

## Chapter 3: Mass Relationships in Chemical Reactions

A periodic table will be required to answer some of these questions.

1. An atom of helium has a mass about four times greater than that of an atom of hydrogen. Which choice makes the correct comparison of the relative numbers of helium and hydrogen atoms in equal masses of the two elements?
- A) There are about four times as many helium atoms as hydrogen atoms.
  - B) There are about two times as many helium atoms as hydrogen atoms.
  - C) The number of helium and hydrogen atoms is the same.
  - D) There are about half as many helium atoms as hydrogen atoms.
  - E) There are about one-fourth as many helium atoms as hydrogen atoms.
- Ans: E Category: Easy Section: 3.1

2. There are two stable isotopes of chlorine: chlorine-35, with a mass of 34.968853 amu; and chlorine-37, with a mass of 36.965903. Given that the average atomic mass of a chlorine atom is 35.45 amu, which of the following statements is true?
- A) Chlorine contains almost exclusively of  $^{35}_{17}\text{Cl}$ , with very little  $^{37}_{17}\text{Cl}$ .
  - B) Chlorine contains more  $^{35}_{17}\text{Cl}$  than  $^{37}_{17}\text{Cl}$ .
  - C) Chlorine contains roughly equal amounts of  $^{35}_{17}\text{Cl}$  and  $^{37}_{17}\text{Cl}$ .
  - D) Chlorine contains more  $^{37}_{17}\text{Cl}$  than  $^{35}_{17}\text{Cl}$ .
  - E) Chlorine contains almost exclusively of  $^{37}_{17}\text{Cl}$ , with very little  $^{35}_{17}\text{Cl}$ .
- Ans: B Category: Easy Section: 3.1

3. An atom of bromine has a mass about four times greater than that of an atom of neon. Which choice makes the correct comparison of the relative numbers of bromine and neon atoms in 1,000 g of each element?
- A) The number of bromine and neon atoms is the same.
  - B) There are one thousand times as many bromine atoms as neon atoms.
  - C) There are one thousand times as many neon atoms as bromine atoms.
  - D) There are four times as many neon atoms as bromine atoms.
  - E) There are four times as many bromine atoms as neon atoms.
- Ans: D Category: Easy Section: 3.1

4. An atom of bromine has a mass about four times greater than that of an atom of neon. How many grams of neon will contain the same number of atoms as 1,000 g of bromine?
- A) 4 g Ne B) 250 g Ne C) 400 g Ne D) 1,000 g Ne E) 4,000 g Ne
- Ans: B Category: Medium Section: 3.1

5. An average atom of uranium (U) is approximately how many times heavier than an atom of potassium?
- A) 6.1 times B) 4.8 times C) 2.4 times D) 12.5 times E) 7.7 times
- Ans: A Category: Easy Section: 3.1

6. Boron obtained from borax deposits in Death Valley consists of two isotopes. They are boron-10 and boron-11 with atomic masses of 10.013 amu and 11.009 amu, respectively. The atomic mass of boron is 10.81 amu (see periodic table). Which isotope of boron is more abundant, boron-10 or boron-11?
- A) Cannot be determined from data given  
 B) Neither, their abundances are the same.  
 C) Boron-10  
 D) Boron-11

Ans: D Category: Medium Section: 3.1

7. The element oxygen consists of three naturally occurring isotopes:  $^{16}\text{O}$ ,  $^{17}\text{O}$ , and  $^{18}\text{O}$ . The atomic mass of oxygen is 16.0 amu. What can be implied about the relative abundances of these isotopes?
- A) More than 50% of all O atoms are  $^{17}\text{O}$ .  
 B) Almost all O atoms are  $^{18}\text{O}$ .  
 C) Almost all O atoms are  $^{17}\text{O}$ .  
 D) The isotopes all have the same abundance, i.e. 33.3%.  
 E) The abundances of  $^{17}\text{O}$  and  $^{18}\text{O}$  are very small.

Ans: E Category: Medium Section: 3.1

8. What is the average mass, in grams, of one potassium atom?

- A)  $5.14 \times 10^{-23}$  g  
 B)  $6.49 \times 10^{-23}$  g  
 C)  $6.02 \times 10^{-18}$  g  
 D) 31.0 g  
 E) 39.1 g

Ans: B Category: Easy Section: 3.2

9. What is the average mass, in grams, of one atom of iron?

- A)  $6.02 \times 10^{23}$  g  
 B)  $1.66 \times 10^{-24}$  g  
 C)  $9.28 \times 10^{-23}$  g  
 D) 55.85 g  
 E)  $55.85 \times 10^{-23}$  g

Ans: C Category: Easy Section: 3.2

10. What is the average mass, in grams, of one arsenic atom?

- A)  $5.48 \times 10^{-23}$  g B) 33.0 g C) 74.9 g D)  $1.24 \times 10^{-22}$  g E)  $8.04 \times 10^{21}$  g

Ans: D Category: Easy Section: 3.2

11. The mass of  $1.21 \times 10^{20}$  atoms of sulfur is

- A)  $3.88 \times 10^{21}$  g. B) 2.00 mg. C) 32.06 g. D) 6.44 mg. E)  $2.00 \times 10^{-4}$  g.

Ans: D Category: Medium Section: 3.2

12. The mass of  $1.63 \times 10^{21}$  silicon atoms is

- A)  $2.71 \times 10^{-23}$  g. D)  $1.04 \times 10^4$  g.  
 B)  $4.58 \times 10^{22}$  g. E)  $7.60 \times 10^{-2}$  g.  
 C) 28.08 g.

Ans: E Category: Medium Section: 3.2







37. The molecular formula of aspirin is  $C_9H_8O_4$ . How many aspirin molecules are present in one 500-milligram tablet?

- A) 2.77 molecules  
 B)  $2.77 \times 10^{-3}$  molecules  
 C)  $1.67 \times 10^{24}$  molecules  
 D)  $1.67 \times 10^{21}$  molecules  
 E) None of these is correct.

