

This set of review questions is designed to help you prepare for the *first* midterm exam, which will include the following two basic chemistry topics: (1) **chemical reactions and stoichiometry** (mole relationships, chemical equations and chemical reaction, sequential reactions, limiting reactants, net ionic equations, gravimetric analysis and volumetric analysis) and (2) **thermochemistry** (thermochemical equations, standard enthalpy of formation and Hess's law). These questions are intended to provide you with practice at solving quantitative problems. It is in your best interests to work through **all** these questions independently *before the exam*.

Please note that the first midterm exam may also include questions related to Chapter 1 (Introduction) and Chapter 4 (Industrial Processes).

Complete answers to these review questions are available on the course web page and at the Reserve Desk in the MacLaughlin Library. Remember that photocopying the answers to the questions **in no way** substitutes for working through the questions on your own!

PART A Chemical Reactions and Stoichiometry

- Name the following compounds:
 - $\text{K}_2\text{Cr}_2\text{O}_7$
 - $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
 - Ag_2S
 - N_2O_5
 - $(\text{NH}_4)_2\text{SO}_3$
 - $\text{Fe}(\text{MnO}_4)_2$
 - ClO_2
 - $\text{Ba}(\text{HCO}_3)_2$
- Write chemical formulae corresponding to the following names:
 - potassium hydrogen sulfate
 - lithium oxide
 - magnesium chlorate
 - manganese (II) nitrite
 - aluminum carbonate
 - copper (I) chromate
 - mercury (II) iodide
 - dibromine trioxide
- A cup containing 325 g coffee solution has 301 mg caffeine, $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ (194 g mol^{-1}). Answer the following questions:
 - the number of moles of caffeine present
 - the number of N atoms in the cup from the caffeine
 - the concentration of the caffeine in the cup in ppm (density of coffee = 1 g mL^{-1})
 - the number of moles of H_2O which could be produced on complete combustion of 301 mg caffeine
- Given a solution of $0.108 \text{ M (mol L}^{-1}\text{) FeCl}_3$:
 - What mass (g) of FeCl_3 is present in 1.0 L of solution?
 - How many mmol of Cl^- are present in 242 mL of solution?
 - Give a "recipe" for the preparation of 1.50 L of a solution with $[\text{FeCl}_3] = 2.50 \text{ mmol L}^{-1}$.
 - Give a "recipe" for the preparation of 0.500 L of a solution with $[\text{Cl}^-] = 0.268 \text{ mol L}^{-1}$.
- What is the concentration of Pb^{2+} (in ppm) in a solution formed by diluting 3.5 mL of 2.4 ppm Pb^{2+} solution to 105 mL?
 - Now give your answer to Part (a) in parts per billion (ppb).
- You dissolved 1.234 g CaF_2 in 234 mL pure water. What is the fluoride ion concentration in:
 - mol L^{-1}
 - ppm
- Data on mercury poisoning show that the residence time of mercury in the body is 0.30 years. Calculate the total mass of mercury in all compartments of the body (blood, bone, brain, *etc.*) for a constant intake of mercury in the diet of 6.0 mg per day. Give answer in grams.
- Calculate the number of kmol of Fe^{3+} in $5.0 \times 10^2 \text{ m}^3$ of a solution labelled "1.0 M $\text{Fe}_2(\text{SO}_4)_3$ ".
- A compound referred to by its mnemonic NDMA is thought to be carcinogenic, and has been detected in trace amounts in some water supplies in a nearby community. Analysis shows that the compound has C 32.43%, H 8.163%, N 37.81% and O 21.60%. The approximate molar mass for NDMA is 2.2×10^2 . Determine:
 - the simplest molecular formula
 - the true molecular formula
 - the precise molar mass for NDMA
- Balance the following chemical equations:
 - $\text{Mg}_3\text{N}_2(\text{s}) + \text{H}_2\text{O}(\text{R}) \div \text{Mg}(\text{OH})_2(\text{s}) + \text{NH}_3(\text{g})$
 - $\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \div \text{N}_2(\text{g}) + \text{H}_2\text{O}(\text{R})$
 - $\text{Cu}(\text{s}) + \text{HNO}_3(\text{aq}) \div 3 \text{ Cu}(\text{NO}_3)_2(\text{aq}) + \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{R})$

