MULTIPLE CHOICE

50. 5.80 g of dioxane (C₄H₈O₂) is how many moles of dioxane?
   a. 0.0658 mol
   b. 0.0707 mol
   c. 0.0725 mol
   d. 0.0804 mol
   e. none of these

ANS: A

Strategy: add up the atomic weights of dioxane to obtain the molecular weight of dioxane. Then divide 5.80 g of dioxane into the molecular weights of dioxane to obtain the number of moles of dioxane. 4C + 8H + 2H = 88 gmol⁻¹. 5.8 g/88 gmol⁻¹ = 0.0658 mol.

51. How many molecules of tetrahydrofuran (C₄H₈O) are present in 2.00 x 10⁻⁹ mol of tetrahydrofuran?
   a. 1.67 x 10¹³
   b. 3.01 x 10¹⁴
   c. 1.20 x 10¹⁵
   d. 2.17 x 10¹⁶
   e. none of these

ANS: C

Strategy: There are 6.02 x 10²³ molecules in a mol of tetrahydrofuran. Multiply this number by the number of moles of tetrahydrofuran.
2.00 x 10⁻⁹ mol x 6.02 x 10²³ molecules mol⁻¹ = 1.20 x 10¹⁵ molecules.

52. 8.55 x 10⁻³ mol of an unknown compound has a mass of 0.137 g. The compound could be
   a. CH₄
   b. C₂H₆
   c. C₃H₈
   d. C₄H₁₀
   e. none of these

ANS: A

Strategy: the number of g of the unknown divided by the MW of the compound equals the number of moles of the unknown, so the MW is the number of g divided by the number of moles.
MW = 0.137 g/8.55 x 10⁻³ mol = 16 g mol⁻¹. CH₄ has a molecular weight of 16.
66. What is the atomic percentage of sulfur in a compound with the empirical formula $\text{SF}_6$?
   a. 21.95%
   b. 25.23%
   c. 29.67%
   d. 36.00%
   e. none of these

   ANS: A

   Strategy: compute the MW of $\text{SF}_6$ (146) and then divide the AW of S (32) by the MW.
   $\% \text{S} = \frac{32.0}{146} \times 100\% = 21.9\%$

   IMPORTANT. THE WRONG ANSWER WAS GIVEN IN THE PREVIOUS VERSION OF THE ANSWERS.

67. Compute the percentage by mass of carbon in a compound with the empirical formula $\text{C}_2\text{H}_2\text{O}$.
   a. 28.57%
   b. 40.00%
   c. 57.14%
   d. 80.00%
   e. none of these

   ANS: C

   Strategy: compute the relative MW of $\text{C}_2\text{H}_2\text{O}$ and then divide the total AW in $\text{C}_2\text{H}_2\text{O}$ by the MW.
   $24/42 \times 100\% = 57.14\%$

71. A 50.00-g sample of a compound is analyzed and found to contain 21.85 g of phosphorus and 28.15 g of oxygen. The empirical formula for this compound is

   a. $\text{PO}_3$
   b. $\text{P}_2\text{O}$
   c. $\text{P}_2\text{O}_5$
   d. $\text{P}_3\text{O}_2$
   e. none of these

   ANS: C

   Strategy: compute the number of moles of P and O in the compound. The ratio of the number of moles is equal to the empirical formula when the number of atoms are in the ratio of whole numbers.

   $\text{P} = 21.85 \text{ g} / 30.97 \text{ g mol}^{-1} = 0.683 \text{ mol}$
   $\text{O} = 28.15 \text{ g} / 16.00 \text{ g mol}^{-1} = 1.76 \text{ mol}$

   The ratio of P to O is 1 to 2.5 or 2 to 5 in small whole numbers. Therefore the empirical Formula is $\text{P}_2\text{O}_5$ (c above).
76. The empirical formula for a hydrocarbon is found to be \( \text{CH}_2 \). In a separate experiment, the molar mass is determined to be approximately 112 g mol\(^{-1}\). The number of hydrogens in the molecular formula of the hydrocarbon is therefore

a. 8  
b. 12  
c. 16  
d. 20  
e. none of these

ANS: C

The relative MW of \( \text{CH}_2 \) is 14 g mol\(^{-1}\). The actual MW is 112 g mol\(^{-1}\). Divide the empirical MW into the actual MW to obtain the number of \( \text{CH}_2 \) units. \( \frac{112}{14} = 8 \) so the actual molecular formula is \( (\text{CH}_2)_8 = \text{C}_8\text{H}_{16} \). Thus, there are 16 H atoms in the molecule.