Ans: D Category: Medium Section: 3.3

38. Formaldehyde has the formula  $CH_2O$ . How many molecules are there in 0.11 g of formaldehyde?

- A)  $6.1 \times 10^{-27}$  B)  $3.7 \times 10^{-3}$  C) 4 D)  $2.2 \times 10^{21}$  E)  $6.6 \times 10^{22}$

Ans: D Category: Medium Section: 3.3

39. How many molecules are there in 8.0 g of ozone,  $O_3$ ?

- A) 3 molecules  
 B)  $3.6 \times 10^{24}$  molecules  
 C)  $1.0 \times 10^{23}$  molecules  
 D)  $3.0 \times 10^{23}$  molecules  
 E)  $6.0 \times 10^{23}$  molecules

Ans: C Category: Medium Section: 3.3

40. How many moles of HCl are represented by  $1.0 \times 10^{19}$  HCl molecules?

- A)  $1.7 \times 10^{-5}$  mol  
 B)  $1.5 \times 10^{-3}$  mol  
 C)  $1.0 \times 10^{19}$  mol  
 D) 36.5 mol  
 E)  $6.02 \times 10^4$  mol

Ans: A Category: Easy Section: 3.2

41. How many sodium atoms are there in 6.0 g of  $Na_3N$ ?

- A)  $3.6 \times 10^{24}$  atoms  
 B)  $4.6 \times 10^{22}$  atoms  
 C)  $1.3 \times 10^{23}$  atoms  
 D) 0.217 atoms  
 E) 0.072 atoms

Ans: C Category: Medium Section: 3.3

42. How many moles of oxygen atoms are there in 10 moles of  $KClO_3$ ?

- A) 3 mol B) 3.3 mol C) 10 mol D) 30 mol E)  $6.02 \times 10^{24}$  mol

Ans: D Category: Easy Section: 3.3

43. How many sulfur atoms are there in 21.0 g of  $Al_2S_3$ ?

- A)  $8.42 \times 10^{22}$  atoms  
 B)  $2.53 \times 10^{23}$  atoms  
 C)  $2.14 \times 10^{23}$  atoms  
 D)  $6.02 \times 10^{23}$  atoms  
 E)  $6.30 \times 10^{26}$  atoms

Ans: B Category: Medium Section: 3.3

44. How many sulfur atoms are present in 25.6 g of  $Al_2(S_2O_3)_3$ ?

- A) 0.393 B) 6 C)  $3.95 \times 10^{22}$  D)  $7.90 \times 10^{22}$  E)  $2.37 \times 10^{23}$

Ans: E Category: Medium Section: 3.3

45. How many fluorine atoms are there in 65 g of  $\text{CF}_4$ ?  
 A) 0.74 atoms D)  $1.8 \times 10^{24}$  atoms  
 B) 3.0 atoms E)  $2.4 \times 10^{23}$  atoms  
 C)  $4.5 \times 10^{23}$  atoms  
 Ans: D Category: Medium Section: 3.3
46. How many moles of O atoms are in 25.7 g of  $\text{CaSO}_4$ ?  
 A) 0.189 mol D)  $1.14 \times 10^{23}$  mol  
 B) 0.755 mol E)  $4.55 \times 10^{23}$  mol  
 C) 4.00 mol  
 Ans: B Category: Medium Section: 3.3
47. How many O atoms are there in 51.4 g  $\text{CaSO}_4$ ?  
 A) 4 B)  $2.40 \times 10^{24}$  C) 1.13 D)  $9.09 \times 10^{23}$  E)  $2.28 \times 10^{23}$   
 Ans: D Category: Medium Section: 3.3
48. How many moles of Cl atoms are there in 65.2 g  $\text{CHCl}_3$ ?  
 A) 0.548 mol B) 1.09 mol C)  $3.3 \times 10^{23}$  mol D) 1.64 mol E) 3.0 mol  
 Ans: D Category: Medium Section: 3.3
49. How many carbon atoms are there in 10 lbs of sugar,  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ?  
 A)  $9.6 \times 10^{25}$  atoms D) 4.21 atoms  
 B)  $8.0 \times 10^{24}$  atoms E) 342 atoms  
 C) 159 atoms  
 Ans: A Category: Medium Section: 3.3
50. How many grams of sulfur are there in 6.0 g of  $\text{Fe}_2(\text{SO}_4)_3$ ?  
 A) 2.40 g B) 0.48 g C) 6.00 g D) 0.92 g E) 1.44 g  
 Ans: E Category: Medium Section: 3.3
51. How many grams of sodium are there in 10. g of sodium sulfate,  $\text{Na}_2\text{SO}_4$ ?  
 A) 0.16 g B) 0.32 g C) 3.2 g D) 1.6 g E) 142 g  
 Ans: C Category: Medium Section: 3.3
52. How many grams of nitrogen are there in 7.5 g of  $\text{Ca}(\text{NO}_3)_2$ ?  
 A) 0.64 g B) 1.3 g C) 0.15 g D) 1.15 g E) 2.3 g  
 Ans: B Category: Medium Section: 3.3
53. The mass of four moles of molecular bromine ( $\text{Br}_2$ ) is  
 A) 80 g. B) 320 g. C) 640 g. D) 140 g. E)  $24 \times 10^{23}$  g.  
 Ans: C Category: Easy Section: 3.3
54. Calculate the mass of 4.50 moles of chlorine gas,  $\text{Cl}_2$ .  
 A)  $6.34 \times 10^{-2}$  g B) 4.5 g C) 15.7 g D) 160 g E) 319 g  
 Ans: E Category: Easy Section: 3.3

