Unit II Homework Set
General Chemistry I

1. (***Spring 2015***) On the last exam, we considered potential applications of nanoparticles based on calcium carbonate, $CaCO_3(s)$. In Chapter 4 we saw that dissolving carbon dioxide in water forms carbonic acid, $H_2CO_3(aq)$, a weak acid. We demonstrated in class that a solution of sodium hydroxide reacts with the carbonic acid formed by adding "dry" ice, $CO_2(s)$, to the solution, and we followed the reaction using a "universal" indicator.

$$H_2CO_3(aq) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + 2H_2O(\ell)$$

Cancer cells are more acidic than noncancerous tissue. Because carbonate is the anion of a weak acid, carbonate compounds are basic, and because nanoparticles tend to accumulate in cancer cells, it is hoped that nanoparticles based on calcium carbonate might be used to treat cancer.

One way to determine the amount of calcium carbonate in a sample is to react it with a strong acid, such as... well... $HBr(aq)$, which we considered in Question 1.

$$2HBr(aq) + CaCO_3(s) \rightarrow H_2CO_3(aq) + CaBr_2(aq)$$

A sample of $CaCO_3$ nanoparticles was reacted with HBr(aq) according to the chemical equation shown above. It took 267 mL of 0.114 M HBr(aq) to react with all of the calcium carbonate. How many grams of $CaCO_3$ were contained in the sample? (The molar mass of $CaCO_3$ is 100.09 g/mol.)

As long as we're talking about acid-base chemistry, please name the following acids:

$HBr(aq)$ $HBrO_3(aq)$ $HBrO(aq)$

2. (***Fall 2008***) In class we talked about ways to determine the amount of iron in the solid mass formed when we carried out the thermite reaction. We speculated that the mass could be reacted in a strong acid to get the iron into solution as Fe^{2+}(aq), and that the remaining solid could be isolated, dried, and weighted to determine by difference the amount of iron in the mass.

~~Write a balanced chemical equation for the reaction of iron metal with HNO_3(aq).~~ (*redox reaction)

A redox titration provides a more elegant way to determine the amount of iron in the solution. An aqueous solution of potassium permanganate reacts with $Fe(NO_3)_2$ according to the following chemical equation:

$$KMnO_4(aq) + 8HNO_3(aq) + 5Fe(NO_3)_2(aq) \rightarrow Mn(NO_3)_2(aq) + 5Fe(NO_3)_3(aq) + KNO_3(aq) + 4H_2O(l)$$

A solution of $Fe(NO_3)_2$(aq) was formed by reacting the product from a thermite reaction in HNO_3(aq). That solution was titrated with a 0.537 M solution of $KMnO_4$(aq) according to the above equation, and it took 121 mL to convert all of the Fe^{2+} to Fe^{3+}.

How many moles of Fe^{2+} were contained in the original solution?

So, based on your above answer, how many grams of iron were formed in the thermite reaction?

3. (***Fall 2007***) We carried out the following reaction in class:

$$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

If 73.5 mL of 0.200 M KI(aq) was required to precipitate all of the lead(II) ion from an aqueous solution, how many moles of Pb^{2+} were originally in the solution?

We worked #4 in class, so the solutions are included here.

4. (***Fall 2011***) The balanced chemical equation for the reaction between ethanol, CH_3CH_2OH, and potassium dichromate is given below.

$$3CH_3CH_2OH(aq) + 2K_2Cr_2O_7(aq) + 8H_2SO_4(aq) \rightarrow 3CH_3COOH(aq) + 2Cr_2(SO_4)_3(aq) + 2K_2SO_4(aq) + 11H_2O(l)$$

It would be very difficult to predict the products of this redox reaction, but if we know the products and balance the chemical equation, then we can use the reaction to determine the amount of ethanol. (Indeed, this is the reaction is used in breathalyzers to measure alcohol content.)