11. When aluminum metal is dissolved in perchloric acid, aluminum (III) perchlorate and hydrogen gas are formed. In the balanced equation for this reaction, what are the coefficients of hydrogen gas and perchloric acid, respectively?
12. Write the balanced equation for the combustion of liquid ethanol (C₂H₆O) and calculate how many grams of water vapour are produced on complete combustion of 9.37 g ethanol with excess oxygen gas.
13. In the reaction:

$$\text{Cr}_2\text{O}_3(\text{s}) + 3 \text{C}(\text{s}) \div 2 \text{Cr}(\text{s}) + 3 \text{CO}(\text{g})$$
 it was found that when 300 g of Cr₂O₃(s) were reacted with excess carbon, only 191 g of Cr(s) were obtained. What is the percent yield of Cr(s)?
14. Copper metal can be obtained from Cu₂O(s) by the reaction:

$$\text{Cu}_2\text{O}(\text{s}) + \text{H}_2(\text{g}) \div 2 \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{l})$$
 What mass (in t) of Cu(s) can be prepared from 1.00 Mg (megagrams) of an ore that contains 76.0% Cu₂O(s)?
15. In the following unbalanced reaction sequence

$$\begin{aligned} \text{N}_2(\text{g}) + \text{H}_2(\text{g}) &\div \text{NH}_3(\text{g}) \\ \text{NH}_3(\text{g}) + \text{O}_2(\text{g}) &\div \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{l}) \\ \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) &\div \text{HNO}_3(\text{aq}) \end{aligned}$$
 Determine the theoretical yield of HNO₃(aq), in moles, beginning with 2.4 mol of H₂(g).
16. Potassium perchlorate, KClO₄, can be prepared by the following sequence of reactions:

$$\begin{aligned} \text{Cl}_2(\text{g}) + 2 \text{KOH} &\div \text{KCl} + \text{KClO} + \text{H}_2\text{O} \\ 3 \text{KClO} &\div 2 \text{KCl} + \text{KClO}_3 \\ 4 \text{KClO}_3 &\div 3 \text{KClO}_4 + \text{KCl} \end{aligned}$$
 (a) What mass of Cl₂(g), in kg, is needed to prepare 1.00 kg of KClO₄ by this sequence of reactions?
 (b) Recalculate the answer when the last step is only 75% efficient.
17. 4.21 g of H₂ gas reacts with 26.7 g of O₂(g) to form water. Calculate mass of all substances *left* after the reaction.
18. Write the net ionic equations for the following equations (check first if they are balanced!).
 (a) AgNO₃(aq) + Na₂S(aq) ÷ Ag₂S(s) + NaNO₃(aq)
 (b) Ba(ClO₄)₂(aq) + (NH₄)₂SO₄(aq) ÷ NH₄ClO₄(aq) + BaSO₄(s)
 (c) Al₂(SO₃)₃(s) + HNO₃(aq) ÷ Al(NO₃)₃(aq) + SO₂(g) + H₂O(l)
 (d) HF(aq) + Na₂CO₃(aq) ÷ NaF(aq) + H₂O(l) + CO₂(g) (Note that HF(aq) is a weak acid.)
19. Calculate the volume (in mL) of 0.1076 M sulfuric acid required to completely neutralize 50.00 mL of an aqueous solution of 0.2532 M potassium hydroxide.
20. What is the molarity of a Ba(OH)₂ solution if a 25.00 mL sample of the solution requires 31.50 mL of a 0.3200 M HCl solution for titration to the endpoint?
21. In a titration, a 0.6120 g sample of a strong acid, HX, requires 20.30 mL of 0.3000 M NaOH(aq) for complete reaction. What is the molar mass and the chemical name of the strong acid?
22. Rust, Fe₂O₃(s), can be removed from porcelain according to the reaction:

$$\text{Fe}_2\text{O}_3(\text{s}) + 6 \text{Na}_2\text{C}_2\text{O}_4(\text{aq}) + 6 \text{HCl}(\text{aq}) \div 2 \text{Na}_3\text{Fe}(\text{C}_2\text{O}_4)_3(\text{aq}) + 6 \text{NaCl}(\text{aq}) + 3 \text{H}_2\text{O}(\text{l})$$
 How many grams of rust can be removed by 500.0 mL of 2.84 M Na₂C₂O₄(aq)?
23. Calculate the maximum mass of lead chloride, PbCl₂, which can be obtained by mixing 50.0 mL of 0.200 M Pb(NO₃)₂ solution with 100.0 mL of 0.126 M NaCl solution. The precipitation reaction is:

$$\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NaCl}(\text{aq}) \div \text{PbCl}_2(\text{s}) + 2 \text{NaNO}_3(\text{aq})$$
24. An impure sample of CaCO₃(s) is dissolved in an excess of 1.08 M HCl solution. Excess HCl is titrated with 1.26 M NaOH solution. The mass of the impure sample was 1.058 g; the volume of HCl solution added was 50.0 mL; the volume of NaOH solution used was 28.3 mL.
 (a) Give net ionic equations for the reaction in each case
 (b) Calculate the percent purity of the CaCO₃ sample
25. The copper in a 2.00 g mineral sample was determined quantitatively by the following reactions:

$$\begin{aligned} 2 \text{Cu}^{2+}(\text{aq}) + 4 \text{I}^{-}(\text{aq}) &\div 2 \text{CuI}(\text{aq}) + \text{I}_2(\text{s}) \\ \text{I}_2(\text{s}) + 2 \text{S}_2\text{O}_3^{2-}(\text{aq}) &\div \text{S}_4\text{O}_6^{2-}(\text{aq}) + 2 \text{I}^{-}(\text{aq}) \end{aligned}$$
 If 31.4 mL of 0.0500 M Na₂S₂O₃ solution was required for the titration, calculate the percent by mass of Cu in the mineral.
26. A hydrate of ferrous sulfate has the formula FeSO₄·xH₂O. To determine a value of x, a student dissolves a 4.2852 g hydrate sample in water, followed by reduction of Fe²⁺ ions to Fe(s) using magnesium turnings. The precipitated Fe(s) is then washed, filtered and dried until a constant mass of 0.8607 g is reached. What is the value of x?
27. A sample of a mixture containing NaCl and BaCl₂·2H₂O weigh 2.4103 g. On heating the sample, all water that was in the BaCl₂·2H₂O was driven off and the residue that remained (BaCl₂ and NaCl) weighed 2.1058 g. From these data,
 (a) calculate the mass of BaCl₂·2H₂O in the original sample
 (b) calculate the % Ba in the original sample

PART B Thermochemistry (I)

- Write the thermochemical equations which would correspond to the following sentences (no need to give the actual ΔH value).
 - Heat of formation of isoamyl alcohol $C_5H_{12}O(l)$
 - Heat of formation of ammonium iodide
 - $\Delta H = !$ [the enthalpy of formation of $CrO_2Cl_2(l)$]
 - $\Delta H = ! 2$ [the enthalpy of formation of mercury (I) bromate, $HgBrO_3(s)$]
 - Heat of combustion of glucose $C_6H_{12}O_6(s)$
 - Heat of combustion of benzoic acid $C_7H_6O_2(s)$
- Which one of the following compounds has $\Delta H_f^\circ = 0$ at 298 K?
 - $I_2(s)$
 - $O_3(g)$
 - $KBr(s)$
 - $H_2O(l)$
 - $NH_3(g)$
- For the decomposition of aluminum oxide,

