Chapter 1—The Atomic Nature of Matter: Selected Answersc for Practice Exam.

MULTIPLE CHOICE

50. 5.80 g of dioxane ($C_4H_8O_2$) 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 $gmol^{-1}$ = 0.658 mol.

51. How many molecules of tetrahydrofuran (C_4H_8O) are present in 2.00 x 10^{-9} mol of tetrahydrofuran?
    a. 1.67 x 10^{13}
    b. 3.01 x 10^{14}
    c. 1.20 x 10^{15}
    d. 2.17 x 10^{16}
    e. none of these

    ANS: C

    Strategy: There are 6.02 x 10^{23} 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 10^{23} molecules mol^{-1} = 1.20 x 10^{15} molecules.

52. 8.55 x10^{-3} mol of an unknown compound has a mass of 0.137 g. The compound could be
    a. CH_4
    b. C_2H_6
    c. C_3H_8
    d. C_4H_{10}
    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}. CH_4 has a molecular weight of 16.

66. What is the atomic percentage of sulfur in a compound with the empirical formula 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 SF_6 (146) and then divide the AW of S (32) by the MW.
%S = 32.0/146 x 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 C_2H_2O.
a. 28.57%
b. 40.00%
c. 57.14%
d. 80.00%
e. none of these

ANS:C
Strategy: compute the relative MW of C_2H_2O and then divide the total AW in C_2H_2O by the MW.
24/42 x 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. PO_3
b. P_2O
c. P_2O_5
d. P_3O_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.
P = 21.85 g/ 30.97 $gmol^{-1}$ = 0.683 mol
O = 28.15 g/16.00 $gmol^{-1}$ = 1.76 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 P_2O_5 (c above).

76. The empirical formula for a hydrocarbon is found to be 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 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 CH_2 units. 112/14 = 8 so the actual Molecular formula is $(CH_2)_8 = C_8H_{16}$. 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 mol x 22.4 L mol^{-1} = 1.00 L

12. How many molecules are present in 36.5 g of CO_2 (molar mass = 44.01 g/mol)?

(a) 8.29 x 10^{-1} molecules
(b) 5.00 molecules
(c) 5.00 x 10^{23} molecules
(d) 7.84 x 10^{23} molecules
(e) None of the above

ANS: C

Strategy: a mole of any substance contains 6.02 x 10^{23} molecules. 34.5 g of CO_2 = 0.782 mol of CO_2. this is close to a mol so by inspection the only possible answer is 5.00 x 10^{23} molecules, i.e., 0.782 mol x 6.02 x 10^{23} molecules mol^{-1}.

13. Nitrogen exists as molecules of formula N_2. All of the following statements are true but one. Which is *not* true?

(a) 28 g of nitrogen contains 6.02 x 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 X 10^{23} nitrogen atoms weigh 14 G.
(e) None of the above

ANS: C is incorrect. Since nitrogen exists as N_2 molecules, one mole of N_2 has a molecular weight of 2 x 14 = 28 g mol^{-1}.

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

$2\ C_3H_6 + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

10. The complete combustion of gaseous ethane (C_2H_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
    $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 3\ H_2O$
    $2\ C_2H_6$ (2 x 30 g) + $7\ O_2$ (7 x 32 g) = 60 g + 224 g = 284 g.

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

    $N_2(g) + 3\ H_2(g) = 2\ NH_3(g)$

    How much N_2 would be required to react completely with 1.50 mol of H_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_2 reacts with 1 mol of N_2, so 1.50 mol of H_2 reacts with 0.50 mol of N_2. The weight of 0.50 mol of N_2 is 14 g.

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

$N_2(g) + 3\ H_2(g) = 2\ NH_3(g)$
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 N_2 produces 2 moles of NH_3, 40 L of N_2 produces 80 L of NH_3.

31. The gaseous elements H_2 and O_2 react explosively to form water (H_2O). 3.00 L of H_2 is mixed with 2.00 L of 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. O_2, 0.50 L
b. O_2, 1.00 L
c. H_2, 1.00 L
d. H_2, 2.00 L
e. none of these

ANS:A

Strategy: from the equation $2\ H_2 + O_2 \rightarrow 2\ H_2Ol$, 2 L of H_2 will react with 1 L of O_2, so 3 L of O_2 will react completely with 1.5 L of O_2 leaving 0.5 L of 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. 

    d. 

    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. 

b. 

c. 

d. 

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. 

b. 

c. 

d. 

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. 

b. 

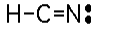
c. 

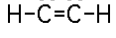
d. 

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?

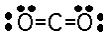
a. 

b. 

c. 

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 C_2H_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.

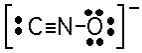
32. Which of the following Lewis structures contains an error?
    a. 

    b. 

    c. 

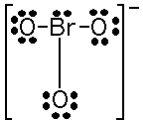
    d. all of these
    e. none of these

    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,  ?
    a. -2
    b. -1
    c. +1
    d. +2
    e. none of these

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

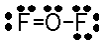
34. What is the formal charge on the bromine atom in the Lewis structure,

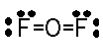
    
    a. +1
    b. +2
    c. +3
    d. +5
    e. none of these

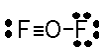
    ANS: B
    From the formula for formal charge, FC (Br) = 7 – 5 = +2.

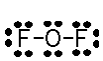
35. What is the formal charge on the nitrogen atom in the Lewis structure,  ?
    a. -1
    b. 0
    c. +1
    d. +2
    e. none of these

    ANS: B
    FC (N) = 4 – 4 = 0

36. Which of the following is a correct Lewis dot structure for OF_2?
    a. 

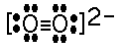
    b. 

    c. 

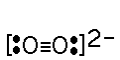
    d. 

    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^{2-}?
    a. 

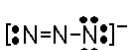
    b. 

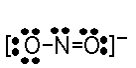
    c. 

    d. all of these
    e. none of these

    ANS: A
    IMPORTANT. THIS IS ANOTHER TYPO. THE CORRECT ANSWER IS E. O_2^{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 CORRRECT
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.