A. It took 4.23 mL of 0.0764 *M* $K_2Cr_2O_7(aq)$ to titrate a blood sample. How moles CH_3CH_2OH were contained in the sample. If the volume of the sample is 10.0 mL, what was the concentration of ethanol in molarity (mol/L)?

$$4.23\text{ mL} \times \left(\frac{1\text{ L}}{1000\text{ mL}}\right) \times \left(\frac{0.0764\text{ mol } K_2Cr_2O_7}{1\text{ L}}\right) \times \left(\frac{3\text{ mol } CH_3CH_2OH}{2\text{ mol } K_2Cr_2O_7}\right) = 4.84_8 \times 10^{-4}\text{ mol } CH_3CH_2OH$$

$$\left(\frac{4.84_8 \times 10^{-4}\text{ mol } CH_3CH_2OH}{10.0\text{ mL} \times \left(1\text{ L}/1000\text{ mL}\right)}\right) = \left(\frac{0.0485\text{ mol } CH_3CH_2OH}{1\text{ L}}\right) = 0.0485\text{ M } CH_3CH_2OH$$

B. Blood alcohol content (BAC) is grams of ethanol per 100 mL of blood, which corresponds to percent by mass. Convert your answer to Part A to BAC.

Given that....

$$100\text{ mL blood} \times \left(\frac{1\text{ L}}{1000\text{ mL}}\right) \times \left(\frac{0.0485\text{ mol } CH_3CH_2OH}{\text{L}}\right) \times \left(\frac{46.07\text{ g } CH_3CH_2OH}{\text{mol } CH_3CH_2OH}\right) = 0.223\text{ g ethanol}$$

So the BAC is 0.233, corresponding to 0.233 g ethanol/100 mL of blood.

5. (***Summer 2010***) A solid powder consisting of a mixture of $Pb(NO_3)_2(s)$ and $NaNO_3(s)$ was discovered in a warehouse. Authorities wish to evaluate the level of risk due to lead exposure, so a small amount of the solid was collected and submitted to the Department of Environmental Protection (DEP). A technician dissolved 0.629 g of the solid in water, and slowly added a 0.103 M solution of $NaCl(aq)$, precipitating $PbCl_2(s)$ according to the reaction

$$Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$$

The solid precipitate was collected and dried, yielding 0.1676 g of $PbCl_2(s)$. The molar mass of $PbCl_2$ is 278.106 g/mol.

A. What was the minimum volume (in mL) of 0.103 M $NaCl(aq)$ was required to precipitate all of the lead in the solution as $PbCl_2(s)$?

B. What was the mass of $Pb(NO_3)_2(s)$ present in the 0.629 g sample of solid tested by this procedure?

C. What is the mass percent $Pb(NO_3)_2(s)$ in the sample?

D. Could we have used addition of $NaCl(aq)$ to test for $Hg(NO_3)_2(s)$ as described above? Explain briefly, i.e. resist the urge to fill the remaining space with your answer.

6. (***Spring 2015***)Write balanced "molecular" equations (ME) and net ionic equations (NIE) for the following reactions, all of which involve HBr(*aq*).

   A. HBr(*aq*) + Sn(*s*) →

   B. HBr(*aq*) + $Pb(NO_3)_2$(*aq*) →

   C. HBr(*aq*) + $KC_2H_3O_2$(*aq*) →

7. (***Fall 2012***) Write balanced molecular equations (ME) and net ionic equations (NIE) for the following reactions. *Be sure to include the correct states in your final equations and charges for ions in the NIE.* If you have written several equations, draw a box around the one you want to be graded. Write MEs for all reactions, but if no reaction actually occurs (i.e. everything cancels in the NIE), then write "no reaction" for the NIE.

   A. HCl(*aq*) + $NaNO_2$(*aq*) →

   B. HCl(*aq*) + Al(*s*) →

   C. HCl(*aq*) + $Pb(NO_3)_2$(*aq*) →

   D. The following chemical equations are balanced, but they do not correspond to actual chemical equations. Explain why no reaction occurs if the reactants are combined.