77. Under certain conditions of temperature and pressure, 1.00 mole of any gas occupies a volume of 22.4 L. Thus, under these same conditions, 0.04465 mol of any gas will occupy a volume of

a. 1.00 L  
b. 10.0 L  
c. 22.4 L  
d. 32.0 L  
e. none of these

ANS: A

Strategy: the number of moles for gases at the same pressure and temperature is directly proportional to the volume. Thus, 0.04465 mol of a gas will equal the number of moles multiplied by 22.4 L.

\[
0.04465 \text{ mol} \times 22.4 \text{ L mol}^{-1} = 1.00 \text{ L}
\]

12. How many molecules are present in 36.5 g of \( \text{CO}_2 \) (molar mass = 44.01 g/mol)?

(a) \( 8.29 \times 10^{23} \) molecules  
(b) \( 5.00 \times 10^{23} \) molecules  
(c) \( 5.00 \times 10^{23} \) molecules  
(d) \( 7.84 \times 10^{23} \) molecules  
(e) None of the above

ANS: C

Strategy: a mole of any substance contains \( 6.02 \times 10^{23} \) molecules. 34.5 g of \( \text{CO}_2 \) = 0.782 mol of \( \text{CO}_2 \). This is close to a mol so by inspection the only possible answer is \( 5.00 \times 10^{23} \) molecules, i.e., \( 0.782 \text{ mol} \times 6.02 \times 10^{23} \text{ molecules mol}^{-1} \).

13. Nitrogen exists as molecules of formula \( \text{N}_2 \). All of the following statements are true but one. Which is not true?

(a) 28 g of nitrogen contains \( 6.02 \times 10^{23} \) molecules.  
(b) 14 g of nitrogen is a mole of nitrogen atoms.  
(c) One mole of nitrogen molecules weighs 14 g.  
(d) \( 6.02 \times 10^{23} \) nitrogen atoms weigh 14 g.  
(e) None of the above

ANS: C is incorrect. Since nitrogen exists as \( \text{N}_2 \) molecules, one mole of \( \text{N}_2 \) has a molecular weight of \( 2 \times 14 = 28 \text{ g mol}^{-1} \).
Chapter 2—Stoichiometry. Selected Answers

MULTIPLE CHOICE

4. Consider the unbalanced chemical equation for the complete combustion of butanoic acid (\(C_4H_8O_2\)): \(C_4H_8O_2 + O_2 \rightarrow CO_2 + H_2O\). When the reaction is balanced using smallest integer coefficients, the coefficient for \(O_2\) is
   a. 3
   b. 4
   c. 5
   d. 6
   e. none of these

ANS: C

Strategy: Balance the atoms which appear the least number of time or appear in the most Complex formula first. Thus, balance C and H first. This leads to a balance of the C and H atoms. Then balance the O atoms. This leads to the final equation: \(C_4H_8O_2 + 5 O_2 \rightarrow 4 CO_2 + 4 H_2O\). Coefficient of O is 5.

5. Ammonia (\(NH_3\)) reacts with oxygen to produce nitrogen oxide (NO) and water. If this reaction is described with a balanced chemical equation using smallest integer coefficients, the coefficient for nitrogen oxide is
   a. 1
   b. 2
   c. 3
   d. 4
   e. none of these

ANS: D

Use the same strategy as in 4 and the balance equation becomes
\(4 NH_3 + 5O_2 \rightarrow 4 NO + 6 H_2O\)

6. Propene gas (\(C_3H_6\)) burns completely in oxygen to produce carbon dioxide and water as the only products. If this reaction is described with a balanced chemical equation using smallest integer coefficients, the coefficient for water is
   a. 1
   b. 3
   c. 6
   d. 9
   e. none of these

ANS: C

Use the same strategy as the above two questions and the balanced equation becomes

\(C_3H_6 + 9O_2 \rightarrow 3CO_2 + 3H_2O\)
2 C\textsubscript{2}H\textsubscript{6} + 9 O\textsubscript{2} \rightarrow 6 CO\textsubscript{2} + 6 H\textsubscript{2}O

10. The complete combustion of gaseous ethane (C\textsubscript{2}H\textsubscript{6}) in oxygen yields just carbon dioxide and water. When this reaction is balanced using smallest integer coefficients, and these coefficients are interpreted as moles, what is the total mass of the reactants?
   a. 62 g
   b. 126 g
   c. 142 g
   d. 284 g
   e. none of these

   ANS: D

   Strategy: Balance the equation and then compute the weight of the reactants from the Coefficients.
   Balanced equation
   \[ 2 \text{C}_2\text{H}_6 + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 3 \text{H}_2\text{O} \]
   \[ 2 \text{C}_2\text{H}_6 \times (2 \times 30 \text{ g}) + 7 \text{O}_2 \times (7 \times 32 \text{ g}) = 60 \text{ g} + 224 \text{ g} = 284 \text{ g}. \]

