Stoichiometry Exercise

Topic 1: The Mole Concept & Molar Mass

Multiple Choice Questions (MCQs)

1. What is the formula mass of $CuSO_4 \cdot 5H_2O$? (Atomic masses: Cu=63.5, S=32, O=16, H=1)
   a) 159.5
   b) 185.5
   c) 249.5
   d) 149.5
2. How many moles of molecules are there in 16g of oxygen gas (O_2)?
   a) 1
   b) 0.5
   c) 0.1
   d) 0.05
3. What is the mass of 4 moles of hydrogen gas (H_2)?
   a) 8.064g
   b) 4.032g
   c) 1g
   d) 1.008g
4. If one mole of carbon contains x atoms, what is the number of atoms contained in 12g of Magnesium (Mg)?
   a) x
   b) 0.5x
   c) 2x
   d) 1.5x
5. Which term is the same for one mole of oxygen gas and one mole of water?
   a) Volume

b) Mass

c) Atoms

d) Molecules

6. Calculate the number of atoms in 3.4 moles of nitrogen atoms.

   a) 3.4×10^{23}

   b) 2.05×10^{24}

   c) 6.02×10^{23}

   d) 1.7×10^{24}

Short Questions

1. **What is a mole?**

   A mole is the standard SI unit for measuring the amount of a substance. It is defined as the amount of substance that contains as many elementary entities (atoms, molecules, ions, etc.) as there are atoms in exactly 12 grams of carbon-12. This number is known as Avogadro's number, which is approximately 6.022×10^{23}. One mole of any substance will always contain this constant number of particles.

2. **Describe how Avogadro's number is related to a mole of any substance.**

   Avogadro's number (6.022×10^{23}) is the fundamental link between the microscopic world of atoms and the macroscopic world we measure. One mole of any pure substance, regardless of its composition or state, contains exactly Avogadro's number of constituent particles. For example, one mole of iron contains 6.022×10^{23} atoms, and one mole of water contains 6.022×10^{23} molecules.

3. **Why do one mole of hydrogen molecules and one mole of H-atoms have different masses?**

   They have different masses because their constituent particles are different. One mole of hydrogen atoms (H) contains 6.022×10^{23} hydrogen atoms, with a molar mass of approximately 1 g/mol. One mole of hydrogen molecules (H_2) contains 6.022×10^{23} diatomic molecules. Since each molecule is made

of two atoms, the molar mass is approximately 2 g/mol. The difference in mass comes from the difference in the particles being counted.

4. **Calculate the number of molecules in 9.0 g of steam (H_2O).**
   First, the molar mass of H_2O is 18 g/mol. The number of moles in 9.0 g is 9.0 g / 18 g/mol = 0.5 moles. Using Avogadro's number, the number of molecules is 0.5 mol × 6.022×10^{23} molecules/mol = 3.011×10^{23} molecules.

Multiple Choice Questions (MCQs)

1. What is the mass of carbon present in 44g of carbon dioxide (CO_2)?
   a) 12g
   b) 6g
   c) 24g
   d) 44g
2. A compound with the chemical formula Na_2CX_3 has a formula mass of 106 amu. What is the atomic mass of element X? (Na=23, C=12)
   a) 106
   b) 23
   c) 12
   d) 16
3. Identify the substance that has a formula mass of 133.5 amu.
   a) $MgCl_3$
   b) S_2Cl_3
   c) BCl_3
   d) $AlCl_3$
4. TNT contains 7 C-atoms, 5 H-atoms, 3 N-atoms, and 6 O-atoms. What is its empirical formula?
   a) $C_7H_5N_3O_6$
   b) $C_7H_5N_3O_6$ (It is already the simplest ratio)
   c) $C_6H_3NO_2$
   d) CHNO

5. A molecule contains four phosphorus atoms and ten oxygen atoms. What is its empirical formula?
   a) P_4O_{10}
   b) P_2O_5
   c) PO_3
   d) P_4O_8
6. Which of the following is an example of an empirical formula?
   a) Al_2Cl_6
   b) Hg_2Cl_2
   c) NaCl
   d) C_6H_6

