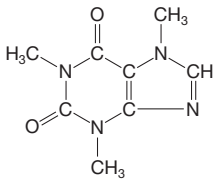
Name: _____

CH101 covers chapters 1–14 of McQuarrie's General Chemistry (4e). Below are some *selected problems* that cover some of the more important topics from CH101 that are necessary pre-requisite skills for CH102.

1. [McQuarrie 1–11] Arrange the following quantities in order of increasing length: (a) 100 nm, (b) 1.0 km, (c) 1.0×10^3 cm, (d) 100 pm, (e) 1.00×10^3 nm, and (f) 1000 m.

2. [McQuarrie 2–31] The caffeine molecule is depicted to the right.
   a. To determine the molecular weight from a structure, first write the condensed formula for the molecule. Make sure that everyone in your group got the same formula.
   b. Calculate the molecular mass of caffeine to five significant figures (lines represent bonds between adjacent atoms).
   c. Calculate the mass percentages of carbon, hydrogen, nitrogen, and oxygen in caffeine.



caffeine

3. [McQuarrie 2–81] 40.0 mg of compound X_4O_{10} contains 22.5 mg of oxygen atoms. What is the atomic mass of atom X?

4. [McQuarrie 3–3] Balance the following chemical equation: $C_6H_{12}O_6(s) + O_2(g) \longrightarrow CO_2(g) + H_2O(l)$

5. [Based on McQuarrie 3–45] Consider the following unbalanced chemical equation of hydrochloric acid with a highly-toxic arsenic compound: $HCl(aq) + 3\ As_2O_3(s) + 4\ NaNO_3(aq) + H_2O(l) \longrightarrow NO(g) + H_3AsO_4(aq) + NaCl(aq)$
   a. What is the name of As_2O_3?
   b. Balance the equation. Hint: leave the "3" and "4" prefixes in the equation.
   c. Could the sodium nitrate ($NaNO_3$) be replaced with potassium nitrate, KNO_3? Explain your reasoning.

6. [Based on McQuarrie 4–15] A He-Ne laser produces light of wavelength 633 nm. Let's say that some atom is able to absorb the light given off by this He-Ne laser.
   a. What is the frequency of this light (in Hz)?
   b. How much energy (in J) is absorbed by the atom if it absorbs the light with wavelength 633 nm? What is this amount of energy called?

7. [McQuarrie 4–7] Boron has the following five successive ionization energies (all in aJ): 1.33, 4.04, 6.08, 41.5, 54.5.
   a. Convert 1.33 aJ to the following energy units: (i) J, and (ii) kW·hr
   b. Plot the logarithm of the ionization energies versus the number of electrons removed. Make sure to label the axes
   c. Based on your graph, how many valence electrons does a boron atom have? How many core electrons?

8. [McQuarrie 6–37] Without referring to any tables or figures, predict which of the following pairs has the larger relative size: a. Li and Li^+; b. Cu^+ and Cu^{2+}; c. Cl and Cl^-; d. O^{2-} and O^{2+}

9. [McQuarrie 5–49] Without using any references except the periodic table, arrange the following sets of atoms in order of increasing atomic radius:
   a. Kr, He, Ar, Ne b. K, Na, Rb, Li c. Be, Ne, F, N

10. [McQuarrie 7–7] Write the Lewis formula for the molecules:
    (a) acetylene, C_2H_2 (b) diazine, N_2H_2 (c) fluorine cyanide, FCN (d) $COCl_2$

11. [McQuarrie 7–61] Write the Lewis formula for oxalate ion, $C_2O_4^{2-}$. Give resonance forms and indicate formal charges.

12. [Based on McQuarrie 8–59] Consider the following oxychlorine ions: ClO_2^-, ClO_3^-, and ClO_4^-.
    (a) Draw the Lewis structure and all of the important resonance forms for each ion.
    (b) Use VSEPR theory to predict the shape of the ions. What are the O-Cl-O bond angles in these ions?
    (c) Rank the molecules in order of shortest to longest Cl–O bonds.
    (d) Which, if any, of these molecules are polar?

13. [McQuarrie 8–39] Predict which of the following molecules are polar: CF_4, AsF_3, CH_2Cl_2, IOF_5.

