

WORKSHOP ON STOICHIOMETRY
worked answers to postwork questions

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

$$\text{Amount of substance (in mol)} = \frac{\text{mass of substance}}{\text{formula weight}} \quad \text{or} \quad n = \frac{m}{M}$$

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

$$\text{Molecular weight of SO}_3 = 32.07 (\text{S}) + (3 \times 16.00 (\text{O})) = 80.07$$

$$\text{Mass of 1.87 mol of SO}_3 = 1.87 \times 80.07 = 149.73 = 150 \text{ g (3 significant figures)}$$

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

$$\text{Molecular weight of SiCl}_4 = 28.09 + (4 \times 35.45) = 169.89$$

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

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

$$\text{Molecular weight of H}_2\text{O} = (2 \times 1.008 (\text{H})) + 16.00 (\text{O}) = 18.016$$

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

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

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%			

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

- 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 $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, what mass of this compound would be required per tablet to provide the desired amount of Fe^{2+} ?

Formula weight of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$:

$$55.85 \text{ (Fe)} + 32.07 \text{ (S)} + (4 \times 16.00 \text{ (O)}) + 7 \times (2 \times 1.008 \text{ (H)} + 16.00 \text{ (O)}) = 278.032$$

$$50 \text{ mg of Fe} = \frac{\text{mass (in g)}}{\text{atomic mass (in g mol}^{-1}\text{)}} = \frac{50 \times 10^{-3}}{55.85} \text{ mol}$$

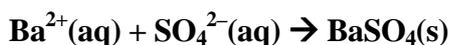
Mass of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ = number of moles \times formula mass

$$= \frac{50 \times 10^{-3}}{55.85} \times 278.032 = 0.24891 = 0.25 \text{ g (2 significant figures)}$$

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

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

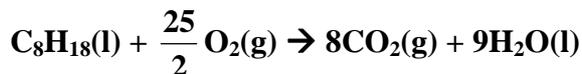
- Q9. Write the net ionic equation for the reaction that occurs when a solution of barium nitrate is mixed with a solution of sodium sulfate. A white precipitate of barium sulfate forms.



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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.



- (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



$$\begin{aligned} \text{total amount of MOH} &= \frac{\text{mass of NaOH (in g)}}{\text{formula mass of NaOH (in g mol}^{-1}\text{)}} + \frac{\text{mass of KOH (in g)}}{\text{formula mass of KOH (in g mol}^{-1}\text{)}} \\ &= \left(\frac{0.500}{39.998} \right) + \left(\frac{0.800}{56.108} \right) = 0.02676 \text{ mol} \end{aligned}$$

Therefore 0.02676 mol of HCl is required.

$$\begin{aligned} \text{Volume (in L)} &= \frac{\text{number of moles (in mol)}}{\text{concentration (in M)}} = \frac{0.02676}{0.200} = 0.1338 \text{ L} \\ &= 134 \text{ mL (3 significant figures)} \end{aligned}$$

Q10. A solution was prepared by dissolving nickel (II) nitrate-6-water, $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, (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 $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$:

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

$$\text{Amount of } \text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = \frac{\text{mass (in g)}}{\text{formula mass (in g mol}^{-1}\text{)}} = \frac{29.1}{290.806} \\ = 0.100 \text{ mol (3 significant figures)}$$

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

Each $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ dissociates to give *one* $\text{Ni}^{2+}(\text{aq})$ ion.

$$\text{Amount of } \text{Ni}^{2+} \text{ ions in 100 mL} = \text{concentration (in M)} \times \text{volume (in L)} \\ = 0.100 \times \frac{100}{1000} \\ = 0.0100 \text{ mol}$$

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

Each $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ dissociates to give *two* $\text{NO}_3^{2-}(\text{aq})$ ions.

$$\text{Amount of } \text{NO}_3^{2-} \text{ ions in 100 mL} = \text{concentration (in M)} \times \text{volume (in L)} \\ = 2 \times 0.100 \times \frac{100}{1000} \\ = 0.0200 \text{ mol}$$

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

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

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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?



$$\text{Amount of NaCl} = \text{volume (in L)} \times \text{concentration (in M)} = \frac{20}{1000} \times 0.0080 \text{ mol}$$

$$\therefore \text{Amount of AgNO}_3 \text{ required} = 0.0080 \times 0.020$$

$$\begin{aligned} \text{Volume of AgNO}_3 \text{ required} &= \frac{\text{number of moles (in mol)}}{\text{concentration (in M)}} \\ &= \frac{0.0080}{0.010} = 0.016 \text{ L} = 16 \text{ mL (2 significant figures)} \end{aligned}$$