      1. HBr(*aq*) + KNO_3(*aq*) → HNO_3(*aq*) + KBr(*aq*)

      2. HBr(*aq*) + Ag(*s*) → AgBr(*s*) + $^1/_2H_2$(*g*)

8. (***Fall 2015***) Write balanced molecular equations (ME) and net ionic equations (NIE) for the following reactions. *Be sure to include the correct states in your final equations and charges for ions in the NIE.*

   A. $CuCl_2$(*aq*) + Pb(*s*) →

   B. K_2SO_4(*aq*) + $CaCl_2$(*aq*) →

   C. KF(*aq*) + HI(*aq*) →

9. (***Spring 2015***) A reaction between sulfur and fluorine produced a gas that was believed to have the formula SF_n, where n is an integer. The gas was collected, dried to remove water vapor, and weighted, giving a mass of 0.661 g. The gas occupied a volume of 150.3 mL at 23.1 °C and 751 mmHg.

   A. Determine the molar mass of the gas.

   B. What is the formula of the gas? In other words, what is the value of n?

   C. Why did we have to dry the gas? (Be specific – don't just say that water vapor is an impurity, so it had to be removed. How does the presence of water vapor affect the experiment?)

10. (***Spring 2015***) Appendicitis is caused by inflammation of the appendix, an organ of no apparent value (at least not to modern humans) that we can live without just fine. An appendectomy, the procedure in which the appendix is removed, can be done by conventional surgery, but the more common practice today involves laparoscopic surgery. The incision is smaller, so the recovery time is faster; however, the procedure requires using a scope, and limited visibility is an issue. But we know how to solve that problem.

    In order to increase the work space and visibility, the abdominal cavity is inflated with a gas. The gases most commonly used for this procedure are CO_2(*g*) and N_2O(*g*). The pressures used range from around 10 to 25 mmHg gauge pressure; in other words, that is the pressure above atmospheric pressure. The World Laparoscopy Hospital website gives these values as typical:

    > *Normal size human abdominal cavity needs 1.5 L CO_2 to achieve intra-abdominal actual pressure of 12 mmHg [above atmospheric pressure].*

A. Assuming a temperature of 37°C (normal body temperature) and an atmospheric pressure of 760 mmHg, how many moles of CO_2 would be required for one laparoscopic appendectomy?

Suppose N_2O gas was used instead of CO_2. Would the number of moles required for the procedure increase, decrease, or remain the same? Explain your reasoning.

B. The gases used in this procedure have advantages and disadvantages relative to each other. For example, N_2O gas has a mild analgesic effect. On the other hand...

> *During prolonged laparoscopic procedure N_2O should not be a preferred gas for pneumoperitoneum because it supports combustion better than air.*

Consider this reaction with methane.

$$4N_2O(g) + CH_4(g) \longrightarrow 4N_2(g) + 2H_2O(g) + CO_2(g) \qquad \Delta H = -1131\ \text{kJ/mol}$$

1. How much heat would be released by reacting 25 g CH_4 with an excess of N_2O?
2. ~~Assign oxidation numbers for all of the atoms in this reaction. Write the oxidation numbers in parentheses above the formula.~~

~~$4N_2O(g) + CH_4(g) \longrightarrow 4N_2(g) + 2H_2O(g) + CO_2(g)$~~

~~Which element is oxidized? ______ Which is reduced?~~

(*redox rxn, we'll cover these after dot structures)

11. (***Fall 2015***) We never got a chance to consider the "deflategate" controversy using the ideal gas law, so I thought we might do it here.

Tom Brady and the New England Patriots were accused of deflating footballs used in their AFC championship game against the Indianapolis Colts on January 18, 2015. The NFL requires footballs to be inflated to a pressure between 12.5 and 13.5 "psi." During halftime it was discovered that some of the footballs used by the Patriots were 2 psi below the minimum allowed pressure. Patriots supporters claimed that the drop in pressure was due to the difference in temperature between the locker room and the playing field.

A. Let's assume that the footballs were filled to 12.5 psi before game and checked with a pressure gauge. That's "gauge pressure" (psi-g) – the actual pressure (sometimes called "absolute" pressure) inside the ball would be 27.2 psi.

What's the difference between gauge pressure and absolute pressure? In other words, explain why the numbers are different.

