WORKSHOP ON STOICHIOMETRY
worked answers to postwork questions

Q1. Write the equation that relates amount of a substance to mass.

Amount of substance (in mol) $= \dfrac{\textbf{mass of substance}}{\textbf{formula weight}}$ **or** $n = \dfrac{m}{M}$

Q2. Calculate the mass of 1.87 mol of sulfur trioxide.

Molecular weight of SO_3 = 32.07 (S) + (3 × 16.00 (O)) = 80.07

Mass of 1.87 mol of SO_3 = 1.87 × 80.07 = 149.73 = 150 g (3 significant figures)

Q3. Calculate the amount (in mol) present in 200.0 g of silicon tetrachloride.

Molecular weight of $SiCl_4$ = 28.09 + (4 × 35.45) = 169.89

$$n = \frac{m}{M} = \frac{200.0}{169.89} = 1.1772 = 1.177 \text{ (4 significant figures)}$$

Q4. Calculate the mass of 2.00×10^{20} molecules of water.

Molecular weight of H_2O = (2 × 1.008 (H)) + 16.00 (O) = 18.016

$$n = \frac{\text{number of atoms}}{\text{Avogadro's number}} = \frac{2.00 \times 10^{20}}{6.022 \times 10^{23}} \text{ mol}$$

$$m = n \times M = \left(\frac{2.00 \times 10^{20}}{6.022 \times 10^{23}}\right) \times 18.016 = 5.9834 \times 10^{-3} = 5.98 \times 10^{-3} \text{ g (3 significant figures)}$$

Q5. Calculate the volume (in L) present in 5.45×10^{22} atoms of helium at STP.

$$n = \frac{\text{number of atoms}}{\text{Avogadro's number}} = \frac{5.45 \times 10^{22}}{6.022 \times 10^{23}} \text{ mol}$$

$$\text{Volume occupied} = n \times 22.4 = \frac{5.45 \times 10^{22}}{6.022 \times 10^{23}} \times 22.4 = 2.027 = 2.03 \text{ L (3 significant figures)}$$

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Q6. Calculate the relative atomic mass of a natural sample of zinc, which contains the isotopes with masses and abundances given:

isotope	atomic weight	abundance	isotope	atomic weight	abundance
^{64}Zn	63.929	48.6%	^{68}Zn	67.925	18.8%
^{66}Zn	65.926	27.9%	^{70}Zn	69.925	0.6%
^{67}Zn	66.927	4.1%			

$$\textbf{atomic weight} = \left(63.929\times\frac{48.6}{100}\right)+\left(65.926\times\frac{27.9}{100}\right)+\left(66.927\times\frac{4.1}{100}\right)$$
$$+\left(67.925\times\frac{18.8}{100}\right)+\left(69.925\times\frac{0.6}{100}\right)=65.3963=65.4\,(\text{3 significant figures})$$

Q7. An iron supplement is used to treat anaemia and 50 mg (*i.e.* 50×10^{-3} g) of Fe^{2+} is required per tablet. If the iron compound used in the tablet is $FeSO_4{\cdot}7H_2O$, what mass of this compound would be required per tablet to provide the desired amount of Fe^{2+}?

Formula weight of $FeSO_4{\cdot}7H_2O$:

55.85 (Fe) + 32.07 (S) + (4 × 16.00 (O)) + 7 × (2 × 1.008 (H) + 16.00 (O)) = 278.032

$$\textbf{50 mg of Fe} = \frac{\text{mass (in g)}}{\text{atomic mass (in g mol}^{-1})} = \frac{50\times10^{-3}}{55.85}\ \text{mol}$$

Mass of $FeSO_4{\cdot}7H_2O$ = number of moles × formula mass

$$= \frac{50\times10^{-3}}{55.85} \times 278.032 = 0.24891 = 0.25\text{ g (2 significant figures)}$$

Q8. Write the equation that relates concentration of a solution to amount of solute and volume of solution.

$$\textbf{concentration (in M)} = \frac{\text{number of moles of solute (in mol)}}{\text{volume of solute (in L)}}$$

Q9. Write the net ionic equation for the reaction that occurs when a solution of barium nitrate is mixed with a solution of sodium sulfate. A white precipitate of barium sulfate forms.

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

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Q10. One of the components of petrol is octane, C_8H_{18}.

(i) Write the balanced equation for the complete combustion of octane to form carbon dioxide gas and liquid water.

$$C_8H_{18}(l) + \frac{25}{2} O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$$

(ii) What amount (in mol) of carbon dioxide is formed when 5.5 mol (1 L) of petrol is burnt?

1 mol of $C_8H_{18}(l)$ produces 8 mol of $CO_2(g)$

$\therefore$ 5.5 mol of $C_8H_{18}(l)$ produces $8 \times 5.5 = 44$ mol of $CO_2(g)$

(iii) What volume of carbon dioxide would this represent at STP?

