ What is the mass in grams of 100 atoms of the carbon-12 isotope?

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CHAPTER 3 REVIEW

Atoms: The Building Blocks of Matter

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. The element boron, B, has an atomic mass of 10.81 amu according to the periodic table. However, no single atom of boron has a mass of exactly 10.81 amu. How can you explain this difference?

The periodic table reports the average atomic mass, which is a weighted average of all isotopes of boron.

2. How did the outcome of Rutherford's gold-foil experiment indicate the existence of a nucleus?

A few alpha particles rebounded and therefore must have "hit" a dense bundle of matter. Because such a small percentage of particles were redirected, he reasoned that this clump of matter, called the nucleus, must occupy only a small fraction of the atom's total space.

3. Ibuprofen, $C_{13}H_{18}O_2$, that is manufactured in Michigan contains 75.69% by mass carbon, 8.80% hydrogen, and 15.51% oxygen. If you buy some ibuprofen for a headache while you are on vacation in Germany, how do you know that it has the same percentage composition as the ibuprofen you buy at home?

The law of definite proportions states that a chemical compound contains the same elements in exactly the same proportions by mass regardless of the site of the sample or the source of the compound.

4. Complete the following chart, using the atomic mass values from the periodic table:

Compound	Mass of Fe (g)	Mass of O (g)	Ratio of O:Fe
FeO	55.85	16.00	0.2865
Fe_2O_3	111.70	48.00	0.4297
Fe_3O_4	167.55	64.00	0.3820

5. Complete the following table:

Element	Symbol	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
Sodium	**Na**	**11**	22	**11**	**11**	**11**
Fluorine	F	9	19	**9**	**10**	**9**
Bromine	**Br**	**35**	80	**35**	45	**35**
Calcium	**Ca**	**20**	40	20	**20**	**20**
Hydrogen	**H**	1	**1**	**1**	0	**1**
Radon	**Rn**	**86**	222	**86**	**136**	86

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

6. **1.51×10^{24} atoms** **a.** How many atoms are there in 2.50 mol of hydrogen?

1.51×10^{24} atoms **b.** How many atoms are there in 2.50 mol of uranium?

4.65 mol **c.** How many moles are present in 107 g of sodium?

7. A certain element exists as three natural isotopes, as shown in the table below.

Isotope	Mass (amu)	Percent natural abundance	Mass number
1	19.99244	90.51	20
2	20.99395	0.27	21
3	21.99138	9.22	22

20 amu Calculate the average atomic mass of this element.

c. 60.4 kg; 1.88×10^4 dm^3
d. 0.94 g/cm^3; 5.3×10^{-4} m^3
e. 2.5×10^3 kg; 2.7×10^6 cm^3
7. 2.8 g/cm^3
8. a. 0.72 μm
b. 2.5×10^3 atoms
9. 1300 L/min
10. 1.3×10^6 cal/h
11. 5.44 g/ cm^3
12. 2.24×10^4 cm^3
13. 32 000 uses
14. 2500 L
15. 9.5 L/min

MOLE CONCEPT

1. a. 3.7×10^{-4} mol Pd
b. 150 mol Fe
c. 0.040 mol Ta
d. 5.38×10^{-5} mol Sb
e. 41.1 mol Ba
f. 3.51×10^{-8} mol Mo
2. a. 52.10 g Cr
b. 1.5×10^4 g or 15 kg Al
c. 8.23×10^{-7} g Ne
d. 3×10^2 g or 0.3 kg Ti
e. 1.1 g Xe
f. 2.28×10^5 g or 228 kg Li
3. a. 1.02×10^{25} atoms Ge
b. 3.700×10^{23} atoms Cu
c. 1.82×10^{24} atoms Sn
d. 1.2×10^{30} atoms C
e. 1.1×10^{21} atoms Zr
f. 1.943×10^{14} atoms K
4. a. 10.00 mol Co
b. 0.176 mol W
c. 4.995×10^{-5} mol Ag
d. 1.6×10^{-15} mol Pu
e. 7.66×10^{-7} mol Rn
f. 1×10^{-11} mol Ce
5. a. 2.5×10^{19} atoms Au
b. 5.10×10^{24} atoms Mo
c. 4.96×10^{20} atoms Am
d. 3.011×10^{26} atoms Ne
e. 2.03×10^{18} atoms Bi
f. 9.4×10^{16} atoms U
6. a. 117 g Rb
b. 223 g Mn
c. 2.11×10^5 g Te
d. 2.6×10^{-3} g Rh
e. 3.31×10^{-8} g Ra
f. 8.71×10^{-5} g Hf
7. a. 0.749 mol CH_3COOH
b. 0.0213 mol $Pb(NO_3)_2$
c. 3×10^4 mol Fe_2O_3
d. 2.66×10^{-4} mol $C_2H_5NH_2$
e. 1.13×10^{-5} mol $C_{17}H_{35}COOH$
f. 378 mol $(NH_4)_2SO_4$
8. a. 764 g $SeOBr_2$
b. 4.88×10^4 g $CaCO_3$
c. 2.7 g $C_{20}H_{28}O_2$
d. 9.74×10^{-6} g $C_{10}H_{14}N_2$
e. 529 g $Sr(NO_3)_2$
f. 1.23×10^{-3} g UF_6
9. a. 2.57×10^{24} formula units WO_3
b. 1.81×10^{21} formula units $Sr(NO_3)_2$
c. 4.37×10^{25} molecules $C_6H_5CH_3$
d. 3.08×10^{17} molecules $C_{29}H_{50}O_2$
e. 9.0×10^{26} molecules N_2H_4
f. 5.96×10^{23} molecules $C_6H_5NO_2$
10. a. 1.14×10^{24} formula units $FePO_4$
b. 6.4×10^{19} molecules C_5H_5N
c. 6.9×10^{20} molecules $(CH_3)_2CHCH_2OH$
d. 8.7×10^{17} formula units $Hg(C_2H_3O_2)_2$
e. 5.5×10^{19} formula units Li_2CO_3
11. a. 52.9 g F_2
b. 1.19×10^3 g or 1.19 kg $BeSO_4$
c. 1.388×10^5 g or 138.8 kg $CHCl_3$
d. 9.6×10^{-12} g $Cr(CHO_2)_3$
e. 6.6×10^{-4} g HNO_3
f. 2.38×10^4 g or 23.8 kg $C_2Cl_2F_4$
12. 0.158 mol Au
0.159 mol Pt
0.288 mol Ag
13. 0.234 mol C_6H_5OH
14. 3.8 g I_2
15. 1.00×10^{22} atoms C
16. a. 0.0721 mol $CaCl_2$
55.49 mol H_2O
b. 0.0721 mol Ca^{2+}
0.144 mol Cl^-
17. a. 1.325 mol $C_{12}H_{22}O_{11}$
b. 7.762 mol NaCl
18. 0.400 mol ions
19. 4.75 mol atoms
20. a. 249 g H_2O
b. 13.8 mol H_2O
c. 36.1 mL H_2O
d. 36.0 g H_2O
21. The mass of a sugar molecule is much greater than the mass of a water molecule. Therefore, the mass of 1 mol of sugar molecules is much greater than the mass of 1 mol of water molecules.
22. 1.52 g Al