Short Questions

1. **Differentiate between an empirical formula and a molecular formula.**
   The empirical formula shows the simplest whole-number ratio of atoms of each element in a compound. The molecular formula shows the actual number of atoms of each element in a molecule of the compound. For example, for benzene, the molecular formula is C_6H_6, but its empirical formula is CH. The molecular formula is often a whole-number multiple of the empirical formula.
2. **Potassium burns in air to form potassium oxide and potassium nitride. Predict the formula of these two compounds.**
   Potassium is a Group 1 element with a valency of +1. Oxygen has a common valency of -2, so the formula of potassium oxide is K_2O. The nitride ion is given as N^{3-} (not N^+ as in the original text, which is likely a typo). With K^+ and N^{3-}, the formula for potassium nitride is K_3N.
3. **Calculate the molar masses of Indigo ($C_{16}H_{10}N_2O_2$) and Indoxyl (C_8H_7NO).**

- **Indigo ($C_{16}H_{10}N_2O_2$):** (16×12) + (10×1) + (2×14) + (2×16) = 192 + 10 + 28 + 32 = **262 g/mol**

- **Indoxyl (C_8H_7NO):** (8×12) + (7×1) + (1×14) + (1×16) = 96 + 7 + 14 + 16 = **133 g/mol**

4. **Balance the following chemical equation: $K + H_2O \rightarrow KOH + H_2$**
   The balanced chemical equation is:
   $2K + 2H_2O \rightarrow 2KOH + H_2$
   This ensures an equal number of each type of atom on both the reactant and product sides.

Multiple Choice Questions (MCQs)

1. Calculate the mass of 3.24×10183.24×1018 atoms of iron (Fe).
   a) 3.01 x 10^{-4} g
   b) 3.02 x 10^{-4} g
   c) 5.38 x 10^{-41} g
   d) 55.85 g
2. Calculate the number of atoms in 23g of Na.
   a) 1 x 6.022 x 10^{23}
   b) 1 x 6.022 x 10^{23}
   c) 23 x 6.022 x 10^{23}
   d) 0.5 x 6.022 x 10^{23}
3. Calculate the mass of 2×10192×1019 molecules of nitrogen gas (N_2).
   a) 2.8 x 10^{-4} g
   b) 9.3 x 10^{-4} g
   c) 9.3 x 10^{-4} g (Molar mass N_2 = 28 g/mol)
   d) 4.65 x 10^{-4} g
4. What is the mass of 1.2 moles of Potassium (K)?
   a) 1.2 g
   b) 39 g
   c) 46.8 g
   d) 39.1 g

5. Calculate the number of molecules in 2.5 moles of carbon dioxide.
   a) 1.505×10^{24}
   b) 6.022×10^{23}
   c) 2.5×10^{23}
   d) 4.0×10^{-24}

Short Questions

1. **Calculate the number of moles in 2.4 g of Helium (He).**
   The molar mass of Helium is 4 g/mol. The number of moles is calculated as mass divided by molar mass: moles = 2.4 g / 4 g/mol = **0.6 moles**.
2. **Calculate the mass in grams of 0.25 moles of steam (H_2O).**
   The molar mass of H_2O is 18 g/mol. Mass = moles × molar mass = 0.25 mol × 18 g/mol = **4.5 grams**.
3. **Show that a 0.5g sample of Potassium (K) contains 1.28 x 10^{-2} moles.**
   The molar mass of Potassium (K) is approximately 39.1 g/mol. The number of moles is calculated as mass divided by molar mass: moles = 0.5 g / 39.1 g/mol ≈ **0.0128 moles**, which is 1.28×10^{-2} moles.
4. **Calculate the number of atoms present in a 0.5g sample of Potassium (K).**
   From the previous question, we know the sample contains 1.28×10^{-2} moles. The number of atoms = moles × Avogadro's number = $(1.28 \times 10^{-2}$ mol) × $(6.022 \times 10^{23}$ atoms/mol) ≈ **7.71×10^{21} atoms**.