38. Halothane is an anaesthetic that is 12.17% C, 0.51% H, 40.48% Br, 17.96% Cl and 28.87% F by weight. Calculate the molecular formula of this compound if each molecule contains one hydrogen atom.

Answer: C$_2$HBrClF$_3$

39. In small quantities, the nicotine in tobacco is addictive. In large quantities, it is a deadly poison. Calculate the molecular formula of nicotine, C$_x$H$_y$N$_z$, if the molecular weight is 162.2 g/mol, and 0.438 grams of this compound burn to form 1.188 grams of CO$_2$ and 0.341 grams of water.

Answer: C$_{10}$H$_{14}$N$_2$

**Balancing Equations**

40. The balanced equation for the decomposition of ammonium dichromate

$$A \ (\text{NH}_4)_2\text{Cr}_2\text{O}_7(s) \rightarrow B \ \text{Cr}_2\text{O}_3(s) + C \ \text{N}_2(g) + D \ \text{H}_2\text{O}(g)$$

has which of the following sets of coefficients?

(a) A = 2, B = 2, C = 2, D = 4  
(b) A = 1, B = 1, C = 1, D = 4  
(c) A = 1, B = 1, C = 1, D = 2  
(d) A = 1, B = 1, C = 2, D = 2  
(e) A = B = C = D = 1

Answer: (b)

41. Calculate the sum of the coefficients in the balanced chemical equation for the following reaction: A H$_2$S(g) + B O$_2$(g) $\rightarrow$ C SO$_2$(g) + D H$_2$O(g)

(a) 6  
(b) 8  
(c) 9  
(d) 11  
(e) 17

Answer: (c)

42. What is the sum of the coefficients when the following chemical equation is balanced?

$$A \ \text{Ca}_3\text{P}_2\text{O}_7(s) + B \ C(s) \rightarrow C \ \text{Ca}_3\text{P}_2(s) + D \ \text{CO}(g)$$

(a) 6  
(b) 12  
(c) 18  
(d) 20  
(e) none of the above

Answer: (c)

**Stoichiometry**

What are the products of a decomposition of a carbonate?

43. Thermal decomposition of an unknown carbonate led to a 35.1% weight loss. The unknown was which of the following compounds?

(a) Li$_2$CO$_3$  
(b) MgCO$_3$  
(c) CaCO$_3$  
(d) ZnCO$_3$  
(e) BaCO$_3$

Answer: (d)

44. Calcium carbonate decomposes on heating to form calcium oxide and carbon dioxide:

$$\text{CaCO}_3(s) \rightarrow \text{CaO(s)} + \text{CO}_2(g).$$
Which of the following would cause the weight loss during the decomposition of a sample of CaCO₃ to appear too large?

(a) The CaCO₃ contained some CaO before it was heated.
(b) The crucible was wet when it was weighed before the CaCO₃ was heated.
(c) The crucible was heated for too short a time.
(d) The student read the last weight as 40.3047 g instead of the actual value of 30.3047 g.
(e) All of these would cause the weight loss to appear too large.

Answer: (b)

45. A crucible and sample of CaCO₃, weighing 42.670 g, was heated until red hot to decompose the sample.

\[ \text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g) \]

The crucible weighed 35.351 g. What is the theoretical weight of the crucible and residue after the decomposition is complete?

(a) 3.219 g  (b) 4.100 g  (c) 38.570 g  (d) 39.451 g  (e) 49.989 g

Answer: (d)

This series of steps is similar to the alum lab

46. Nitrogen reacts with hydrogen to form ammonia

\[ \text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \]

which burns in the presence of oxygen to form nitrogen oxide,

\[ \text{NH}_3(g) + 5 \text{O}_2(g) \rightarrow 4 \text{NO}(g) + 6 \text{H}_2\text{O}(g) \]

which reacts with excess oxygen to form nitrogen dioxide.

\[ 2 \text{NO}(g) + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g) \]

How much nitrogen would we have to start with to make 10 moles of nitrogen dioxide?