55. What is the mass of 3.00 moles of ethanol,  $C_2H_6O$ ?  
 A)  $4.99 \times 10^{-24}$  g B) 138 g C)  $6.52 \times 10^{-2}$  g D) 50 g E)  $1.81 \times 10^{24}$  g  
 Ans: B Category: Easy Section: 3.3
56. What is the mass of 0.20 mole of  $C_2H_6O$  (ethanol)?  
 A) 230 g B) 46 g C) 23 g D) 4.6 g E) None of these.  
 Ans: E Category: Easy Section: 3.3
57. What is the mass of  $8.25 \times 10^{19}$   $UF_6$  molecules?  
 A) 352 g B) 0.0482 g C)  $1.37 \times 10^{-4}$  g D)  $2.90 \times 10^{22}$  g E)  $8.25 \times 10^{19}$  g  
 Ans: B Category: Medium Section: 3.3
58. A mass spectrometer works by ionizing atoms or molecules, and then accelerating them past oppositely charged plates. The mass is obtained by  
 A) measuring the force of impact on a detecting screen, and then calculating the mass using force = mass  $\times$  acceleration.  
 B) suspending the ions in an applied electric field, and then calculating mass by the setting the downward gravitational force equal to the upward electrostatic force.  
 C) measuring the magnitude of deflection as the ions pass through a magnetic field to obtain the charge-to-mass ratio, and then calculating the mass from that ratio.  
 D) measuring the time it takes for the ions to hit the detector at a known distance to calculate the acceleration, and then calculating mass from force = mass  $\times$  acceleration.  
 Ans: C Category: Medium Section: 3.4
59. The empirical formula of a compound of uranium and fluorine that is composed of 67.6% uranium and 32.4% fluorine is  
 A)  $U_2F$  B)  $U_3F_4$  C)  $UF_4$  D)  $UF_6$  E)  $UF_8$   
 Ans: D Category: Medium Section: 3.6
60. The percent composition by mass of a compound is 76.0% C, 12.8% H, and 11.2% O. The molar mass of this compound is 284.5 g/mol. What is the molecular formula of the compound?  
 A)  $C_{10}H_6O$  B)  $C_9H_{18}O$  C)  $C_{16}H_{28}O_4$  D)  $C_{20}H_{12}O_2$  E)  $C_{18}H_{36}O_2$   
 Ans: E Category: Medium Section: 3.6
61. A compound was discovered whose composition by mass is 85.6% C and 14.4% H. Which of the following could be the molecular formula of this compound?  
 A)  $CH_4$  B)  $C_2H_4$  C)  $C_3H_4$  D)  $C_2H_6$  E)  $C_3H_8$   
 Ans: B Category: Medium Section: 3.6
62. An organic thiol compound is 38.66% C, 9.73% H, and 51.61% S by mass. What is the empirical formula of this compound?  
 A)  $C_2H_6S$  B)  $C_3H_8S$  C)  $C_4H_{10}S$  D)  $C_4H_{12}S$  E)  $C_5H_{14}S$   
 Ans: A Category: Medium Section: 3.6



63. The percent composition by mass of an unknown chlorinated hydrocarbon was found to be 37.83% C, 6.35% H, and 55.83% Cl by mass. What is the empirical formula of this compound?

- A)  $C_2H_4Cl$  B)  $C_3H_7Cl$  C)  $C_3H_6Cl_2$  D)  $C_4H_9Cl$  E)  $C_5H_{11}Cl$

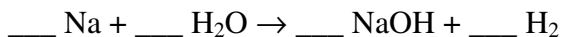
Ans: A Category: Medium Section: 3.6

64. Which one of the following chemical reactions is balanced?

- A)  $HCl + KMnO_4 \rightarrow Cl_2 + MnO_2 + H_2O + KCl$   
B)  $HCl + KMnO_4 \rightarrow Cl_2 + MnO_2 + 2H_2O + KCl$   
C)  $2HCl + 2KMnO_4 \rightarrow Cl_2 + MnO_2 + 2H_2O + 2KCl$   
D)  $6HCl + 2KMnO_4 \rightarrow 2Cl_2 + 2MnO_2 + 4H_2O + 2KCl$   
E)  $8HCl + 2KMnO_4 \rightarrow 3Cl_2 + 2MnO_2 + 4H_2O + 2KCl$

Ans: E Category: Medium Section: 3.6

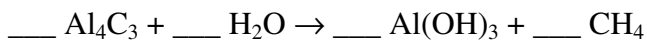
65. What is the coefficient of  $H_2O$  when the following equation is properly balanced with the smallest set of whole numbers?



- A) 1 B) 2 C) 3 D) 4 E) 5

Ans: B Category: Medium Section: 3.7

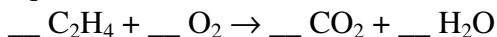
66. What is the coefficient of  $H_2O$  when the following equation is properly balanced with smallest set of whole numbers?



- A) 3 B) 4 C) 6 D) 12 E) 24

Ans: D Category: Medium Section: 3.7

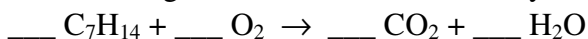
67. When balanced with smallest set of whole numbers, the coefficient of  $O_2$  in the following equation is



- A) 1. B) 2. C) 3. D) 4. E) 6.

Ans: C Category: Medium Section: 3.7

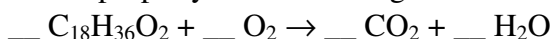
68. When a chemical equation is balanced, it will have a set of whole number coefficients that cannot be reduced to smaller whole numbers. What is the coefficient for  $O_2$  when the following combustion reaction of a hydrocarbon is balanced?



- A) 42 B) 21 C) 11 D) 10 E) none of these

Ans: B Category: Medium Section: 3.7

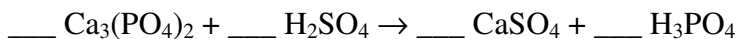
69. What is the coefficient preceding  $O_2$  when the following combustion reaction of a fatty acid is properly balanced using the smallest set of whole numbers?



- A) 1 B) 8 C) 9 D) 26 E) 27

Ans: D Category: Medium Section: 3.7

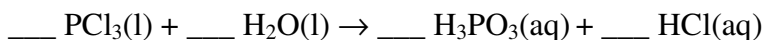
70. What is the coefficient of  $\text{H}_2\text{SO}_4$  when the following equation is properly balanced with the smallest set of whole numbers?