21. Consider the production of ammonia gas through the reaction of nitrogen with hydrogen as described by the balanced equation,

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

   How much N\textsubscript{2} would be required to react completely with 1.50 mol of H\textsubscript{2}?
   a. 14.0 g
   b. 28.0 g
   c. 42.0 g
   d. 126 g
   e. none of these

   ANS: A

   Strategy: from the balance equation, 3 mol of H\textsubscript{2} reacts with 1 mol of N\textsubscript{2}, so 1.50 mol of H\textsubscript{2} reacts with 0.50 mol of N\textsubscript{2}. The weight of 0.50 mol of N\textsubscript{2} is 14 g.
23. Consider the production of ammonia gas through the reaction of nitrogen with hydrogen as described by the balanced equation,

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

If all gas volumes are measured under the same conditions of pressure and temperature, what volume of ammonia gas would be produced by the complete reaction of 40.0 L of nitrogen?

a. 20.0 L  
b. 26.7 L  
c. 40.0 L  
d. 80.0 L  
e. none of these

ANS: D

Strategy: volumes of gases reacting are directly proportional to the number of moles of Gases reacting. Since 1 mol of \( \text{N}_2 \) produces 2 moles of \( \text{NH}_3 \), 40 L of \( \text{N}_2 \) produces 80 L of \( \text{NH}_3 \).

31. The gaseous elements \( \text{H}_2 \) and \( \text{O}_2 \) react explosively to form water (\( \text{H}_2\text{O} \)). 3.00 L of \( \text{H}_2 \) is mixed with 2.00 L of \( \text{O}_2 \) and the mixture is ignited in a strong steel vessel. If the gas volumes are all measured at the same temperature and pressure, which gas remains unreacted, and what is its volume?

a. \( \text{O}_2 \), 0.50 L  
b. \( \text{O}_2 \), 1.00 L  
c. \( \text{H}_2 \), 1.00 L  
d. \( \text{H}_2 \), 2.00 L  
e. none of these

ANS: A

Strategy: from the equation \( 2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O} \), 2 L of \( \text{H}_2 \) will react with 1 L of \( \text{O}_2 \), so 3 L of \( \text{O}_2 \) will react completely with 1.5 L of \( \text{O}_2 \) leaving 0.5 L of \( \text{O}_2 \) unreacted.
15. In which of the following atoms is the number of valence electrons equal to six?
   a. P
   b. Se
   c. Sb
   d. all of these
   e. none of these

   ANS: B

   Se (atomic number, AN = 34 is in group 6 and therefore has 6 valence electrons in the atom. P (AN = 15) and Sb (AN = 51) are in group 5 and have 5 valence electrons in the atom.

16. In which of the following atoms is the number of valence electrons equal to three?
   a. Ge
   b. Sn
   c. Pb
   d. all of these
   e. none of these

   ANS: E

   Ge (AN = 32), Sn (AN = 50) and Pb (AN = 82) are all in group 4 and have 4 valence electrons.

19. Which of the following is the correct Lewis dot symbol for the gallium atom?
   a. *Ga*
   b. *Ga*•
   c. *Ga*•
   d. *Ga*•
   e. none of these

   ANS: C

   Ga (AN = 31) is in group 3 and therefore has 3 valence electrons.
20. Which of the following is the correct Lewis dot symbol for the selenium atom?
  a. \( \cdot \text{Se} \cdot \)
  b. \( \cdot \text{Se} \cdot \)
  c. \( \cdot \text{Se} \cdot \)
  d. \( \cdot \text{Se} \cdot \)
  e. none of these

ANS: C
Se (AN = 34) is in group 6 and has 6 valence electrons.

23. Which of the following is the correct Lewis dot symbol for the \( P^{2+} \) ion?
  a. \( \left[ \cdot \text{P} \cdot \right]^{2+} \)
  b. \( \left[ \cdot \text{P} \cdot \right]^{2+} \)
  c. \( \left[ \cdot \text{P} \cdot \right]^{2+} \)
  d. \( \left[ \cdot \text{P} \cdot \right]^{2+} \)
  e. none of these

ANS: E
Strategy: consider the number of valence electrons in the atom (equal to the group number) and then note that
Addition of an electron will produce a negatively charged atom and removal of an electron will produce a positive
Charge. Thus, \( P^{2+} \) has two less valence electrons than the atom. Since P is in group 5, \( P^{2+} \) has 3
valence electrons.
None of the answers have 3 valence electrons.
24. Which of the following is the correct Lewis dot symbol for the $S^-$ ion?
   a. $[\textcircled{S}]^-$
   b. $[\textcircled{S}]^-$
   c. $[\textcircled{S}]^-$
   d. $[\textcircled{S}]^-$
   e. none of these

ANS: B
Following the same strategy as 23, $S^-$ will have one more electron than the atom $S$. Since $S$ is in group 6 the atom has 6 valence electrons and $S^-$ will have 7 valence electrons.

