Chemistry 2 Summer 2008
Exam 3 KEY Chapters 11, 13, & 15

You might find the following useful.

$$PV = nRT \qquad R = \frac{0.082058 \text{ L} \bullet \text{atm}}{\text{K} \bullet \text{mol}} \text{ or } \frac{8.3145 \text{ L} \bullet \text{kPa}}{\text{K} \bullet \text{mol}}$$

$$PV = \frac{g}{M}RT \qquad g = \text{mass} \qquad M = \text{molar mass}$$

$$P_{\text{total}} = \Sigma P_{\text{partial}} \quad \text{or} \quad P_{\text{total}} = (\Sigma n_{\text{each gas}})\frac{RT}{V}$$

Answer the following by writing the word, words, letter, letters or number in each blank that best completes each sentence. (1 point each blank)

1. Something that is **miscible** can be mixed in any proportion without any limit to solubility.
2. A polar molecule or ion (or a portion of a molecule or polyatomic ion) that is attracted to water is called **hydrophilic ("water loving")**.
3. A(n) **polymer** is a large molecule composed of repeating units.
4. A(n) **peptide bond** is an amide functional group that forms when the carboxylic acid group on one amino acid reacts with the amine group of another amino acid.
5. A(n) **condensation reaction** is a chemical reaction in which two substances combine to form a larger molecule with the release of a small molecule, such as water.
6. A(n) **salt bridge** is a link in a protein structure between a negatively charged side-chain and a positively charged side-chain.
7. **Hydrogenation** is a process by which hydrogen is added to an unsaturated triglyceride to convert double bonds to single bonds. This can be done by combining the unsaturated triglyceride with hydrogen gas and a platinum catalyst.
8. **Hydrolysis** is a chemical reaction in which larger molecules are broken down into smaller molecules by a reaction with water in which a water molecule is split in two, each part joining a different product molecule.
9. A(n) **substrate** is a molecule that an enzyme causes to react.

10. A(n) **active site** is a specific section of the protein structure of an enzyme in which the substrate fits and reacts.

Answer the following by writing one of these words or phrases in each blank.
(1/2 point per blank)

algebra	glycogen	necessary unit conversions
Celsius	hard	not
cholesterol	increases	oils
close to each other	insoluble	point masses
correct equation	Kelvin	precipitate
directly	large	probability
dispersed	larger	protein
fatty acids	molar mass	single
fats	molarity	smaller
fructose	moles of gas	starches
glucose units	monosaccharides	sugars
glycerol		

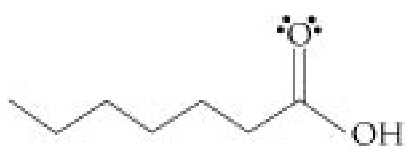
11. As the temperature of a gas increases, the particles' velocity **increases**.
12. The particles of an ideal gas are assumed to be **point masses**, that is, particles that have a mass but occupy no volume.
13. Although gas temperatures are often measured with thermometers that report temperatures in **Celsius** scientists generally use **Kelvin** temperatures for calculations.
14. The observation that the pressure of an ideal gas is inversely proportional to the volume it occupies if the **moles of gas** and the temperature are constant is a statement of Boyle's Law.
15. For an ideal gas, volume and temperature described in kelvins are **directly** proportional if the number of gas particles and pressure are constant. This is a statement of Charles' Law.
16. It is always a good idea to include the units in a solved equation as well as the numbers. If the units cancel to yield a reasonable unit for the unknown property, you can feel confident that you picked the **correct equation**, that you did the **algebra** correctly to solve for your unknown, and that you have made the **necessary unit conversions**.