A) 3 B) 8 C) 10 D) 11 E) none of these

Ans: A Category: Medium Section: 3.7

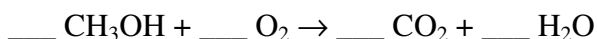
71. Balance the equation below using the smallest set of whole numbers. What is the coefficient of  $\text{H}_2\text{O}$ ?



A) 1 B) 2 C) 3 D) 5 E) none of these

Ans: C Category: Medium Section: 3.7

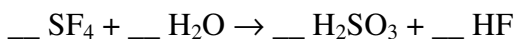
72. What is the coefficient of  $\text{O}_2$  when the following equation is properly balanced with the smallest set of whole numbers?



A) 1 B) 2 C) 3 D) 7 E) none of these

Ans: C Category: Medium Section: 3.7

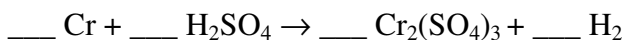
73. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Do not forget to count coefficients of one. The sum of the coefficients is



A) 4. B) 6. C) 7. D) 9. E) none of these.

Ans: D Category: Medium Section: 3.7

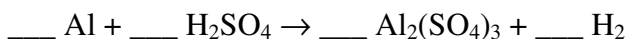
74. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Don't forget to count coefficients of one. The sum of the coefficients is



A) 4. B) 9. C) 11. D) 13. E) 15.

Ans: B Category: Medium Section: 3.7

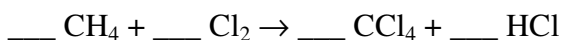
75. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Do not forget to count coefficients of one. The sum of the coefficients is



A) 3. B) 5. C) 6. D) 9. E) 12.

Ans: D Category: Medium Section: 3.7

76. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Do not forget to count coefficients of one. The sum of the coefficients is



A) 4. B) 6. C) 8. D) 10. E) 12.

Ans: D Category: Medium Section: 3.7

77. Ammonia reacts with diatomic oxygen to form nitric oxide and water vapor:  
 $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$   
 When 40.0 g  $\text{NH}_3$  and 50.0 g  $\text{O}_2$  are allowed to react, which is the limiting reagent?  
 A)  $\text{NH}_3$  B)  $\text{O}_2$  C)  $\text{NO}$  D)  $\text{H}_2\text{O}$  E) No reagent is limiting.  
 Ans: B Category: Medium Section: 3.9
78. Ammonia reacts with diatomic oxygen to form nitric oxide and water vapor:  
 $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$   
 When 20.0 g  $\text{NH}_3$  and 50.0 g  $\text{O}_2$  are allowed to react, which is the limiting reagent?  
 A)  $\text{NH}_3$  B)  $\text{O}_2$  C)  $\text{NO}$  D)  $\text{H}_2\text{O}$  E) No reagent is limiting.  
 Ans: A Category: Medium Section: 3.9
79. When 22.0 g  $\text{NaCl}$  and 21.0 g  $\text{H}_2\text{SO}_4$  are mixed and react according to the equation below, which is the limiting reagent?  
 $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$   
 A)  $\text{NaCl}$  B)  $\text{H}_2\text{SO}_4$  C)  $\text{Na}_2\text{SO}_4$  D)  $\text{HCl}$  E) No reagent is limiting.  
 Ans: A Category: Medium Section: 3.9
80. Vanadium(V) oxide reacts with calcium according to the chemical equation below. When 10.0 moles of  $\text{V}_2\text{O}_5$  are mixed with 10.0 moles of  $\text{Ca}$ , which is the limiting reagent?  
 $\text{V}_2\text{O}_5(\text{s}) + 5\text{Ca}(\text{l}) \rightarrow 2\text{V}(\text{l}) + 5\text{CaO}(\text{s})$   
 A)  $\text{V}_2\text{O}_5$  B)  $\text{Ca}$  C)  $\text{V}$  D)  $\text{CaO}$  E) No reagent is limiting.  
 Ans: B Category: Medium Section: 3.9
81. Chlorine gas can be made from the reaction of manganese dioxide with hydrochloric acid.  
 $\text{MnO}_2(\text{s}) + 4\text{HCl}(\text{aq}) \rightarrow \text{MnCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) + \text{Cl}_2(\text{g})$   
 According to the above reaction, which is the limiting reagent when 28 g of  $\text{MnO}_2$  are reacted with 42 g of  $\text{HCl}$ ?  
 A)  $\text{MnO}_2$  B)  $\text{HCl}$  C)  $\text{MnCl}_2$  D)  $\text{Cl}_2$  E) No reagent is limiting.  
 Ans: B Category: Medium Section: 3.9
82. How many grams of  $\text{Cl}_2$  can be prepared from the reaction of 16.0 g of  $\text{MnO}_2$  and 30.0 g of  $\text{HCl}$  according to the following chemical equation?  
 $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$   
 A) 0.82 g B) 5.8 g C) 13.0 g D) 14.6 g E) 58.4 g  
 Ans: C Category: Medium Section: 3.9
83. Hydrogen chloride gas can be prepared by the following reaction:  
 $2\text{NaCl}(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow 2\text{HCl}(\text{g}) + \text{Na}_2\text{SO}_4(\text{s})$   
 How many grams of  $\text{HCl}$  can be prepared from 2.00 mol  $\text{H}_2\text{SO}_4$  and 150 g  $\text{NaCl}$ ?  
 A) 7.30 g B) 93.5 g C) 146 g D) 150 g E) 196 g  
 Ans: B Category: Medium Section: 3.9

84. Calculate the mass of FeS formed when 9.42 g of iron reacts with 8.50 g of sulfur according to the following reaction.  

$$\text{Fe(s)} + \text{S(s)} \rightarrow \text{FeS(s)}$$
 A) 17.9 g B) 87.9 g C) 26.0 g D) 14.8 g E)  $1.91 \times 10^{-3}$  g  
 Ans: D Category: Medium Section: 3.9
85. What is the theoretical yield of chromium that can be produced by the reaction of 40.0 g of  $\text{Cr}_2\text{O}_3$  with 8.00 g of aluminum according to the chemical equation below?  