Volume occupied = $44 \times 22.4 = 985.6 = 9.9 \times 10^2$ L (2 significant figures)

Q11. Hydrogen iodide gas (5.0 L at STP) is dissolved in water and the volume made up to 1.0 L. What is the molarity of the solution?

$$\text{Amount of HI} = \frac{\text{volume (in L)}}{22.4\text{ L}} = \frac{5.0}{22.4} = 0.2232 \text{ mol}$$

$$\text{Molarity of solution} = \frac{\text{number of moles (in mol)}}{\text{volume (in L)}} = \frac{0.2232}{1.0} = 0.22 \text{ M (2 significant figures)}$$

Q12. What volume of 0.200 M hydrochloric acid would be needed to react completely with a mixture of 0.500 g of sodium hydroxide and 0.800 g of potassium hydroxide?

Formula weight of NaOH = 22.99 (Na) + 16.00 (O) + 1.008 (H) = 39.998

Formula weight of KOH = 39.10 (K) + 16.00 (O) + 1.008 (H) = 56.108

$$HCl + MOH \rightarrow H_2O + MCl \qquad (M = K \text{ or } Na)$$

$$\text{total amount of MOH} = \frac{\text{mass of NaOH (in g)}}{\text{formula mass of NaOH (in g mol}^{-1})} + \frac{\text{mass of KOH (in g)}}{\text{formula mass of KOH (in g mol}^{-1})}$$

$$= \left(\frac{0.500}{39.998}\right) + \left(\frac{0.800}{56.108}\right) = 0.02676 \text{ mol}$$

Therefore 0.02676 mol of HCl is required.

$$\text{Volume (in L)} = \frac{\text{number of moles (in mol)}}{\text{concentration (in M)}} = \frac{0.02676}{0.200} = 0.1338 \text{ L}$$

$$= 134 \text{ mL (3 significant figures)}$$

Q10. A solution was prepared by dissolving nickel (II) nitrate-6-water, $Ni(NO_3)_2 \cdot 6H_2O$, (29.1 g) in some water and making the volume up to 1.00 L with water. Assuming complete dissociation of the solid into ions, calculate:

(i) The amount (in mol) of nickel(II) ions in 100 mL of this solution.

Formula weight of $Ni(NO_3)_2 \cdot 6H_2O$:

$$58.69\ (Ni) + 2 \times (14.01\ (N) + 3 \times 16.00\ (O)\ ) + 6 \times (2 \times 1.008\ (H) + 16.00\ (O)) = 290.806$$

$$\text{Amount of } Ni(NO_3)_2 \cdot 6H_2O = \frac{\text{mass (in g)}}{\text{formula mass (in g mol}^{-1})} = \frac{29.1}{290.806}$$

$$= 0.100 \text{ mol (3 significant figures)}$$

$$\text{Concentration of solution} = \frac{\text{number of moles (in mol)}}{\text{volume (in L)}} = \frac{0.100}{1.00\,\text{L}} = 0.100\,\text{M}$$

Each $Ni(NO_3)_2 \cdot 6H_2O$ dissociates to give *one* Ni^{2+}(aq) ion.

$$\text{Amount of } Ni^{2+} \text{ ions in 100 mL} = \text{concentration (in M)} \times \text{volume (in L)}$$

$$= 0.100 \times \frac{100}{1000}$$

$$= 0.0100\,\text{mol}$$

(ii) The amount (in mol) of nitrate ions in 100 mL of this solution.

Each $Ni(NO_3)_2 \cdot 6H_2O$ dissociates to give *two* NO_3^{2-} (aq) ions.

$$\text{Amount of } NO_3^{2-} \text{ ions in 100 mL} = \text{concentration (in M)} \times \text{volume (in L)}$$

$$= 2 \times 0.100 \times \frac{100}{1000}$$

$$= 0.0200\,\text{mol}$$

(iii) The number of individual nickel(II) ions in 100 mL of solution.

Number of Ni^{2+} ions = number of moles × Avogadro's number
$= 0.0100 \times (6.022 \times 10^{23}) = 6.022 \times 10^{21}$

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Q14. What volume of 0.010 M silver nitrate solution will exactly react with 20 mL of 0.0080 M sodium chloride solution?

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

Amount of NaCl = volume (in L) × concentration (in M) = $\frac{20}{1000} \times 0.080\,\text{mol}$

$\therefore$ Amount of $AgNO_3$ required = 0.0080 × 0.020

$$\textbf{Volume of } AgNO_3 \textbf{ required} = \frac{\text{number of moles (in mol)}}{\text{concentration (in M)}}$$

$$= \frac{0.0080}{0.010} = 0.016\,\text{L} = 16\,\text{mL (2 significant figures)}$$