B. According to reports, the temperature in the locker room before the game was 74°F (23°C) and the temperature on the field at halftime was 48°F (9°C). Assuming a pressure of 27.2 psi at 23°C, what would the pressure be after the temperature dropped to 9°C?

What is another assumption you make in the above calculation?

C. Would a temperature drop from 23°C to 9°C account for the footballs being 2 psi below the minimum allowed pressure?

Explain your reasoning.

12. (***Fall 2015***) Looks like we might finally be getting some fall weather, with cooler and less humid days. Which is heavier, humid air or dry air? Briefly explain your reasoning.

13. (***Fall 2015***) We looked at the decomposition of hydrogen peroxide in class. The reaction is slow, but if you add a catalyst, it proceeds rather quickly.

$$2H_2O_2(aq) \longrightarrow 2H_2O(\ell) + O_2(g)$$

A. If a catalyst is added to 154 mL of 0.882 *M* $H_2O_2(aq)$, how many moles of $O_2(g)$ are produced, assuming the reaction goes to completion?

B. The oxygen gas from the above procedure was collected and dried to remove water vapor. The volume of $O_2(g)$ was 726 mL at 23.9°C and 735 mmHg. Determine the amount (moles) of O_2 gas collected.

C. What was the percent yield for the reaction?

D. Why was it necessary to remove the water vapor?

14. (***Fall 2012***) You may have heard that a few days ago Felix Baumgartner jumped from a balloon roughly 24 miles above Earth, breaking the record for the highest skydive. He reached speeds of more than 700 miles per hour and became the first skydiver to exceed the speed of sound during free fall. You will not be surprised to hear that this project was funded by Red Bull, but the underlying science is solid, and it is hoped that the work designing the suit worn by Baumgartner will lead to safer space suits for astronauts who must escape during a launch failure.

The helium-filled plastic balloon used to carry Baumgartner to the edge of space also required an impressive bit of science and engineering. The thickness of the plastic is about one-tenth that of a Ziploc bag (more like a dry cleaner bag), yet it had to be strong enough to sustain very cold temperatures. The balloon was designed to expand to 3.0×10^7 cubic feet (8.5×10^8 L) to accommodate the extreme temperatures and pressures (–67.8°C and 0.027 mmHg, respectively) at the altitude required to break the record.

A. Determine the volume of the helium in the balloon just before it was released, assuming a pressure of 1.0 atm and a temperature of 23°C.

B. Using the conditions at the time of the jump (8.5×10^8 L, –67.8°C, 0.027 mmHg), calculate the mass of helium in the balloon.

C. If a pinhole was formed in the suit, which gas would escape faster, nitrogen or oxygen?

Explain your reasoning. To receive full credit, your explanation should include the underlying scientific principle as well as the property of the two gases that allowed you to answer the question.

15. (***Fall 2012***) The following reaction goes to completion in water:

$$2HCl(aq) + K_2S(aq) \rightarrow H_2S + 2KCl$$

A. Is this reaction a precipitation reaction, an acid-base reaction, or a redox reaction?

B. A solution was prepared by dissolving 0.716 g of K_2S in 50 mL of water. It required 45.9 mL of $HCl(aq)$ to react completely with the K_2S in solution. What is the concentration of the HCl solution in mol/L?

C. It was observed during the course of the reaction that a gas was evolving from the solution. An inverted tube filled with water was placed in the solution and a 4.11 mL sample of the gas was collected at 22.5 °C and 128 mmHg. Set up the calculation that would give you the moles of gas collected. You do not have to carry out the calculation, but be sure to show the set up clearly.

D. What else do you need to know to determine the molar mass of the gas?

E. It is reasonable to expect that the gas formed was $H_2S(g)$, but when you calculated the molar mass of the gas it was less than the molar mass of H_2S.

Why? A complete answer will explain why the calculated molar mass of the gas was different than the molar mass of H_2S, and also why the molar mass was <u>less</u> than the molar mass of H_2S.

16. (Summer 2010) Several years ago an undergraduate working in my lab needed acetylene gas, HCCH(g), for an experiment. Normally acetylene is purchased in a tank like other gases, but in the published experiment he was trying to repeat, the researchers generated acetylene by adding calcium carbide to a large volume of water and collecting the acetylene gas, according to this reaction

$$CaC_2(s) + H_2O(l) \rightarrow HCCH(g) + CaO(s)$$

Additional information for this problem is given in the info sheet passed out with this exam.

