WORKSHOP ON STOICHIOMETRY

POST-WORK

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

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

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

Molecular weight of $SO_3 = 32.07 + (3 \times 16.00) = 80.07$
Mass of 1.87 mol of $SO_3 = 1.87 \times 80.07 = 149.73 = 150$ g (3 significant figures)

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

Molecular weight of $SiCl_4 = 28.09 + (4 \times 35.45) = 169.89$
$n = m/M = 200.0/169.89 = 1.1772 = 1.177$ (4 significant figures)

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

Molecular weight of $H_2O = (2 \times 1.008) + 16.00 = 18.016$
$n = (2.00 \times 10^{20}) / N_A = 3.32116 \times 10^{-4}$ mol
$m = n \times M = (2.00 \times 10^{20} / N_A) \times 18.016 = 5.9834 \times 10^{-3} = 5.98 \times 10^{-3}$ g (3 significant figures)

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

$n = (5.45 \times 10^{22} / N_A) = 9.050 \times 10^{-2}$ mol
Volume occupied = $5.45 \times 10^{22} / N_A \times 22.4 = 2.027 = 2.03$ L (3 significant figures)

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%			

Atomic weight of Zn = $63.929 \times 0.486 + 65.926 \times 0.279 + 66.927 \times 0.041 + 67.925 \times 0.188 + 69.925 \times 0.006 = 65.3963 = 65.4$ (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 $FeSO_4 \cdot 7H_2O = 55.85 + 32.07 + (4 \times 16.00) + (7 \times 18.016) = 278.032$
50 mg of Fe = $50 \times 10^{-3} / 55.85$ mol
Mass of $FeSO_4 \cdot 7H_2O = 50 \times 10^{-3} / 55.85 \times 278.032 = 0.24891 = 0.25$ g (2 significant figures)

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

Concentration (in mol L^{-1}) = $\dfrac{\text{amount (in mol)}}{\text{volume (in L)}}$

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.

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

Q10. Petrol is composed largely of octane, C_8H_{18}. (i) Write the balanced equation for the complete combustion of octane to form carbon dioxide gas and liquid water.

$C_8H_{18}(l) + 12½O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$

(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?

Amount of HI = 5.0 / 22.4 = 0.2232 mol
Molarity of solution is therefore 0.22 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 + 16.00 + 1.008 = 39.998
Formula weight of KOH = 39.10 + 16.00 + 1.008 = 56.108
$HCl + MOH \rightarrow H_2O + MCl$ (M = K or Na)
Total amount of MOH = (0.500 / 39.998) + (0.800 / 56.108) = 0.02676 mol
Therefore 0.02676 mol of HCl is required.
Volume = amount / concentration = 0.02676 / 0.200 = 0.1338 L = 134 mL (3 significant figures)

Q13. 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 $Ni(NO_3)_2{\cdot}6H_2O = 58.69 + 2 \times (14.01 + 3 \times 16.00) + (6 \times 18.016) = 290.806$
Amount of $Ni(NO_3)_2{\cdot}6H_2O = 29.1 / 290.806 = 0.100$ (3 significant figures)
Amount of Ni^{2+} ions in 100 mL = $0.100 \times 0.100 = 0.0100$ mol

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

Amount of NO_3^- ions = $0.0100 \times 2 = 0.0200$ mol

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

Number of Ni^{2+} ions = $0.0100 \times N_A = 6.022 \times 10^{21}$

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 = 0.0080×0.020
$\therefore$ Amount of $AgNO_3$ required = 0.0080×0.020
Volume = amount / concentration = $0.0080 \times 0.020 / 0.010 = 0.016$ L = 16 mL (2 sig figures)