14. Naming.
    a. [McQuarrie 10–5] Write the systematic name for: $Hg_2Cl_2(s)$, $Cr(NO_3)_3(s)$, and $CoBr_2(s)$
    b. [McQuarrie 10–11,13] Write the formula for: copper(II) acetate, cobalt(III) sulfite, and potassium dichromate.
    c. [McQuarrie 10–29] Name the following hydrates: $ZnSO_4 \cdot H_2O(s)$, $BaCl_2 \cdot 2H_2O(s)$, and $Na_2S \cdot 9H_2O(s)$

15. [McQuarrie 10–61] Indicate which element is oxidized and which is reduced in the reactions described by the following chemical equations. In each, also indicate which species is the oxidizing agent.
    (a) $Ca(s) + Cl_2(g) \longrightarrow CaCl_2(s)$; (b) $4\ Al(s) + 3\ O_2(g) \longrightarrow 2\ Al_2O_3(s)$; and (c) $2\ Rb(s) + Br_2(l) \rightarrow 2\ RbBr(s)$

16. [McQuarrie 10–43] As we discussed in lecture, equations like the following ones **<u>are not correct</u>** because notation like "$Fe(NO_3)_3(aq)$" is misleading at best (and outright wrong at worst). For each of the following incorrectly-formatted equations, write the appropriate <u>net-ionic equation</u>.
    (a) $Fe(NO_3)_3(aq) + NaOH(aq) \longrightarrow Fe(OH)_3(s) + NaNO_3(aq)$
    (b) $Zn(ClO_4)_2(aq) + K_2S(aq) \longrightarrow ZnS(s) + KClO_4(aq)$
    (c) $Pb(NO_3)_2(aq) + KOH(aq) \longrightarrow Pb(OH)_2(s) + KNO_3(aq)$
    (d) $Zn(NO_3)_2(aq) + Na_2CO_3(aq) \longrightarrow ZnCO_3(s) + NaNO_3(aq)$

17. Consider the following quantities: 0.500 mol Cl_2, 4.00 N_A (Avogadro's number) molecules of H_2, the amount of calcium containing 4.0×10^{24} electrons, and 7.0×10^{14} u of Ba.
    a. How many moles of Cl_2, H_2, Ca, and Ba are there?.
    b. Which has the most moles? Which is the smallest number of moles?
    c. Arrange the four samples in this problem in order of increasing <u>mass</u>.

18. Hydrogen fluoride is a gas at room temperature, $HF(g)$. When 0.80 moles of HF are dissolved in 2.0 L, the resulting solution contains 1.70×10^{-2} moles of fluoride ion.
    a. Is HF a molecular compound or an ionic compound? Write the balanced chemical equation for the production of fluoride from HF.
    b. What are the units "M"? What is the concentration (in M) of fluoride ions in the solution?
    c. Is HF a strong electrolyte, weak electrolyte, or a non-electrolyte? Explain your answer.

19. A stock solution of aqueous calcium chloride has a concentration of 2.8 M.
    a. How much of the stock solution do you need to add to make a 300. mL solution with a concentration of 0.20 M?
    b. The 300. mL of 0.20 M solution of calcium chloride is mixed with 400. mL of a 0.20 M aqueous solution of sodium sulfate and a precipitate forms. What is the mass of the precipitate? What are the concentrations in (M) of all of the species remaining in solution?

20. [McQuarrie 12–50] How many mL of 6.00 M $HNO_3(aq)$ must be added to water to prepare 50.0 milliliters of 0.50 M HNO_3(aq)? How much water must be added?

21. A standard solution is prepared for the analysis of fluoxymesterone ($C_{20}H_{29}FO_3$; $M = 336$ g/mol), an anabolic steroid. A stock solution is prepared by dissolving 16.8 mg of fluoxymesterone in enough water to give a total volume of 500.0 mL. A 1.0 µL aliquot of this stock solution is transferred to a 250-mL volumetric flask and diluted to a final volume of 250.0 mL.
    a. What is the concentration of the diluted solution (in M)?
    b. What is a better unit of concentration (using SI prefixes) for the concentration of the diluted solution?

22. [McQuarrie 12–5] How many moles of solute are in 50 µL of a 0.020 M $C_6H_{12}O_6(aq)$ solution? How many molecules?

23. [Based on McQuarrie 12–35] A mixture contains unknown amounts of $NaOH(s)$ and $NaCl(s)$ and weighs 0.365g. It was found that the sample requires 31.7 mL of 0.150 M $HCl(aq)$ to react with all the $NaOH(s)$.
    a. How many moles of NaOH are present in the mixture? How do you know? How many moles of NaCl?
    b. What is the mass percentage of the $NaOH(s)$ in the mixture?

24. The atmospheric pressure at the surface of Venus is 75 atm. Convert 75 atm to torr, bars, and kPa.

25. Air bags are activated when a severe impact causes a steel ball to compress a spring and electrically ignite a detonator cap. This action causes sodium azide (NaN_3) to decompose: $NaN_3(s) \longrightarrow Na(s) + N_2(g)$
    a. Notice: this equation is not balanced! Always assume equations are not balanced. Write the balanced equation.
    b. What mass of sodium azide (in g) must be reacted to inflate an air bag to 100. L at 27 °C and 1.00 atm?