~~A. Is this a redox reaction? Explain your reasoning.~~ (*redox rxn, we'll cover these after dot structures)

B. If 0.035 moles of HCCH(g) is needed for the experiment, how many grams of CaC_2 would be required?

C. Let's assume you worked part B correctly and added that amount of CaC_2(s) to water as described above, producing 718 mL of gas at 20.0°C and 751 mm Hg. How many moles of HCCH(g) did you actually collect. Think about how you collected the gas as you consider your approach to solving this problem.

D. What was your percent yield in this reaction?

E. If the temperature of the gas collected increased, but the pressure remained the same, (circle one)

1. the volume of gas would	increase	remain the same	decrease
2. the density of the gas would	increase	remain the same	decrease
3. the speed of the gas molecules would	increase	remain the same	decrease
4. the average kinetic energy of the gas molecules would	increase	remain the same	decrease

17. (***Fall 2007***) In class we used a simple apparatus consisting of a series of light bulbs of increasing wattage to measure solution conductivity. The more light bulbs that light up, the greater the conductivity of the solution.

A. If we use this apparatus to test a 0.1 M solution of sulfuric acid, H_2SO_4(aq), all of the bulbs light up, but if we test a 0.1 M solution of sulfurous acid, H_2SO_3(aq), only a few bulbs light up. Explain this difference in behavior between the two solutions. Do not just say how the solutions are different – explain why this difference is reflected in the numbers of lit bulbs for the two solutions.

B. Write a balanced chemical equation for the reaction that would occur between the following solutions. As on the first page, be sure to include the correct states.

$$H_2SO_4(aq) + \quad Ba(OH)_2(aq) \rightarrow$$

Notice I did not specify whether I wanted the "molecular" equation or the net ionic equation. Why is that not necessary in this reaction?

C. If you start adding 0.1 M $Ba(OH)_2$(aq) to 50mL of 0.1 M H_2SO_4(aq), an interesting thing happens: the number of bulbs that are lit starts to <u>decrease</u> until only one bulb is lit. If you keep adding $Ba(OH)_2$(aq), the number of lit bulbs begins to increase until once again all of the bulbs are lit.

Why does the number of lit bulbs decrease as $Ba(OH)_2$(aq) is added?

Is this consistent with your chemical equation in part B above? (It should be.) Explain.

D. At the point where the number of lit bulbs decreased to one, just before the number of light bulbs began to increase, what was the total volume of 0.1 M $Ba(OH)_2$(aq) that had been added? Explain your reasoning. (You can explain in words or do a calculation.)

18. (***Fall 2007***) Commonly used gases in the laboratory are generally obtained from pressurized metal gas cylinders, but for small amounts of occasionally used gases, it is sometimes easier just to prepare them chemically as needed. For example, nitrogen monoxide, NO(g), can be prepared in the lab by the following chemical reaction:

$$3Cu(s) + 8HNO_3(aq) \rightarrow 2NO(g) + 3Cu(NO_3)_2(aq) + 4H_2O(l)$$

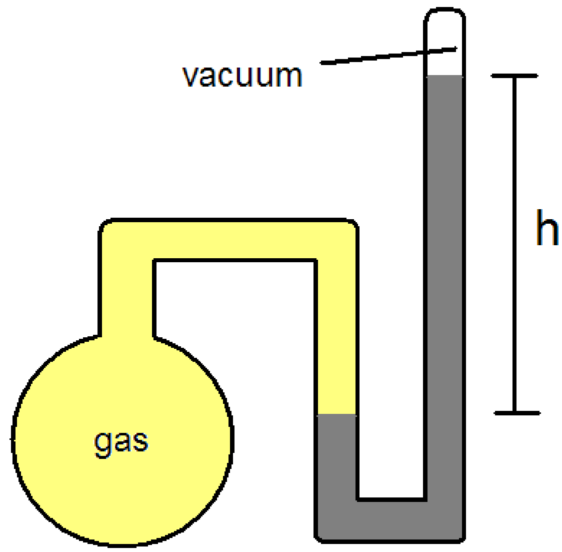
A. One recipe calls for adding 0.50 L of 5.0 M $HNO_3(aq)$ to 25 g of copper metal.