$$2 Al_2O_3(s) \div 4 Al(s) + 3 O_2(g) \quad \Delta H = +3340 \text{ kJ}$$
 When 960 kJ of heat is absorbed, how many grams of $Al(s)$ is produced?
 - 7.75 g
 - 15.5 g
 - 31.0 g
 - 46.5 g
 - 62.0 g
- Consider the following reaction with the decomposition of sodium azide

$$2 NaN_3(s) \div 2 Na(s) + 3 N_2(g)$$
 The enthalpy change for the reaction at 1 atm is equal to:
 - $2 \Delta H_f^\circ [NaN_3(s)]$
 - $! \Delta H_f^\circ [NaN_3(s)]$
 - $+\Delta H_f^\circ [NaN_3(s)]$
 - $! 2 \Delta H_f^\circ [NaN_3(s)]$
 - $3 \Delta H_f^\circ [N_2(g)] + 2 \Delta H_f^\circ [Na(s)]$
- Given:

$$CH_4(g) + 2 O_2(g) \div CO_2(g) + 2 H_2O(l) \quad \Delta H^\circ = ! 890 \text{ kJ mol}^{-1}$$

$$C_2H_4(g) + 3 O_2(g) \div 2 CO_2(g) + 2 H_2O(l) \quad \Delta H^\circ = ! 1410 \text{ kJ mol}^{-1}$$
 Calculate ΔH° for the reaction:

$$2 CH_4(g) + O_2(g) \div C_2H_4(g) + 2 H_2O(l)$$
- Given the following standard heats of combustion at 25°C:

	<u>ΔH° combustion (kJ mol⁻¹)</u>
C(s, graphite)	! 395.5
H ₂ (g)	! 285.8
CH ₄ (g)	! 890.2

 Calculate the standard molar enthalpy of formation of $CH_4(g)$.

ANSWERS**PART A Chemical Reactions and Stoichiometry**

- potassium dichromate
 - nickel (II) sulfate hexahydrate
 - silver (I) sulfide
 - 1.55×10^{13} moles of caffeine
 - 926 ppm
 - 18 g
 - 78.4 mmol
 - 0.080 ppm
 - 0.66 g
 - $C_2H_6N_2O$
 - dinitrogen pentaoxide
 - ammonium sulfite
 - iron (II) permanganate
 - 3.74×10^{21} N atoms
 - 7.76×10^{13} moles of H_2O produced
 - add 34.7 mL of solution to 1.50 L flask and make up to the mark with water
 - add 414 mL of solution to 0.500 L flask and make up to the mark with water
 - 80 ppb
 - 1.0×10^3 kmol
 - $C_6H_{18}N_6O_3$
 - chlorine dioxide
 - barium bicarbonate
- $KHSO_4$
 - Li_2O
 - $Mg(ClO_3)_2$
 - $Mn(NO_2)_2$
 - $Al_2(CO_3)_3$
 - Cu_2CrO_4
 - HgI_2
 - Br_2O_3
14. 0.675 t
15. 1.6 mol
 16. (a) 2.05 kg
 17. 0.85 g H_2 ; 30.1 g H_2O
18. (a) $2 Ag^+(aq) + S^{2-}(aq) \div Ag_2S(s)$
 - (b) $Ba^{2+}(aq) + SO_4^{2-}(aq) \div BaSO_4(s)$
 - (c) $Al_2(SO_3)_3(s) + 6 H^+(aq) \div 2 Al^{3+}(aq) + 3 SO_2(g) + 3 H_2O(l)$
 - (d) $2 HF(aq) + CO_3^{2-}(aq) \div 2 F^-(aq) + H_2O(l) + CO_2(g)$
19. 58.83 mL
 20. 0.2016 M
 21. 100.5 g mol^{-1} ; $HClO_4$
 22. 37.8 g
 23. 1.75 g
 24. (b) 86.8%
 25. 4.99%
 26. 7.002
 27. (a) 2.064 g
 - (b) 48.15%

PART B Thermochemistry (I)

- a
- c
- d
- $! 370 \text{ kJ mol}^{-1}$
- $! 76.9 \text{ kJ mol}^{-1}$