26. During a chemical reaction 75 J of energy is transferred to the surroundings, initially at 22.3 °C, as heat. The final temperature of the surroundings was recorded as 37.1 °C.
    a. What is the heat capacity (in J/K) of the surroundings?
    b. If the surroundings being discussed here is actually a sample of liquid ethanol, with $c_{sp} = 2.57$ J g^{-1}K^{-1}, what is the mass of the ethanol?
    c. What is the molar heat capacity of ethanol, C_p, in J mol^{-1}K^{-1}?

27. [McQuarrie 13–74] A website claims that it requires 10,000 gallons of air to burn one gallon of gasoline. Using octane, $C_8H_{18}(l)$, as the chemical formula of gasoline and the fact that air is 21% oxygen by volume, calculate the volume of air at 0 °C and 1.00 bar that is required to burn a gallon of gasoline. Is the information on the website correct? Take the density of octane to be 0.70 g/mL. Note: 1 gallon = 3.79 L.

28. Consider the reaction: $C_3H_8(g) + 3\ O_2(g) \longrightarrow CH_4(g) + 2\ CO_2(g) + 2\ H_2O(l)$, $\Delta H = -1330.$ kJ/mol. Using this information, compute the following:
    a. Heat of reaction at constant pressure (in kJ) when 3.000 moles of propane react with excess O_2 at 25 °C
    b. Heat of reaction at constant pressure (in kJ) when 25 moles of propane reacts with 1.5 moles of oxygen gas.
    c. The enthalpy of reaction, ΔH, for: $2\ CH_4(g) + 4\ CO_2(g) + 4\ H_2O(l) \longrightarrow 2\ C_3H_8(g) + 6\ O_2(g)$
    d. The enthalpy of reaction, ΔH, for: $\frac{1}{2}\ C_3H_8(g) + 3/2\ O_2(g) \longrightarrow \frac{1}{2}\ CH_4(g) + CO_2(g) + H_2O(l)$

29. An atomization reaction breaks a compound apart into its gaseous atoms. Use the following atomization reactions and their enthalpies of atomization to obtain the expression for the enthalpy change of the reaction, $\Delta H°_{rxn}$ for the combustion of one mole of $NH_3(g)$ to yield gaseous water and dinitrogen pentoxide, $N_2O_5(g)$, in terms of ΔH_1, ΔH_2, ΔH_3, and ΔH_4.

$NH_3(g) \longrightarrow N(g) + 3\ H(g)$,	ΔH_1
$H_2O(g) \longrightarrow 2\ H(g) + O(g)$,	ΔH_2
$O_2(g) \longrightarrow 2\ O(g)$	ΔH_3
$N_2O_5(g) \longrightarrow 2\ N(g) + 5\ O(g)$	ΔH_4

30. [McQuarrie 14–57] A 2.50 g sample of powdered zinc is added to 100.0 mL of a 2.0-M solution of hydrochloric acid in a calorimeter with a total heat capacity of 481 J·K^{-1}. The observed increase in temperature is 12.2 K at a constant pressure of one bar. Calculate $\Delta H°_{rxn}$ for the equation, $Zn(s) + 2HCl(aq) \longrightarrow Zn^{2+}(aq) + 2\ Cl^-(aq) + H_2(g)$, which describes the reaction that occurs when the two substances are mixed.

31. Given the information for the following reactions:

$2\ Al(s) + 6\ HCl(aq) \longrightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$	$\Delta H°_1 = -1000.$ kJ/mol
$HCl(g) \longrightarrow HCl(aq)$	$\Delta H°_2 = -80.0$ kJ/mol
$H_2(g) + Cl_2(g) \longrightarrow 2\ HCl(g)$	$\Delta H°_3 = -200.$ kJ/mol
$AlCl_3(s) \longrightarrow AlCl_3(aq)$	$\Delta H°_4 = -305.$ kJ/mol

    a. Calculate $\Delta H°$ for the reaction: $2\ Al(s) + 3\ Cl_2(g) \longrightarrow 2\ AlCl_3(s)$
    b. Calculate the heat at <u>constant volume</u> when 1.35 g of $Al(s)$ reacts with 0.710 g of $Cl_2(g)$ at 1.00 bar and 298.15 K.

32. [McQuarrie 14–75] One proposal for an "effortless" method of losing weight is to drink large amounts of cold water. The body must provide energy in the form of heat in order to bring the temperature of the cold water to body temperature, 37°C. This is provided by the burning of stored carbohydrates or fat.
    a. How much energy in the form of heat must the body provide to warm 1.0 liter of cold water at 4°C (a typical refrigerator temperature) to 37°C?
    b. Calculate how many grams of body fat must be burned to provide this energy. Assume that the burning of fat produces about 39 kilojoules per gram of fat.
    c. How many liters of 4°C water must be consumed to lose 1.0 kilogram (2.2 lbs) of body fat?