(a) 2.5 mol  (b) 5 mol  (c) 10 mol  (d) 15 mol  (e) 20 mol

Answer: (b)

47. “Teflon” is made by polymerizing tetrafluoroethylene (C₂F₄). What would be the volume of 18.5 moles of liquid tetrafluoroethylene at -76°C if the density of this liquid at -76°C is 1.52 g/mL?

(MW: C₂F₄ = 100.0 amu)

(a) 1.22 mL  (b) 1.22 L  (c) 12.2 L  (d) 1,220 L  (e) none of these

Answer: (b)

48. How many grams of hydrogen peroxide, H₂O₂, must decompose by the following reaction to produce 0.400 moles of O₂? (MW: H = 1.008 amu; O = 16.00 amu)

\[ 2 \text{H}_2\text{O}_2(aq) \rightarrow 2 \text{H}_2\text{O}(l) + \text{O}_2(g) \]

(a) less than 25 grams  (b) between 25 and 40 grams  (c) between 40 and 60 grams  
(d) between 60 and 80 grams  (e) more than 80 grams

Answer: (a)
49. Which of the following nitrogen-containing compounds would supply the most nitrogen per gram of fertilizer?
(a) iron azide, Fe(N₃)₂, MW = 140 g/mol
(b) sodium azide, NaN₃, MW = 83 g/mol
(c) potassium nitrite, KNO₂, MW = 85.1 g/mol
(d) potassium azide, KN₃, MW = 81.1 g/mol
(e) There is not enough information to answer this problem.

Answer: (a)

50. How many oxygen molecules are required to react with 15.5 grams of phosphorus when P₄ is burned in oxygen to make tetraphosphorus decaoxide?
(a) 2.50  (b) 5.00  (c) 10.0  (d) 3.76 x 10²³  (e) 3.01 x 10²⁴

Answer: (d)

51. The chemical formula of ethanol is C₂H₅O. It burns in excess oxygen to form CO₂ and H₂O. How many grams of H₂O are produced from the combustion of 25.0 g of ethanol? (AW: H = 1.01; C = 12.0; O = 16.0 amu)
(a) 9.78 g  (b) 18.0 g  (c) 25.0 g  (d) 29.3 g  (e) 54.1 g

Answer: (d)

52. PF₃ reacts with XeF₄ to give PF₅. In theory, how many moles of PF₅ can be produced from 100.0 g of PF₃ and 50.0 g of XeF₄?

\[ 2 \text{PF}_3(g) + \text{XeF}_4(s) \rightarrow 2 \text{PF}_5(g) + \text{Xe}(g) \]

(AW: F = 19.00; P = 30.97; Xe = 131.3 amu)

(a) 0.121 mol  (b) 0.241 mol  (c) 0.482 mol  (d) 1.14 mol  (e) 2.28 mol

Answer: (c)

53. The portable stoves campers use for cooking burn propane, C₃H₈.

\[ A \text{C}_3\text{H}_8(g) + B \text{O}_2(g) \rightarrow C \text{CO}_2(g) + D \text{H}_2\text{O}(g) \]

What weight of propane would have to be burned to form 7.26 g of CO₂? (AW: H = 1.0; C = 12.0; O = 16.0 amu)

(a) 2.42 g  (b) 4.84 g  (c) 7.26 g  (d) 21.8 g  (e) none of the above

Answer: (a)

54. Calculate the weight of O₂ needed to burn 10.0 grams of hydrogen sulfide, H₂S. (AW: H = 1.008, O = 16.00, S = 32.06 amu)

\[ A \text{H}_2\text{S} + B \text{O}_2 \rightarrow C \text{SO}_2 + D \text{H}_2\text{O} \]

(a) 4.70 g  (b) 6.26  (c) 7.04 g  (d) 9.39 g  (e) 14.1 g

Answer: (e)
55. What would happen to the potential yield of sulfur dioxide in the previous question if the amount of oxygen was doubled?
   (a) It would decrease by a factor of 2.  (b) It would decrease by a factor of 1.5.
   (c) It would remain constant.  (d) It would increase by a factor of 1.5.
   (e) It would increase by a factor of 2.