31. Which of the following Lewis structures contains an error?
   a. $\text{H}^=\text{C}=\text{N}$
   b. $\text{H}^=\text{C}^=\text{C}=\text{H}$
   c. $\text{H}^=\text{C}=\text{H}$
   d. all of these
   e. none of these

ANS: B
IMPORTANT: THERE IS A TYPO IN THIS QUESTION. BOTH A AND B CONTAIN ERRORS. HCN MUST HAVE 10 VALENCE ELECTRONS BUT THE STRUCTURE SHOWN FOR A ONLY HAS 8. THE STRUCTURE SHOWN FOR B HAS 12 VALENCE ELECTRONS BUT THE NEUTRAL COMPOSITION $\text{C}_2\text{H}_2$ HAS ONLY 10 VALENCE ELECTRONS. MY GUESS IS THAT A SHOULD HAVE A TRIPLE BOND BETWEEN C AND N AND THAT THE FORMULA SHOWN IS A TYPO.
32. Which of the following Lewis structures contains an error?
   a. \( \overset{+}{\text{O}}=\text{C}=\overset{-}{\text{O}} \)
   b. \( \overset{+}{\text{C}}=\text{O} \)
   c. \( \overset{+}{\text{C}}=\overset{-}{\text{O}} \)
   d. all of these
   e. none of these

   ANS: E
   CO\(_2\) should have 16 valence electrons and all octets.
   CO should have 10 valence electrons and all octets.
   F\(_2\) should have 14 valence electrons and all octets.
   All of the structures fulfill these requirements.

33. What is the formal charge on the nitrogen atom in the Lewis structure, \( \overset{+}{\text{C}}=\text{N} \overset{-}{\text{C}}=\overset{+}{\text{O}} \)?
   a. -2
   b. -1
   c. +1
   d. +2
   e. none of these

   ANS: C
   From the formula for formal charge, \( FC = \text{group number} - [\text{number of unshared electrons} + \frac{1}{2} \text{number of shared Electrons}] \).
   \( FC (\text{N}) = 5 - 4 = +1 \), \( FC (\text{C}) = 4 - 5 = -1 \), \( FC (\text{O}) = 6 - 7 = -1 \)

34. What is the formal charge on the bromine atom in the Lewis structure, \( [\overset{+}{\text{C}}=\text{N} \overset{-}{\text{C}}=\overset{+}{\text{O}}]^- \)?
   a. +1
   b. +2
   c. +3
   d. +5
   e. none of these

   ANS: B
   From the formula for formal charge, \( FC (\text{Br}) = 7 - 5 = +2 \).
35. What is the formal charge on the nitrogen atom in the Lewis structure, $[^{\text{N=O}}]^{+}$?
   a. -1
   b. 0
   c. +1
   d. +2
   e. none of these

ANS: B
FC (N) = 4 – 4 = 0
36. Which of the following is a correct Lewis dot structure for OF$_2$?
   a. 
   b. 
   c. 
   d. 
   e. none of these

ANS: D
The neutral formula OF$_2$ has 6 + 2 x 7 = 20 valence electrons. Only D has 20 valence electrons.

37. Which of the following is a correct Lewis dot structure for O$_2^-$?
   a. 
   b. 
   c. 
   d. all of these
   e. none of these

ANS: A
IMPORTANT. THIS IS ANOTHER TYPO. THE CORRECT ANSWER IS E. O$_2^-$ SHOULD HAVE 14 VALENCE ELECTRONS. A HAS 18!

39. Which of the following Lewis structures can be drawn as two or more resonance forms?
   a. 
   b. 
   c. 
   d. all of these
   e. none of these

ANS: D
RATS, STILL ANOTHER TYPO. A CAN BE WRITTEN IN A SECOND RESONANCE
FORM AND SO CAN C.
ALTHOUGH B CAN BE WRITTEN IN A SECOND RESONANCE FORM IT DOES NOT
HAVE THE CORRECT
NUMBER OF VALENCE ELECTRONS FOR $N_3^-$. CAN YOU FIGURE OUT HOW MANY
VALENCE ELECTRONS
B HAS AND HOW MANY $N_3^-$ HAS?

40. Which of the following must have a Lewis dot structure that violates the octet rule?
   a. $NO_2$
   b. $SO_2$
   c. $CO_2$
   d. all of these
   e. none of these

ANS: A

$NO_2$ has 17 valence electrons and therefore is an odd electron molecule. It cannot fulfill the octet
rule about
All of its atoms. $SO_2$ and $CO_2$ can fulfill the octet rule about all the atoms.