The Mole and Avogadro’s Number

1) What is the SI unit for measurement of number of particles in a substance?
   A) kilogram
   B) ampere
   C) candela
   D) mole
   E) Kelvin

2) How many moles of tungsten atoms are there in $4.8 \times 10^{25}$ atoms of tungsten?
   A) $1.3 \times 10^{-1}$ moles
   B) $8.0 \times 10^{-1}$ moles
   C) $1.3 \times 10^{-2}$ moles
   D) 80 moles
   E) $8.0 \times 10^{2}$ moles

3) How many moles of silver atoms are there in $1.8 \times 10^{20}$ atoms of silver?
   A) $3.0 \times 10^{2}$
   B) $3.3 \times 10^{-3}$
   C) $3.0 \times 10^{-4}$
   D) $1.1 \times 10^{44}$
   E) None of the above

4) How many atoms are there in 5.7 mol of hafnium?
   A) $3.43 \times 10^{24}$ atoms
   B) $1.06 \times 10^{22}$ atoms
   C) $1.06 \times 10^{23}$ atoms
   D) $3.43 \times 10^{23}$ atoms
   E) $6.02 \times 10^{23}$ atoms

5) How many atoms are there in 0.075 mol of titanium?
   A) $1.2 \times 10^{-25}$
   B) $6.4 \times 10^{2}$
   C) $4.5 \times 10^{22}$
   D) 3.6
   E) $2.2 \times 10^{24}$

6) How many molecules are there in 2.1 mol CO$_2$?
   A) $1.26 \times 10^{24}$ molecules
   B) $3.49 \times 10^{-24}$ molecules
   C) $2.53 \times 10^{24}$ molecules
   D) $3.79 \times 10^{24}$ molecules
   E) $1.05 \times 10^{-23}$ molecules
7) How many ammonium ions, NH\textsuperscript{+}, are there in 5.0 mol (NH\textsubscript{4})\textsubscript{2}S?
   A) 3.4 x 10\textsuperscript{2} 
   B) 6.0 x 10\textsuperscript{24} 
   C) 6.0 x 10\textsuperscript{25} 
   D) 3.0 x 10\textsuperscript{24} 
   E) 1.5 x 10\textsuperscript{25}

8) Butanol is composed of carbon, hydrogen, and oxygen. If 1.0 mol of butanol contains 6.0 x 10\textsuperscript{24} atoms of hydrogen, what is the subscript for the hydrogen atom in C\textsubscript{4}H\textsubscript{8}O?
   A) 1 
   B) 8 
   C) 6 
   D) 4 
   E) 10

9) How many moles of helium atoms are there in 2.4 x 10\textsuperscript{24} helium atoms?
   A) 4.0 mol 
   B) 10.0 mol 
   C) 2.4 x 10\textsuperscript{24} mol 
   D) 2.0 mol 
   E) 6.0 mol

10) How many atoms are there in 3.5 moles of arsenic atoms?
    A) 5.8 x 10\textsuperscript{-24} atoms 
    B) 7.5 x 10\textsuperscript{1} atoms 
    C) 2.6 x 10\textsuperscript{2} atoms 
    D) 2.1 x 10\textsuperscript{24} atoms 
    E) 1.7 x 10\textsuperscript{23} atoms

11) How many bromide ions are there in 1.5 moles of MgBr\textsubscript{2}?
    A) 2.8 x 10\textsuperscript{2} ions 
    B) 1.8 x 10\textsuperscript{24} ions 
    C) 5.0 x 10\textsuperscript{-24} ions 
    D) 9.0 x 10\textsuperscript{23} ions 
    E) 3.0 ions

12) How many hydrogen atoms are in 5 molecules of isopropyl alcohol, C\textsubscript{3}H\textsubscript{8}O?
    A) 5 
    B) 5 x (6.02 x 10\textsuperscript{23}) 
    C) 35 x (6.02 x 10\textsuperscript{23}) 
    D) 35 
    E) None of the above
13) How many moles of \( \text{SO}_3 \) are in \( 2.4 \times 10^{24} \) molecules of \( \text{SO}_3 \)?

A) \( 3.4 \times 10^{22} \)  
B) \( 0.25 \)  
C) \( 4.0 \)  
D) \( 2.9 \times 10^{-23} \)  
E) None of the above

14) Which of the following is NOT a representative particle?