1. How many moles of copper were initially present?
2. How many moles of HNO_3 were added?
3. What is the limiting reagent?
4. How many moles of NO(g) could theoretically be produced in this manner?

B. When an earnest young CHM 1051L student followed this recipe, 5.8 L of gas was collected at a pressure of 746 torr and a temperature of 23.7°C. Assuming all of the gas collected is nitrogen monoxide, how many moles of gas were actually collected?

19. (***Fall 2007***) A certain amount of gas is contained in a closed mercury manometer as shown below. What is the pressure of the gas in torr if h = 12.7 cm?

Assume the right hand tube is as long as you need it to be and no other parameters changed, would h increase, decrease, or remain the same if



A. the moles of gas were doubled?
B. the moles of gas were kept the same, but the molecular weight of the gas was doubled?
C. the temperature was doubled?
D. the atmospheric pressure in the lab was doubled?
E. the mercury in the tube was replaced with water?
F. some gas was added to the vacuum at the top of the tube on the right?
G. the top of the tube on the right was broken off?

20. (***Fall 2008***) According to Wikipedia, "barium hydroxide is used in analytical chemistry for the titration of weak acids, particularly organic acids." Assuming Stephen Colbert has not undermined the integrity of this entry, we decided to use a barium hydroxide solution as the source of hydroxide to titrate a weak organic acid. Barium hydroxide is obtained as the octahydrate, $Ba(OH)_2{\cdot}8H_2O$. What mass of $Ba(OH)_2{\cdot}8H_2O$ would be required to make 500.0 mL of a solution that is 0.1500 M in hydroxide ion?

21. (***Fall 2009***) We normally consider "salty" and "sweet" to be totally different tastes associated with different receptors on the tongue, but studies carried out with "trained testers" suggest that at low concentrations (≤ 0.01 M) table salt (sodium chloride, NaCl) actually tastes sweet. Reference: *Food Qual. Pref.* **2004**, 15, 83.

A. How many grams of NaCl would you need to prepare 75 mL of a 0.25 M NaCl(aq) stock solution?

~~B. How much of the stock solution would you need to prepare 5 mL of 0.010 M NaCl(aq) need for the taste test?~~

No dilution problems on our exam.

22. (***Fall 2009***) A new route to nanocrystalline metal nitrides involves reacting metal chlorides with sodium azide to form the metal azide and sodium chloride, followed by decomposition of the metal azide to give the metal nitride and nitrogen (*Inorg. Chem.* **2009**, *48*, 4470–4477). These reactions are shown below for the synthesis of manganese(II) nitride.

$$MnCl_2(s) + 2\,NaN_3(s) \rightarrow Mn(N_3)_2(s) + 2\,NaCl(s) \qquad (1)$$

$$Mn(N_3)_2(s) \rightarrow MnN(s) + {}^5/_2\,N_2(g) \qquad (2)$$

Note that reaction 1 is a solid state reaction, so ideally the reaction would be carried out with the stoichiometrically correct amount of reactants (i.e. no limiting and excess reagents), giving the desired product in high yield with relatively little unreacted starting material as a contaminant.

A typical reaction used 3.00 g of $MnCl_2$ in this study.

A. How many grams of NaN_3 would be required to give the correct stoichiometry based on reaction 1? (Molar masses are given in the handout.)

B. How many grams of $Mn(N_3)_2$ would be produced, assuming complete conversion of reactants to products.

C. In one early experiment using 3.00 g of $MnCl_2$, only 2.3 g of $Mn(N_3)_2$ was obtained. Determine the percent yield for this experiment.

D. Even if the procedure was optimized to give 100% yield of $Mn(N_3)_2$, the desired compound may not be obtained as a pure compound. Explain and be specific with respect to this reaction.