   Answer: (c)

56. A sample of copper(II) sulfate, CuSO₄, weighing 2.47 grams picks up water from the atmosphere to form a hydrate with the formula CuSO₄·xH₂O. If the sample weighs 3.86 grams after it picks up water, what is the value of x? (AW, H = 1.01, O = 16.0, S = 32.0, Cu = 63.5 amu)
   (a) 2   (b) 2.5   (c) 3   (d) 4   (e) 5

   Answer: (e)

57. Nitrogen reacts with red-hot magnesium to form magnesium nitride,
   \[3 \text{Mg(s)} + \text{N}_2(g) \rightarrow \text{Mg}_3\text{N}_2(s)\]
   which reacts with water to form magnesium hydroxide and ammonia,
   \[\text{Mg}_3\text{N}_2(s) + 6 \text{H}_2\text{O}(l) \rightarrow 3 \text{Mg(OH)}_2(aq) + 2 \text{NH}_3(aq)\]
   How many grams of magnesium would you have to start with to prepare 15.0 grams of ammonia? (AW: H = 1.01, N = 14.0, O = 16.0, Mg = 24.3 amu)
   (a) 13.3 g   (b) 15.0 g   (c) 20.0 g   (d) 32.2 g   (e) none of the above

   Answer: (d)

**Limiting Reagents**

Questions 58-60 refer to the following reaction:
\[2 \text{NO(g)} + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g)\]

58. What is the limiting reagent when 10.0 g of NO react with 10.0 g of O₂ to form NO₂? (AW: N = 14.0, O = 16.0 amu/atom)
   (a) NO   (b) O₂   (c) NO₂   (d) none of these
   (e) There aren't enough data to answer the question.

   Answer: (a)

59. How many moles of the limiting reagent are present in the previous problem?
   (a) 0.313   (b) 0.333   (c) 0.435   (d) 0.625   (e) none of these

   Answer: (b)
60. How much NO₂ can be made in this reaction assuming a yield of 75%?
   (a) 10.8 g  (b) 11.5 g  (c) 14.4 g  (d) 15.3 g  (e) 20.0 g

   Answer: (d)

For fun...

61. J. J. Berzelius found that 11.56 grams of lead sulfide, PbS, were formed when 10.0 grams of lead reacted with 1.56 grams of sulfur, when 10.0 grams of lead reacted with 3.00 grams of sulfur, and when 18.0 grams of lead reacted with 1.56 grams of sulfur. Explain his observations in terms of the concept of limiting reagent.

62. How many grams of HCl are produced when 10.0 g of Cl₂ and 1.00 g of H₂ react? (A.W.: H = 1.008, Cl = 35.45 amu)

   \[ \text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2 \text{HCl}(g) \]

   (a) 5.14 g  (b) 9.04 g  (c) 10.3 g  (d) 11.0 g  (e) 18.1 g

   Answer: (c)

63. What would happen to the amount of HCl produced in the previous question if the amount of H₂ is doubled?
   (a) It would decrease by more than a factor of two.  (b) It would decrease by a factor of two.
   (c) It would remain the same.  (d) It would increase by a factor of two.
   (e) It would increase by more than a factor of two.

   Answer: (c)

64. How many grams of MgO can be produced by burning 10.0 grams of Mg in the presence of 10.0 grams of O₂?

   (a) 10.0 g  (b) 12.6 g  (c) 16.6 g  (d) 20.0 g  (e) 25.2 g

   Answer: (c)

65. When glucose reacts with oxygen in living systems, carbon dioxide and water are produced, and a great deal of energy is liberated.

   \[ \text{C}_6\text{H}_12\text{O}_6(s) + 6 \text{O}_2(g) \rightarrow 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(g) \]

What weight of carbon dioxide can be produced from the reaction of 10.0 grams of glucose with 10.0 grams of oxygen? (A.W., H = 1.01, C = 12.0, O = 16.0 amu)

   (a) 2.29 g  (b) 2.44 g  (c) 13.8 g  (d) 14.7 g  (e) none of these

   Answer: (d)

Solutions

66. “Muriatic acid” is sold in many hardware stores for cleaning bricks and tile. What is the molarity of this solution if 125 mL of the solution contains 27.4 grams of HCl? (H = 1.0, Cl = 35.5 amu)