A) molecule  
B) anion  
C) cation  
D) electron  
E) atom

15) Which of the following elements exists as a diatomic molecule?

A) neon  
B) aluminum  
C) lithium  
D) sulfur  
E) nitrogen

16) Avogadro’s number of representative particles is equal to one _____.

A) liter  
B) kelvin  
C) mole  
D) gram  
E) kilogram

17) All of the following are equal to Avogadro’s number EXCEPT _____.

A) the number of atoms of gold in 1 mol \( \text{Au} \)  
B) the number of atoms of bromine in 1 mol \( \text{Br}_2 \)  
C) the number of molecules of carbon monoxide in 1 mol CO  
D) the number of molecules of nitrogen in 1 mol \( \text{N}_2 \)  
E) the number of formula units of sodium phosphate in 1 mol \( \text{Na}_3\text{PO}_4 \)

18) Avogadro’s number is _____.

A) the weight of a carbon atom  
B) \( 6.02 \times 10^{23} \)  
C) a mole  
D) a dozen  
E) dependent on what is measured
Molar Mass

19) Which of the following is not a true statement concerning the gram atomic mass?
   A) The gram atomic mass is the number of grams of an element that is numerically equal to the atomic mass in amu.
   B) The gram atomic mass is 12 g for magnesium.
   C) The gram atomic mass is the mass of one mole of atoms.
   D) The gram atomic mass is found by checking the periodic table.
   E) The gram atomic mass is the mass of 6.02 x 10^23 atoms of any monatomic element.

20) The gram atomic masses of any two elements contain the same number of _____.
    A) ions
    B) atoms
    C) grams
    D) anions
    E) milliliters

21) The gram formula mass of C_7H_{16} and the gram formula mass of CaCO_3 contain approximately the same number of _____.
    A) anions
    B) carbon atoms
    C) grams
    D) cations
    E) atoms

22) The gram molecular mass of oxygen gas is _____.
    A) 16.0 g
    B) equal to the mass of one mole of oxygen atoms
    C) 32.0 g
    D) there is not enough information given
    E) none of the above

23) What is the gram formula mass of AuCl_3?
    A) 96 g
    B) 130 g
    C) 303.6 g
    D) 626.5 g
    E) 232.5 g

24) What is the gram formula mass of chromic sulfate, Cr_2(SO_4)_3?
    A) 200.0 g
    B) 148.1 g
    C) 344.2 g
    D) 288.0 g
    E) 392.2 g
25) What is the gram formula mass of \((NH_4)_2CO_3\)?
   A) 43 g  
   B) 144 g  
   C) 96 g  
   D) 138 g  
   E) 78 g

26) How many grams are in 0.90 mol Pd?
   A) 0.00846 g  
   B) 106.4 g  
   C) 0.900 g  
   D) 1.80 g  
   E) 95.8 g

27) What is the mass in grams of 5.90 mol C\(_8\)H\(_{18}\)?
   A) 673 g  
   B) 0.0512 g  
   C) 19.4 g  
   D) 389 g  
   E) 3.55 \times 10^{24} g

28) What is the number of moles in 432 g Ba(NO\(_3\))\(_2\)?
   A) 3.25  
   B) 0.605  
   C) 0.237  
   D) 1.65  
   E) 113,000

29) What is the number of moles in 15.0 g AsH\(_3\)?
   A) 1200  
   B) 0.19  
   C) 5.2  
   D) 0.44  
   E) 2.3

30) What is the number of moles in 0.025 g \((NH_4)_2Cr_2O_7\)?
   A) 1.5 \times 10^{22}  
   B) 4.2 \times 10^{-26}  
   C) 6.3  
   D) 1.0 \times 10^{-4}  
   E) 1.0 \times 10^4

31) What is the mass, in grams, of 0.450 moles of Sb?
   A) 5.48 \times 10^1 g  
   B) 2.02 \times 10^1 g  
   C) 0.450 g  
   D) 2.71 \times 10^{23} g
32) What is the number of moles of beryllium atoms in 36 g of Be?
   - A) 2.2 x 10^{25} mol
   - B) 320 mol
   - C) 4.0 mol
   - D) 45.0 mol
   - E) 0.25 mol

33) How many moles of CaBr_{2} are there in 5.0 grams of CaBr_{2}?
   - A) 1.0 x 10^{3} mol
   - B) 2.5 x 10^{-2} mol
   - C) 4.2 x 10^{-2} mol
   - D) 4.0 x 10^{1} mol
   - E) 3.0 x 10^{24} mol