~~E. In reaction 2 is manganese oxidized or reduced? If so, which. Explain your reasoning.~~ (*redox reaction)

23. (***Fall 2009***) Tripelennamine was developed and used as an antipruritic (anti-itch) and antihistamine, but it is also a psychoactive drug and it has been largely replaced by newer antihistamines. Tripelennamine was initially synthesized by the legendary chemist Carl Djerassi, who is also a novelist and playwright (now you can feel good about the liberal studies credit you are getting for this course), but he is probably best known for his work on the first oral contraceptive ("the pill"). Djerassi received his first patent for tripelennamine shortly after getting his B.S. degree.

    Djerassi would have certainly submitted a purified sample of his new compound for elemental analysis. Determine the empirical formula for tripelennamine given the results: 75.26% C; 8.29% H; 16.46% N.

    Can you also determine the molecular formula from the above information? If so, determine the molecular formula. If not, explain why you cannot determine the molecular formula from the information provided.

24. (***Fall 2005***) A convenient way to produce very high purity oxygen in the laboratory is to decompose $KMnO_4(s)$ at high temperature according to the following equation

$$2KMnO_4(s) \rightarrow K_2MnO_4(s) + MnO_2(s) + O_2(g)$$

If 2.50 L of $O_2(g)$ is needed at 1 atm and 20°C, what mass of $KMnO_4(s)$ should be decomposed? You can assume the decomposition of $KMnO_4(s)$ goes to completion.

The oxygen gas was originally formed at "high temperature" before it cooled to 20°C. Will the volume of the gas increase or decrease during the cooling process if kept a constant pressure? Explain your reasoning with either words or equations.

25. (***Fall 2009***) It has been estimated that three trillion cubic feet (3×10^{12} ft^3) of methane, $CH_4(g)$, is released into the atmosphere every year (*The New York Times*, October 14, 2009). Not only would capturing that methane provide an additional source of energy, but it would also stop the leaking of a very potent greenhouse gas into the atmosphere (methane is 25 times more effective at trapping heat than an equal mass of carbon dioxide).

A. How many moles of methane are released into the atmosphere each year?

Methane as natural gas is generally measured in standard cubic feet at 60 °F and 14.73 psia. To answer the above question you will need to convert some or all of the above units. I will take one step in that direction for you: 60 °F = 16 °C. The other information you need is given in the information handout; e.g. 1 ft^3 = 28.32 L.

B. If the methane released into the atmosphere was measured at 25°C, would the volume be less than, equal to, or greater than the volume at 16°C?

____

Would the moles of methane released be less than, equal to, or greater than the moles of methane calculated in part A?

____

C. Given that the heat of combustion of methane is 890 kJ/mol, calculate the amount of energy that could be obtained by the combustion of the methane that escapes each year?

26. (***Fall 2015***) We carried out the thermite reaction way back in Chapter 3 and used that reaction to talk about limiting reagents and percent yield. Since then, it showed up in a recitation exercise and a homework problem.

It's a pretty impressive reaction. A large part of the driving force in the thermite reaction is based on the stability of aluminum oxide, as reflected in ΔH° of the following reaction.

$$2Al(s) + {}^{3}/_{2}O_2(g) \rightarrow Al_2O_3(s) \qquad \Delta H° = -1669.8 \text{ kJ/mol}$$

If 27 g of aluminum reacts with oxygen to form $Al_2O_3(s)$, how much heat is released assuming the reaction goes to completion?

27. **(*Spring 2018*)** Write balanced molecular equations (ME) and net ionic equations (NIE) for the following reactions. *Be sure to include the correct states in your final equations and charges for ions in the NIE.*

A. $HNO_3(aq) + KNO_2(aq) \rightarrow$

ME:

NIE:

B. $Na_2SO_4(aq) + AgNO_3(aq) \rightarrow$

ME:

NIE:

28. **(*Spring 2018*)** Another important reaction in organic synthesis, polymers, and the food industry is hydrogenation. These reactions are typically carried out in "generators" at temperatures and pressures higher than ambient conditions. Sometimes, however, you can get away with milder conditions using a balloon generator, as shown in the image on the right. The balloon is filled with the desired amount of H_2 gas (often determined by a stoichiometric calculation), and then attached to a flask containing the reaction mixture.

