CHM 217H1 Background
"Introduction to Analytical Chemistry"

This document is provided for students who wish to make sure that they are adequately prepared to take CHM217, "Introduction to Analytical Chemistry", and summarizes the key concepts and terms from the prerequisite courses (either CHM138 & 139 combination or CHM151). If you are unsure about any of these concepts, calculations, and operations, you may consult the relevant sections of the course text or your 1st year chemistry texts. You can also contact the course instructor ahead of time for guidance. Note that students enrolled in the course will have an opportunity to take an on-line self-assessment test at the start of the semester to help them gauge their level of prior knowledge and recall.

Basic scientific concepts

- Significant figures, decimal places, and rounding in calculations
- Fundamental SI units and common unit prefixes; unit conversion
- Common chemical units and their conversion to/from SI units

Examples:

1. How many significant figures have each of the following numbers?
    a. 200.06
    b. 6.030×10^{-4}
    c. 0.0780×10^{10}
2. Express a density of 1.23 g cm^{-3} correctly in units of kg m^{-3}
3. Round the following numbers as indicated, using scientific notation:
    a. 21.57 rounded to 3 significant figures
    b. 12.65 rounded to 3 significant figures
    c. Gas constant, R (SI units) to 3 decimal places
    d. Planck's constant, h (SI units) to 3 decimal places
    e. The value of π to 4 significant figures
4. What is a temperature of 37.3 °C when expressed in
    a. Degrees Farenheit (°F)?
    b. Absolute temperature (K)?
5. What is the pressure (in Pa) when 5.0 mN of force is applied over an area of 4.0 cm^2?
6. What is the pressure from question 5 expressed in atmospheres (atm)?
7. A chemist has 200 μL of a solution containing 1.50 mg/mL of a 160 kDa protein. How many moles of protein are there in the sample?
8. What is the difference between a fundamental and a derived unit?
9. What is unit analysis, and why is it useful?

Basic chemical concepts

- Interpretation of simple chemical names and formulae
- Calculation of molecular and formula masses

- Concentration calculations (molar, molal, mass, mole fraction, density)
- Balancing equations; stoichiometry & limiting reagent calculations
- Identification and balancing of acid-base, precipitation and redox reactions
- Formal oxidation numbers; identification of oxidant and reductant

Examples:

10. A solution is prepared by dissolving 273 millimoles of KNO_3 in 250.0 mL of water. Assuming no change in volume, calculate
    a. The resulting molar concentration of KNO_3 in mol/L
    b. The molal concentration of KNO_3 in mol/kg
    c. The mass of potassium in the solution in g
    d. The density of the solution (assume d_{H2O} = 1.00 g/mL)
    e. The mole fraction of nitrate in the solution, as mol%

    (Atomic mass of K = 39.10, N = 14.01, and O = 16.00 g/mol)
11. Calculate the molar mass of barium dichloride dihydrate. What molar concentration of chloride would result from dissolving 1.20 g of this salt in sufficient water to yield 500.0 mL of solution? (Atomic mass of Ba = 137.34, Cl = 34.45, H = 1.008 and O = 16.00 g/mol)
12. What volume of 1.20 mM sodium sulphate solution would be required to *exactly* react with 25.00 mL of the barium dichloride solution from the previous question?
13. 20.00 mL of 0.250 M silver nitrate solution is added to 50.00 mL of 0.150 M calcium(II) chloride solution.
    a. Write a balanced chemical equation for this reaction, indicating the physical states of all reactants and products
    b. Which reagent is in excess?
    c. What is the maximum theoretical yield of precipitate in grams?
14. Identify the formal oxidation number of the **bolded atom** in each of the following:
    a. $Na_2\mathbf{S}O_3$
    b. $K_2\mathbf{S}_2O_3$
    c. $(NH_4)_2\mathbf{Cr}O_4$
    d. $H_2\mathbf{O_2}$
    e. $Na\mathbf{N}_3$
15. Which of the following combinations would you expect to yield a precipitate?
    a. $NiCl_2(aq) + Na_3PO_4(aq)$
    b. $H_2C_6H_6O_6(aq) + NH_3(aq)$
    c. $K_2Cr_2O_7(aq) + I_2(aq)$
    d. $Cu(NO_3)_2(aq) + NaOH(aq)$
    e. $CsCl(aq) + NH_4F(aq)$
16. In the following reactions, which (if any) reagent is being oxidized?
    a. $NCl_3(l) + 3H_2O(l) \rightarrow NH_3(aq) + 3HOCl(aq)$
    b. $AgNO_3(aq) + NH_4I(aq) \rightarrow AgI(s) + NH_4NO_3(aq)$
    c. $2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(g)$
    d. $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$
    e. $5CO(g) + I_2O_5(s) \rightarrow I_2(s) + 5CO_2(g)$

Equilibrium reactions

- Definition of the equilibrium constant; relations between K, Q, and ΔG
- Basic principles of equilibrium calculations; combination of equilibria
- Acids and bases (Arrhenius, Brønsted-Lowry, and Lewis); acid & base strength
- Calculation of pH, K_a, K_b, and equivalence point in acid-base titrations
- Identification of buffers, calculation of buffer composition & pH
- Solubility, precipitation, K_{sp}, and solubility calculations

Other topics

- Standard reduction potentials, electrodes and cells; the Nernst equation
- Chemical bonds (covalent, ionic, coordinate); atomic & molecular orbitals
- Naming, identity, structure, and properties of common functional groups (alkane, alkene, alkyne, alkyl halide, alcohol, aldehyde, ketone, carboxylic acid, ester, ether, phenyl, *etc*.)
- Molecular orbital description of σ and π bonds
- Definition & origin of bonding, non-bonding & anti-bonding MOs
- Delocalization and aromaticity (phenyl group, conjugated dienes and enones)