34) The chemical formula of aspirin is C_{9}H_{8}O_{4}. What is the mass of 0.40 mol of aspirin?
   - A) 72 g
   - B) 45 g
   - C) 160 g
   - D) 10.8 g
   - E) 80 g

Molar Volume

35) What is the volume, in liters, of 0.50 mol of C_{3}H_{8} gas at STP?
   - A) 22.4 L
   - B) 0.0335 L
   - C) 5.60 L
   - D) 16.8 L
   - E) 11.2 L

36) What is the volume, in liters, of 6.8 mol of Kr gas at STP?
   - A) 13,000 L
   - B) 25 L
   - C) 3.3 L
   - D) 152 L
   - E) 0.30 L

37) What is the number of moles in 500 L of He gas at STP?
   - A) 0.05 mol
   - B) 0.2 mol
   - C) 10,000 mol
   - D) 22 mol
   - E) 90 mol
38) What is the number of moles in 9.63 L of H$_2$S gas at STP?
   A) 3.54 mol
   B) 0.104 mol
   C) 216 mol
   D) 14.7 mol
   E) 0.430 mol

39) What is the volume of 2.8 moles of NO$_2$ gas at STP?
   A) 1500 L
   B) 0.13 L
   C) 63 L
   D) 8.0 L
   E) 130 L

40) How many moles of Ar atoms are there in 202 L of Ar gas at STP?
   A) 1.20 x 10$^{24}$ mol
   B) 1.11 x 10$^{-1}$ mol
   C) 4.52 x 10$^{3}$ mol
   D) 9.02 mol
   E) 1.79 mol

41) What is the volume (in liters at STP) of 2.50 mol of carbon monoxide?
   A) 3.1 L
   B) 9.0 L
   C) 56 L
   D) 70 L
   E) 560 L

42) The volume of one mole of substance is 22.4 L at STP for all _____.
   A) liquids
   B) elements
   C) solids
   D) gases
   E) compounds

43) A 22.4-L sample of which of the following substances, at STP, would contain 6.02 x 10$^{23}$ representative particles?
   A) sulfur
   B) cesium iodide
   C) gold
   D) oxygen
   E) All would have the same number of representative particles.
44) Which of the following gas samples would have the largest number of representative particles at STP?
   A) 7.0 L O₂
   B) 0.007 L SO₃
   C) 0.10 L Xe
   D) 12.0 L He
   E) 5.5 L N₂O₄

45) The volume occupied by 1 mol of a gas at STP is _____.
   A) 0°C
   B) 1 kilopascal
   C) 12 grams
   D) 22.4 L
   E) a volume that depends upon the nature of the gas

46) Which combination of temperature and pressure correctly describes standard temperature and pressure, STP?
   A) 100°C and 100 kPa
   B) 0°C and 101 kPa
   C) 1°C and 0 kPa
   D) 22.4°C and 6.02 x 10²³ kPa
   E) 0°C and 22.4 kPa

47) Which of the following conversion processes does NOT depend upon the gram formula mass of a substance? (volume refers to the volume of a gas at STP.)
   A) mass → mole → volume
   B) mass → mole → number of representative particles
   C) volume → mole → number of representative particles
   D) number of representative particles → mole → mass
   E) volume → mole → mass

48) For which of the following conversions does the value of the conversion factor depend upon the formula of the substance?
   A) mass of any substance to moles
   B) volume of gas (STP) to moles
   C) number of particles to moles of gas (STP)
   D) density of gas (STP) to gram formula mass
   E) moles of any substance to number of particles

49) A large weather balloon filled with helium has a volume of 7.00 x 10² L at STP. Which expression should be used to find the mass of helium in the balloon?
   A) (7.00 x 10² / L) x (4 g He/mol)
   B) (22.4 L/mol / 7.00 x 10² L) x (4 g He/mol)
   C) (7.00 x 10² L / 22.4 L/mol) x (4 g He/mol)
D) (22.4 L/mol) x (4 g He/mol)
E) 22.4 L/(4 g/mol)

50) How many moles of hydrogen are present in a 2.76 L sample of acetylene gas (C₂H₂) at STP?
A) 0.123 n
B) 0.246 n
C) 0.345 n
D) 4 x 10²³ n
E) 2.46 x 10²³ n