A. Calculate the moles of $H_2(g)$ contained in the balloon on the right. We can assume they used dry hydrogen, so we do not need to correct for water vapor. The temperature in the lab is 24.5°C. The pressure inside the inflated balloon was measured to be 15 mmHg gauge pressure. Based on the 5 L round bottom flask in the photo, we can estimate the volume of the balloon to be around 11 L.

B. You can also hydrogenate with deuterium, $D_2(g)$, where deuterium is the isotope of hydrogen with one neutron in the nucleus. So the mass of a D atom would be roughly 2 amu, and the molar mass of D_2 would be 4 g/mol.

Assuming you did everything else just the same, which balloon...

1.	is heavier?	H_2	D_2	they're both the same
2.	contains the most gas molecules?	H_2	D_2	they're both the same
3.	contains molecules with the higher average kinetic energy?	H_2	D_2	they're both the same

C. Do you expect a $D_2(g)$ filled balloon to float in air? ________________

Explain.

29. (***Spring 2018***) A recent eye-catching article from ScienceDaily, ***Turning Beer into Fuel****, was actually about the use of alcohols as fuels (*www.sciencedaily.com/releases/2017/12/171206100119.htm). The paper states that compared to ethanol, "a much better fuel alternative is butanol but this is difficult to make from sustainable sources"; however, the article does not say why butanol is better. I found this...

> ***In other words, methanol and ethanol are not great fuel sources because they produce more carbon dioxide than their equivalent hydrocarbons for the same amount of energy. ... Butanol produces LESS carbon dioxide than gasoline for the same amount of energy.***
>
> (biofuel.org.uk/bioalcohols.html)

Combustion of a "mole" of gasoline provides around 4800 kJ of energy and produces roughly 350 g of CO_2. Combustion of a mole of butanol provides 2724 kJ of energy.

$$C_4H_9OH(\ell) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(\ell) + 2724 \text{ kJ/mol}$$

A. How much butanol would be required to provide 4800 kJ of energy?

B. How much carbon dioxide (in g) would be produced in Part A?

C. So, does butanol produces "LESS" carbon dioxide than gasoline for the same amount of energy? Explain.

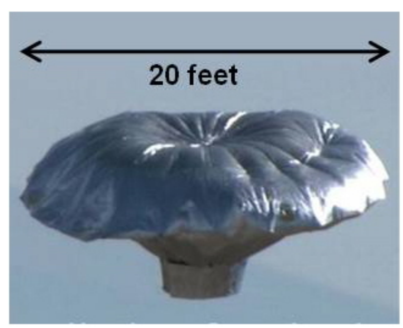
30. Hyperbaric oxygen therapy (HBOT) is very effective in treating burns, crush injuries that impede blood flow, and tissue-damaging infections, as well is carbon monoxide poisoning; however, it has generated some controversy in its application to other maladies (e.g. autism, multiple sclerosis).

A typical oxygen hyperbaric chamber is shown on the right. HBOT can be administered using pressures up to six atmospheres, but lower pressures are more common.

A. If this chamber was pressurized to 3.0 atm with pure oxygen, how many moles of O_2 would be contained in an unoccupied chamber?

B. Given that a full tank of oxygen contains about 2500 moles of the gas, how many times could the chamber be filled with a single tank of oxygen?

Additional Practice Problem: Balloonboy.



On October 15, 2009, a homemade helium balloon was released, and for a while authorities were led to believe that a six-year old boy had been carried away in the balloon. (The incident was later revealed to be a hoax.) The balloon traveled more than 50 miles and reached a height of 7000 feet. The mass that a helium balloon can lift is equal to the mass of the balloon when filled with air minus the mass of the balloon when filled with helium. The shape and span of the balloon are shown in the figure. Could this balloon actually lift a six-year old boy?

(You may not remember this story, but it was huge as it played out in real time. I Googled "balloonboy," and this was the first link the search returned: https://en.wikipedia.org/wiki/Balloon_boy_hoax.)