$$2\text{Al} + \text{Cr}_2\text{O}_3 \rightarrow \text{Al}_2\text{O}_3 + 2\text{Cr}$$
 A) 7.7 g B) 15.4 g C) 27.3 g D) 30.8 g E) 49.9 g  
 Ans: B Category: Medium Section: 3.9
86. Calculate the mass of excess reagent remaining at the end of the reaction in which 90.0 g of  $\text{SO}_2$  are mixed with 100.0 g of  $\text{O}_2$ .  

$$2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$$
 A) 11.5 g B) 22.5 g C) 67.5 g D) 77.5 g E) 400 g  
 Ans: D Category: Medium Section: 3.9
87. What is the maximum number of grams of ammonia,  $\text{NH}_3$ , that can be obtained from the reaction of 10.0 g of  $\text{H}_2$  and 80.0 g of  $\text{N}_2$ ?  

$$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$$
 A) 28.4 g B) 48.6 g C) 56.7 g D) 90.0 g E) 97.1 g  
 Ans: C Category: Medium Section: 3.9
88. How many grams of water could be made from 5.0 mol  $\text{H}_2$  and 3.0 mol  $\text{O}_2$ ?  
 A) 90. g B) 36 g C) 42 g D) 45 g E) 108 g  
 Ans: A Category: Medium Section: 3.9
89. Ammonia reacts with diatomic oxygen to form nitric oxide and water vapor:  

$$4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$$
 What is the theoretical yield of water, in moles, when 40.0 g  $\text{NH}_3$  and 50.0 g  $\text{O}_2$  are mixed and allowed to react?  
 A) 1.30 mol B) 1.57 mol C) 1.87 mol D) 3.53 mol E) None of these.  
 Ans: C Category: Medium Section: 3.9
90. What is the theoretical yield of vanadium, in moles, that can be produced by the reaction of 2.0 mole of  $\text{V}_2\text{O}_5$  with 6.0 mole of calcium based on the following chemical reaction?  

$$\text{V}_2\text{O}_5(\text{s}) + 5\text{Ca}(\text{l}) \rightarrow 2\text{V}(\text{l}) + 5\text{CaO}(\text{s})$$
 A) 1.0 mol B) 1.6 mol C) 2.0 mol D) 2.4 mol E) 4.0 mol  
 Ans: D Category: Medium Section: 3.9

91. What is the theoretical yield of vanadium, in moles, that can be produced by the reaction of 1.0 mole of  $V_2O_5$  with 4.0 mole of calcium based on the following chemical reaction?  
 $V_2O_5(s) + 5Ca(l) \rightarrow 2V(l) + 5CaO(s)$   
 A) 1.0 mol B) 1.6 mol C) 2.0 mol D) 0.80 mol E) None of these  
 Ans: B Category: Medium Section: 3.9
92. What is the theoretical yield of vanadium that can be produced by the reaction of 40.0 g of  $V_2O_5$  with 40.0 g of calcium based on the following chemical reaction?  
 $V_2O_5(s) + 5Ca(l) \rightarrow 2V(l) + 5CaO(s)$   
 A) 11.2 g B) 5.6 g C) 22.4 g D) 40.0 g E) 20.3 g  
 Ans: E Category: Medium Section: 3.9
93. How many grams of Cr can be produced by the reaction of 44.1 g of  $Cr_2O_3$  with 35.0 g of Al according to the following chemical reaction?  
 $2Al + Cr_2O_3 \rightarrow Al_2O_3 + 2Cr$   
 A) 7.56 g B) 30.2 g C) 67.4 g D) 104 g E) None of these.  
 Ans: B Category: Medium Section: 3.9
94. What is the theoretical yield of aluminum that can be produced by the reaction of 60.0 g of aluminum oxide with 30.0 g of carbon according to the following chemical reaction?  
 $Al_2O_3 + 3C \rightarrow 2Al + 3CO$   
 A) 30.0 g B) 7.9 g C) 101.2 g D) 45.0 g E) 31.8 g  
 Ans: E Category: Medium Section: 3.9
95. A 1.375 g sample of mannitol, a sugar found in seaweed, is burned completely in oxygen to give 1.993 g of carbon dioxide and 0.9519 g of water. The empirical formula of mannitol is  
 A) CHO B)  $CH_7O_3$  C)  $C_3H_2O$  D)  $C_3H_7O_3$  E)  $CH_2O$   
 Ans: D Category: Difficult Section: 3.6
96. A 0.8715 g sample of sorbic acid, a compound first obtained from the berries of a certain ash tree, is burned completely in oxygen to give 2.053 g of carbon dioxide and 0.5601 g of water. The empirical formula of sorbic acid is  
 A)  $CH_2O$  B)  $C_3H_4O$  C)  $CH_4O_3$  D)  $C_3H_4O_2$  E)  $C_2H_4O_2$   
 Ans: B Category: Difficult Section: 3.6
97. An oxyhydrocarbon produced in a chemical reaction was determined to have a molecular mass of 120.20 g/mol. Which of the following is a possible empirical formula for this compound?  
 A)  $CH_4O$  B)  $C_2H_6O$  C)  $C_3H_8O$  D)  $C_3H_8O_2$  E)  $C_4H_{10}O_2$   
 Ans: C Category: Easy Section: 3.6