Percent Composition

51) To determine the formula of a new substance, one of the first steps is to find the _____.
A) gram formula mass
B) number of particles per mole
C) percent composition
D) volume at STP
E) value for Avogadro's number

52) If 60.2 grams of Hg combines completely with 24.0 grams of Br to form a compound, what is the percent composition of Hg in the compound?
A) 71.50%
B) 251%
C) 60.10%
D) 39.90%
E) 28.50%

53) What is the percent composition of chromium in BaCrO₄?
A) 9.47%
B) 20.50%
C) 54.20%
D) 25.20%
E) 4.87%

54) What is the mass of silver in 3.4 g AgNO₃?
A) 3.0 g
B) 0.025 g
C) 0.64 g
D) 2.2 g
E) 0.032 g

55) What is the mass of oxygen in 250 g of sulfuric acid, H₂SO₄?
A) 163 g
B) 16 g
C) 41 g
D) 3.9 g
56) If 20.0 grams of Ca combines completely with 16.0 grams of S to form a compound, what is the percent composition of Ca in the compound?
   A) 1.25%
   B) 62.50%
   C) 20.00%
   D) 80.00%
   E) 44.40%

57) What information is needed to calculate the percent composition of a compound?
   A) the density of the compound and Avogadro's number
   B) the weight of the sample to be analyzed and its density
   C) the weight of the sample to be analyzed and its molar volume
   D) the formula of the compound and the gram atomic mass of its elements
   E) the formula of the compound and its density

58) What is the percent composition of carbon, in heptane, C$_7$H$_{16}$?
   A) 68%
   B) 19%
   C) 16%
   D) 84%
   E) 12%

59) What is the percent by mass of carbon in acetone, C$_3$H$_6$O?
   A) 1.61%
   B) 62.10%
   C) 30.00%
   D) 20.70%
   E) 52.00%

60) What is the % of oxygen in the hydrate MgSO$_4$*7H$_2$O?
   A) 13%
   B) 33%
   C) 45%
   D) 72%
   E) 80%

61) What is the empirical formula of a compound that is 40% sulfur and 60% oxygen by weight?
   A) S$_2$O$_3$
   B) SO$_2$
   C) S$_6$O$_4$
   D) SO$_3$
   E) SO

62) What is the empirical formula of a compound that is 50.7% antimony and 49.3% selenium by weight?
A) Sb₃Se₂
B) SbSe₂
C) Sb₂Se₃
D) SbSe
E) Sb₂Se

63) What is the empirical formula of a substance that is 53.5% C, 15.5% H, and 31.1% N by weight?
   A) C₄H₁₄N₂
   B) C₂H₇N
   C) CH₄N₇
   D) C₄,H₁₅,N₂.₂
   E) C₃HN₂

64) The ratio of carbon atoms to hydrogen atoms to oxygen atoms in a molecule of dicyclohexyl maleate is 4 to 6 to 1. What is the molecular formula of this substance if its gram formula mass is 280 g?
   A) C₄H₆O
   B) C₁₂H₁₈O₃
   C) C₈H₁₂O₂
   D) C₂₀H₃₀O₅
   E) C₁₆H₂₄O₄

65) Which of the following compounds has the lowest percent gold content by weight?
   A) AuBr₃
   B) AuOH
   C) AuCl₃
   D) AuI₃
   E) Au(OH)₃

66) Which of the following compounds has the highest oxygen content, by weight?
   A) Na₂O
   B) CO₂
   C) BaO
   D) NO
   E) H₂O

67) All of the following are empirical formulas EXCEPT _____.
   A) C₆H₅Cl
   B) N₂O₄
   C) Sn₃(PO₄)₄
   D) Na₂SO₄
   E) Cr₂O₃

68) Which expression represents the percent by mass of nitrogen in NH₄NO₃?
   A) (80 g NH₄NO₃) / (14 g N) x 100%
B) \( \frac{(80 \text{ g NH}_4\text{NO}_3)}{(28 \text{ g N}) \times 100\%} \)
C) \( \frac{(14 \text{ g N})}{(80 \text{ g NH}_4\text{NO}_3)} \times 100\% \)
D) \( \frac{(28 \text{ g N})}{(80 \text{ g NH}_4\text{NO}_3)} \times 100\% \)
E) \( \frac{(14 \text{ g N})}{(80 \text{ g NH}_4\text{NO}_3)} \times 14 \text{ g} \times 100\% \)