23. 0.14 mol O_2
24. a. 0.500 mol Ag
0.250 mol S
b. 0.157 mol Ag_2S
0.313 mol Ag
0.157 mol S
c. 33.8 g Ag
5.03 g S

PERCENTAGE COMPOSITION

1. a. HNO_3
1.60% H
22.23% N
76.17% O
b. NH_3
82.22% N
17.78% H
c. $HgSO_4$
67.616% Hg
10.81% S
21.57% O
d. SbF_5
56.173% Sb
43.83% F
2. a. 7.99% Li
92.01% Br
b. 94.33% C
5.67% H
c. 35.00% N
5.05% H
59.96% O
d. 2.15% H
29.80% N
68.06% O
e. 87.059% Ag
12.94% S
f. 32.47% Fe
13.96% C
16.29% N
37.28% S
g. $LiC_2H_3O_2$
10.52% Li
36.40% C
4.59% H
48.49% O
h. $Ni(CHO_2)_2$
39.46% Ni
16.15% C
1.36% H
43.03% O
3. a. 46.65% N
b. 23.76% S
c. 89.491% Tl
d. 39.17% O
e. 79.95% Br in $CaBr_2$
f. 78.767% Sn in SnO_2
4. a. 1.47 g O
b. 26.5 metric tons Al
c. 262 g Ag
d. 0.487 g Au
e. 312 g Se
f. 3.1×10^4 g Cl
5. a. 40.55% H_2O
b. 43.86% H_2O
c. 20.70% H_2O
d. 28.90% H_2O
6. a. $Ni(C_2H_3O_2)_2 \cdot 4H_2O$
23.58% Ni
b. $Na_2CrO_4 \cdot 4H_2O$
22.22% Cr
c. $Ce(SO_4)_2 \cdot 4H_2O$
34.65% Ce
7. 43.1 kg Hg
8. malachite: 5.75×10^2 kg Cu
chalcopyrite: 3.46×10^2 kg Cu
malachite has a greater Cu content
9. a. 25.59% V
b. 39.71% Sn
c. 22.22% Cl
10. 319.6 g anhydrous $CuSO_4$
11. 1.57 g $AgNO_3$
12. 54.3 g Ag
8.08 g S
13. 23.1 g $MgSO_4 \cdot 7H_2O$
14. 3.27×10^2 g S

EMPIRICAL FORMULAS

1. a. $BaCl_2$
b. BiO_3H_3 or $Bi(OH)_3$
c. AlN_3O_9 or $Al(NO_3)_3$
d. $ZnC_4H_6O_4$ or $Zn(CH_3COO)_2$
e. $NiN_2S_2H_8O_8$ or $Ni(NH_4)_2SO_4$
f. $C_2HBr_3O_2$ or CBr_3COOH
2. a. CuF_2
b. $Ba(CN)_2$
c. $MnSO_4$
3. a. NiI_2
b. MgN_2O_6 or $Mg(NO_3)_2$
c. MgS_2O_3, magnesium thiosulfate
d. K_2SnO_3, potassium stannate
4. a. As_2S_3
b. Re_2O_7
c. $N_2H_4O_3$ or NH_4NO_3
d. $Fe_2Cr_3O_{12}$ or $Fe_2(CrO_4)_3$
e. $C_5H_9N_3$
f. $C_6H_5F_2N$ or $C_6H_3F_2NH_2$