109. Liquid heptane,  $C_7H_{16}$ , burns in oxygen gas to yield carbon dioxide and water. What mass of water is produced when 15.0 mL of heptane burns completely? (density of heptane = 0.6838 g/mL)  
A) 14.8 g B) 2.70 g C) 31.6 g D) 1.85 g E) 21.6 g  
Ans: A Category: Medium Section: 3.8
110. Liquid heptane,  $C_7H_{16}$ , burns in oxygen gas to yield carbon dioxide and water. What is the minimum mass of oxygen required for the complete reaction of 25.5 mL of heptane? (density of heptane = 0.6838 g/mL)  
A) 8.14 g B) 89.6 g C) 61.3 g D) 30.6 g E) 5.57 g  
Ans: C Category: Medium Section: 3.8
111. Which of the following statements are true about a sample of sulfur and a sample of oxygen if the two samples are of equal mass?  
I. The number of electrons in the two samples is about the same.  
II. The number of protons in the two samples is about the same.  
III. The number of atoms in the two samples is about the same.  
IV. There are roughly twice as many sulfur atoms as oxygen atoms.  
V. There are roughly twice as many oxygen atoms as sulfur atoms.  
Ans: I, II, and V  
Category: Difficult Section: 3.1



112. Nickel has a lower atomic mass than cobalt, even though it has a higher atomic number. One possible explanation is that one of the average atomic masses was miscalculated. In the case of cobalt, there is only one isotope: 100%  $^{59}\text{Co}$  at a mass of 58.9332 amu. For nickel, however, there are five isotopes as given in the table.

isotope	mass (amu)	abundance
$^{58}\text{Ni}$	57.9354	67.76%
$^{60}\text{Ni}$	59.9308	26.16%
$^{61}\text{Ni}$	60.9311	1.25%
$^{62}\text{Ni}$	61.9283	3.66%
$^{64}\text{Ni}$	63.9280	1.16%

A. Using the data in the table, calculate the average atomic mass for nickel.

B. Is the atomic mass for nickel in your periodic table correct?

C. Regardless of your answer to part B, how else could you explain the observation that the atomic mass of nickel is less than the mass of cobalt, even though it has the higher atomic number?

Ans: A. 58.70 amu

B. yes

C. Cobalt has 27 protons and 32 neutrons per atom. While nickel has one more proton than cobalt, it has on average greater enough fewer neutrons than cobalt to lower the average atomic mass of nickel to be less than that of cobalt.

Category: Difficult Section: 3.1

113. How many moles of aluminum are present in an Al cylinder with a mass of 15 g?

Ans: 0.56 mole

Category: Easy Section: 3.2

114. How many moles of iron are present in an iron cylinder that weighs 25 g?

Ans: 0.45 mole

Category: Easy Section: 3.2

115. Calculate the molecular mass, in g/mol, of  $\text{H}_2\text{SO}_4$ .

Ans: 98.09 g/mol

Category: Easy Section: 3.3

116. Calculate the molecular mass, in g/mol, of  $\text{P}_4\text{O}_{10}$ .

Ans: 283.9 g/mol

Category: Easy Section: 3.3

117. Calculate the molecular mass, in g/mol, of  $\text{C}_6\text{H}_{12}\text{O}_6$ .

Ans: 180.2 g/mol

Category: Easy Section: 3.3

118. How many  $\text{ICl}_3$  molecules are present in 1.75 kg of  $\text{ICl}_3$ ?

Ans:  $4.52 \times 10^{24}$

Category: Medium Section: 3.3

119. How many Mg atoms are present in 170 g of Mg?

Ans:  $4.2 \times 10^{24}$

Category: Easy Section: 3.2

120. Calculate the mass of 3.7 moles of  $\text{Br}_2$ .

Ans: 590 g

Category: Easy Section: 3.3

121. Calculate the volume of 0.15 mole of  $\text{Br}_2$ . The density of  $\text{Br}_2$  is 3.12 g/mL.

Ans: 7.7 mL

Category: Medium Section: 3.3

122. A chemistry student determined the empirical formula for titanium sulfide ( $\text{Ti}_x\text{S}_y$ ). To do so, she reacted titanium with excess sulfur in a crucible, and recorded the following data:

Weight of crucible	11.120 g
Weight of titanium	8.820 g
Weight of crucible and product	31.700 g

What is the empirical formula of titanium sulfide?

Ans:  $\text{TiS}_2$

Category: Medium Section: 3.6

123. A chemistry student determined the empirical formula for tungsten oxide ( $\text{W}_x\text{O}_y$ ). To do so, he heated tungsten with oxygen in a crucible. The data that he recorded are shown below:

Weight of crucible	11.120 g
Weight of tungsten	8.820 g
Weight of crucible and product	22.998 g

What is the empirical formula of tungsten oxide?

Ans:  $\text{WO}_4$

Category: Medium Section: 3.6

124. A compound with a percent composition by mass of 87.5% N and 12.5% H was recently discovered. What is the empirical formula for this compound?

Ans:  $\text{NH}_2$

Category: Medium Section: 3.6

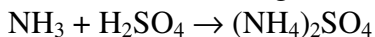
125. Define a *mole*.

Ans: An Avogadro's number of a specific entity, such as an atom or molecule

Category: Easy Section: 3.2

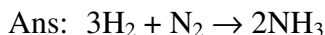
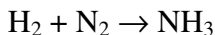
126. If 0.66 mole of a substance has a mass of 99 g, what is the molecular mass of the substance?  
Ans: 150 g  
Category: Medium Section: 3.2
127. Calculate the molecular mass of ethylene glycol,  $C_2H_6O_2$ , a compound frequently used as automobile antifreeze.  
Ans: 62.1 g  
Category: Easy Section: 3.3
128. Calculate the percent composition by mass of sodium in  $Na_2CO_3$ .  
Ans: 43.4%  
Category: Medium Section: 3.5
129. Calculate the percent composition by mass of carbon in  $Na_2CO_3$ .  
Ans: 11.3%  
Category: Medium Section: 3.5
130. Calculate the percent composition by mass of oxygen in  $Na_2CO_3$ .  
Ans: 45.3%  
Category: Medium Section: 3.5
131. A 0.600 g sample of a compound of arsenic and oxygen was found to contain 0.454 g of arsenic. What is the empirical formula of the compound?  
Ans:  $As_2O_3$   
Category: Medium Section: 3.6
132. A sample of unknown ore was analyzed and found to contain 12.7% Al, 19.7% N, and 67.6% O. What is the empirical formula of this ore?  
Ans:  $AlN_3O_9$   
Category: Medium Section: 3.6
133. Phosgene, a poisonous gas used during WWI, is composed of 12.1% C, 16.2% O, and 71.1% Cl. What is the empirical formula of phosgene?  
Ans:  $COCl_2$   
Category: Medium Section: 3.6
134. What percent by mass of oxygen is present in carbon monoxide, CO?  
Ans: 57%  
Category: Medium Section: 3.5
135. Balance the following chemical equation:  
 $NaNO_3 \rightarrow NaNO_2 + O_2$   
Ans:  $2NaNO_3 \rightarrow 2NaNO_2 + O_2$   
Category: Medium Section: 3.7