69) The lowest whole-number ratio of the elements in a compound is called the _____.
A) representative formula
B) ionic compound
C) empirical formula
D) molecular formula
E) binary formula

70) What is the formula of a hydrate of CuSO₄, if when a 1 gram sample of it is heated, the mass of the dry crystal is found to be 0.64 grams?
A) CuSO₄*H₂O
B) CuSO₄*2H₂O
C) CuSO₄*4H₂O
D) CuSO₄*5H₂O
E) CuSO₄*6H₂O

71) Which of the following is not an empirical formula?
A) MoO₂Cl₂
B) BeCr₂O₇
C) C₂N₂H₈
D) C₃H₈O
E) Sb₂S₃

72) Which of the following is an empirical formula?
A) P₄O₁₀
B) C₂H₈N₂
C) H₂O₂
D) C₃H₆O₂
E) C₅H₁₀

73) Which of the following compounds have the same empirical formula?
A) C₄H₁₀ and C₁₀H₄
B) NO and NO₂
C) CO₂ and SO₂
D) C₆H₁₂ and C₇H₁₄
E) C₆H₁₂ and C₆H₁₄

74) Which of the following is NOT a true statement concerning empirical and molecular formulas?
A) The molecular formula of a compound can be some whole-number multiple of its empirical formula.
B) Several compounds can have the same empirical formula, but have different molecular formulas.
C) The molecular formula of a compound can be the same as its empirical formula.
D) If the molecular formula of hydrogen peroxide is H\textsubscript{2}O\textsubscript{2}, its empirical formula is HO.
E) The empirical formula of a compound can be triple its molecular formula.

75) Which of the following sets of empirical formula, gram formula mass, and molecular formula is correct?

A) C\textsubscript{3}H\textsubscript{8}O, 120 g, C\textsubscript{3}H\textsubscript{8}O\textsubscript{2}
B) HO, 34 g, H\textsubscript{2}O
C) CH, 78 g, C\textsubscript{13}H\textsubscript{13}
D) CH\textsubscript{4}N, 90 g, C\textsubscript{3}H\textsubscript{12}N\textsubscript{3}
E) CaO, 56 g, Ca\textsubscript{2}O\textsubscript{2}

76) A 0.60 sample an unknown organic acid found in muscle cells is burned in air and found to contain 0.24 grams of carbon, 0.040 grams of hydrogen, with the rest being oxygen. If the molecular weight of the substance is 90 grams/n, what is the molecular formula?

A) C\textsubscript{2}H\textsubscript{3}O
B) CH\textsubscript{2}O
C) C\textsubscript{3}H\textsubscript{6}O\textsubscript{3}
D) C\textsubscript{2}H\textsubscript{4}O\textsubscript{2}
E) C\textsubscript{4}H\textsubscript{6}O

77) A 0.67 gram sample of chromium is reacted with sulfur. The resulting chromium sulfide has a mass of 1.2888 grams. What is the empirical formula?

A) CrS
B) Cr\textsubscript{2}S
C) Cr\textsubscript{2}S\textsubscript{5}
D) Cr\textsubscript{2}S\textsubscript{3}
E) CrS\textsubscript{2}

Questions 78-80 refer to the answer below:

A) 22.4
B) 6 \times 10^{22}
C) 1.2 \times 10^{24}
D) 149
E) 113

78) Represents the volume occupied by any gas at STP in L/n
79) The number of hydrogen atoms in a 0.9 gram sample of water
80) The molar mass of ammonium phosphate

For questions 81-87, identify the phrase as either TRUE or FALSE.

81) Every substance has the same molar mass
82) Every gas occupies the same number of L of space, irrespective of the # of gas particles present.
83) Argon gas and hydrogen gas have the same molar volume at STP.
84) A 10 gram sample of methane (CH₄) has the same number of molecules as a 10 gram sample of O₂.
85) A 1 mole sample of hydrogen gas has the same number of hydrogen atoms as a 2 mole sample of water molecules (H₂O).
86) Since oxygen is a heavier atom than nitrogen, there are more oxygen atoms per mole than nitrogen atoms per mole.
87) H₂NCHO is both a molecular and empirical formula.
**ANSWERS:**

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<td>D</td>
<td>66)</td>
<td>E</td>
</tr>
</tbody>
</table>