136. Balance the following chemical equation:



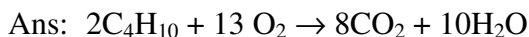
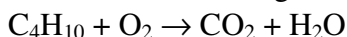
Category: Medium Section: 3.7

137. Balance the following chemical equation:



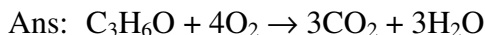
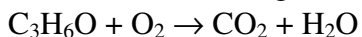
Category: Medium Section: 3.7

138. Balance the following chemical equation:



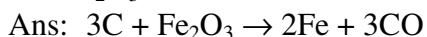
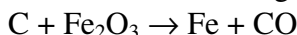
Category: Medium Section: 3.7

139. Balance the following chemical equation:



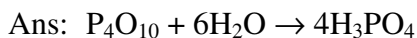
Category: Medium Section: 3.7

140. Balance the following chemical equation:



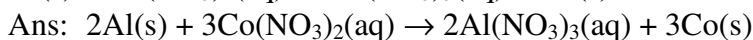
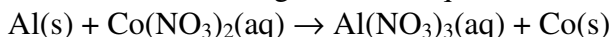
Category: Medium Section: 3.7

141. Balance the following chemical equation:



Category: Medium Section: 3.7

142. Balance the following chemical equation:



Category: Medium Section: 3.7

143. Refer to the (unbalanced) equation  $\text{CS}_2 + \text{CaO} \rightarrow \text{CO}_2 + \text{CaS}$ . How many grams of CaS are produced if 53 g of  $\text{CO}_2$  are produced?

Ans: 170 g

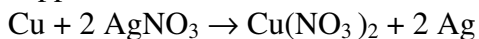
Category: Medium Section: 3.8

144. Refer to the (unbalanced) equation  $\text{CS}_2 + \text{CaO} \rightarrow \text{CO}_2 + \text{CaS}$ . How many grams of CaO are required to react completely with 38 g of  $\text{CS}_2$ ?

Ans: 56 g

Category: Medium Section: 3.8

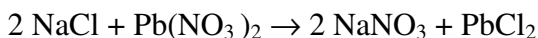
145. How many grams of silver nitrate are necessary to react completely with 7.000 moles of copper?



Ans: 2379 g

Category: Medium Section: 3.8

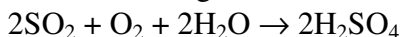
146. What mass of sodium nitrate would be produced from the complete reaction of 1.00 mol of lead nitrate?



Ans: 170. g

Category: Medium Section: 3.8

147. What is the minimum mass of sulfur dioxide necessary to produce 200. g of sulfuric acid in the following reaction?



Ans: 131 g

Category: Medium Section: 3.8

148. What is the minimum mass of oxygen gas necessary to produce 200. g of sulfuric acid in the following reaction?



Ans: 32.6 g

Category: Medium Section: 3.8

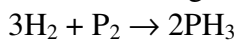
149. What is the minimum mass of water necessary to produce 200. g of sulfuric acid in the following reaction?



Ans: 36.7 g

Category: Medium Section: 3.8

150. How many moles of phosphine ( $\text{PH}_3$ ) are produced for every 4.0 moles of hydrogen that react according to the chemical equation below?



Ans: 2.7 moles

Category: Medium Section: 3.8

151. Calculate the mass of sodium chlorate that must be decomposed to form 6.5 g of oxygen.



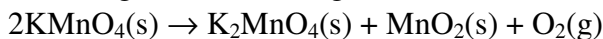
Ans: 14 g

Category: Medium Section: 3.8

152. What is the theoretical yield of  $\text{PI}_3$  if 48.0 g of  $\text{I}_2$  are reacted with an excess of phosphorus according to the following chemical equation?  
 $2\text{P}(\text{s}) + 3\text{I}_2(\text{s}) \rightarrow 2\text{PI}_3(\text{s})$   
 Ans: 51.9 g  
 Category: Medium Section: 3.8
153. Phosphorus reacts with iodine as shown in the chemical reaction below. What is the percent yield of the reaction if 28.2 g  $\text{PI}_3$  is obtained from the reaction of 48.0 g of  $\text{I}_2$  with excess phosphorus?  
 $2\text{P}(\text{s}) + 3\text{I}_2(\text{s}) \rightarrow 2\text{PI}_3(\text{s})$   
 Ans: 54.3%  
 Category: Medium Section: 3.10
154. What is the limiting reagent when 27.0 g of P and 68.0 g of  $\text{I}_2$  react according to the following chemical equation?  
 $2\text{P}(\text{s}) + 3\text{I}_2(\text{s}) \rightarrow 2\text{PI}_3(\text{s})$   
 Ans:  $\text{I}_2$   
 Category: Medium Section: 3.9
155. Determine the number of moles of water produced by the reaction of 155 g of ammonia and 356 g of oxygen.  
 $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$   
 Ans: 13.7 moles  
 Category: Medium Section: 3.9
156. What is the theoretical yield of  $\text{PI}_3$  from the reaction of 27.0 g of P and 68.0 g of  $\text{I}_2$ ?  
 $2\text{P}(\text{s}) + 3\text{I}_2(\text{s}) \rightarrow 2\text{PI}_3(\text{s})$   
 Ans: 73.5 g  
 Category: Medium Section: 3.10
157. When a 0.860 g sample of an organic compound containing C, H, and O was burned completely in oxygen, 1.64 g of  $\text{CO}_2$  and 1.01 g of  $\text{H}_2\text{O}$  were produced. What is the empirical formula of the compound?  
 Ans:  $\text{C}_2\text{H}_6\text{O}$   
 Category: Difficult Section: 3.6
158. When a 0.952 g sample of an organic compound containing C, H, and O is burned completely in oxygen, 1.35 g of  $\text{CO}_2$  and 0.826 g of  $\text{H}_2\text{O}$  are produced. What is the empirical formula of the compound?  
 Ans:  $\text{CH}_3\text{O}$   
 Category: Difficult Section: 3.6

159. The percent composition by mass of tartaric acid is: 32.01% C, 4.03% H, and 63.96% O. Given that the molecular mass of tartaric acid is 150 amu, determine its molecular formula.  
Ans:  $C_4H_6O_6$   
Category: Medium Section: 3.6
160. Oxidation of a hydrocarbon gave a product composed of carbon, hydrogen, and oxygen. The product that was purified and sent off for elemental analysis giving the following mass percents: 68.85% C and 4.95% H. Determine the empirical formula of this compound.  
Ans:  $C_7H_6O_2$   
Category: Medium Section: 3.6
161. Commonly used gases in the laboratory are generally obtained from pressurized metal gas cylinders, but for small amounts of occasionally used gases, it is sometimes easier just to prepare them chemically as needed. For example, nitrogen monoxide,  $NO(g)$ , can be prepared in the lab by the following chemical reaction:  
 $3Cu(s) + 8HNO_3(aq) \rightarrow 2NO(g) + 3Cu(NO_3)_2(aq) + 4H_2O(l)$   
If 5.0 g of copper metal was added to an aqueous solution containing 2.5 moles of  $HNO_3$ , how many moles of  $NO(g)$  would be produced, assuming a 100% yield.  
Ans: 0.052 mole  $NO$   
Category: Medium Section: 3.9
162. Commonly used gases in the laboratory are generally obtained from pressurized metal gas cylinders, but for small amounts of occasionally used gases, it is sometimes easier just to prepare them chemically as needed. For example, nitrogen monoxide,  $NO(g)$ , can be prepared in the lab by the following chemical reaction:  
 $3Cu(s) + 8HNO_3(aq) \rightarrow 2NO(g) + 3Cu(NO_3)_2(aq) + 4H_2O(l)$   
If 15 g of copper metal was added to an aqueous solution containing 6.0 moles of  $HNO_3$ , how many moles of  $NO(g)$  would be produced, assuming a 75% yield.  
Ans: 0.12 mole  $NO$   
Category: Medium Section: 3.10
163. Common gases used in laboratories are generally obtained from pressurized metal gas cylinders, but for small amounts of occasionally-used gases, it is sometimes easier just to prepare them chemically. For example, oxygen gas can be prepared by heating  $KMnO_4(s)$  according to the following chemical reaction:  
 $2KMnO_4(s) \rightarrow K_2MnO_4(s) + MnO_2(s) + O_2(g)$   
How many grams of  $KMnO_4$  would you need to produce 0.27 moles of  $O_2$ , assuming 100% conversion? The molar mass of  $KMnO_4$  is 158.034 g/mol.  
Ans: 85 g  $KMnO_4$  required  
Category: Medium Section: 3.8

164. Common gases used in laboratories are generally obtained from pressurized metal gas cylinders, but for small amounts of occasionally-used gases, it is sometimes easier just to prepare them chemically. For example, oxygen gas can be prepared by heating  $\text{KMnO}_4(\text{s})$  according to the following chemical reaction:



The above procedure was carried out starting with 93.2 g of  $\text{KMnO}_4$ , and it was later determined that all of the  $\text{KMnO}_4$  reacted according to the above equation except 11.7 g. What was the percent yield for the reaction?

Ans: 87.4% yield

Category: Medium Section: 3.10

165. In the Haber process, hydrogen gas reacts with nitrogen gas to produce ammonia. How many kilograms of hydrogen would be required to react completely with 1.0 kg of nitrogen, and how many kilograms of ammonia would be formed?

Ans: 0.22 kg hydrogen required, 1.2 kg ammonia produced

Category: Medium Section: 3.9

166. Ammonium nitrate decomposes to give dinitrogen monoxide and water as shown in the following reaction:



If a 108 g sample of  $\text{NH}_4\text{NO}_3$  decomposes to give 23 g of  $\text{N}_2\text{O}(\text{g})$ , what percent of the original sample remains?

Ans: 61% remains

Category: Medium Section: 3.10

167. Ferrocene,  $\text{Fe}(\text{C}_5\text{H}_5)_2(\text{s})$ , can be prepared by reacting 3.0 g of  $\text{FeCl}_2(\text{s})$  with an equal mass of cyclopentadiene,  $\text{C}_5\text{H}_6(\text{l})$ , and an excess of  $\text{KOH}$ , as shown in the following reaction



A. What is the limiting reagent in this procedure? B. Based on your answer to part A, what mass of  $\text{Fe}(\text{C}_5\text{H}_5)_2$  could theoretically be formed? C. A student who carried out this reaction obtained 2.7 g of ferrocene. What was the percent yield for this reaction?

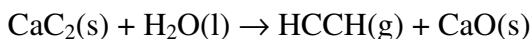
Ans: A.  $\text{C}_5\text{H}_6$  is limiting

B. 4.2 g of ferrocene

C. 64% yield

Category: Medium Section: 3.10

168. Acetylene gas,  $\text{HCCH}(\text{g})$ , can be generated in the laboratory by adding calcium carbide to excess water, as shown in the following reaction



How many grams of  $\text{CaC}_2$  would be required to generate 0.20 moles of  $\text{HCCH}(\text{g})$ ?

Ans: 13 g of  $\text{CaC}_2$  would be required

Category: Medium Section: 3.8