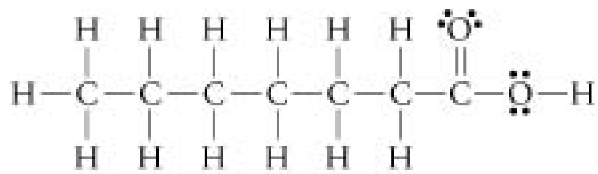
17. There are three different ways to convert between a measurable property and moles in equation stoichiometry problems. For pure liquids and solids, we can convert between mass and moles, using the **molar mass** as a conversion factor. For solutions, **molarity** provides a conversion factor that enables us to convert between moles of solute and volume of solution.
18. Particles of matter tend to become more **dispersed** (spread out).
19. Because there are more possible arrangements for gas particles when they are dispersed throughout a container than when they are concentrated in one corner of it, **probability** suggests that they will spread out to fill the total volume available to them.
20. If less than 1 gram of the substance will dissolve in 100 milliliters (or 100 g) of solvent, the substance is considered **insoluble**.
21. Nonpolar substances are **not** likely to dissolve to a significant degree in polar solvents.
22. If we need to predict the relative water solubility of two similar molecules, we can expect the one with the proportionally **larger** polar portion to have higher water solubility.
23. Soap can be made from animal **fats** and vegetable **oils**, which in turn are composed of triglycerides.
24. **Hard** water is water that contains dissolved calcium ions, Ca^{2+}, magnesium ions, Mg^{2+}, and often iron ions, Fe^{2+} or Fe^{3+}. These ions bind strongly to soap anions, causing the soap to **precipitate** from hard-water solutions.
25. Hydrocarbons (compounds composed of carbon and hydrogen) in which all of the carbon-carbon bonds are **single** bonds are called alkanes.
26. Carbohydrate is a general name for **sugars**, **starches**, and cellulose.
27. Sucrose is a disaccharide that contains glucose and **fructose**.
28. The most common polysaccharides are starch, **glycogen** (sometimes called animal starch), and cellulose. All of these are composed of repeating **glucose units**, but they differ in the way the units are connected.
29. The arrangement of atoms that are **close to each other** in the polypeptide chain is called the secondary structure of the protein.
30. As the starting material for the production of many important body chemicals, including hormones (compounds that help regulate chemical changes in the body), the steroid **cholesterol** is necessary for normal, healthy functioning of our bodies.
31. Digestion is the process of converting **large** molecules into **smaller** molecules capable of passing into the bloodstream to be carried throughout the body and used for many different purposes.

32. In digestion, disaccharides are broken down into **monosaccharides** (glucose, galactose, and fructose), polysaccharides into glucose, **protein** into amino acids, and fat into **glycerol** and **fatty acids**.

33. Predict whether each of the following compounds is soluble in water. (6 points)
    a. nickel(II) perchlorate, $Ni(ClO_4)_2$
       soluble (Ionic compounds tend to be soluble in water.)
    b. the polar molecular compound ethyl amine, $C_2H_5NH_2$
       soluble (Small alcohols and other small polar molecular substances tend to be soluble in water.)
    c. toluene, $C_6H_5CH_3$
       insoluble (Hydrocarbon molecules and other nonpolar molecular substances are insoluble in water.)

34. Write a Lewis structure and condensed chemical formula for the following line drawing. (4 points)

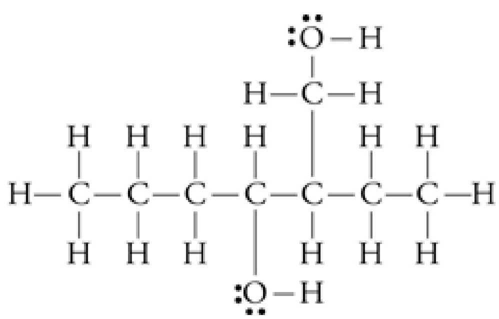


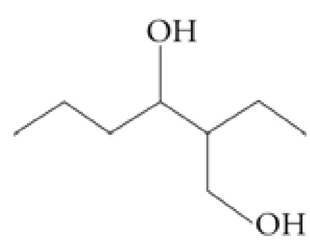


$CH_3(CH_2)_5CO_2H$

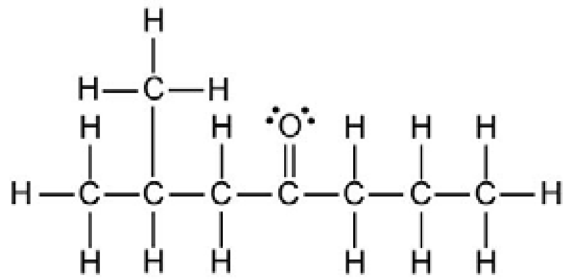
35. Write a Lewis structure and line drawing for the following condensed chemical formula. (4 points)

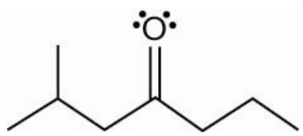
$CH_3CH_2CH_2CH(OH)CH(CH_2OH)CH_2CH_3$





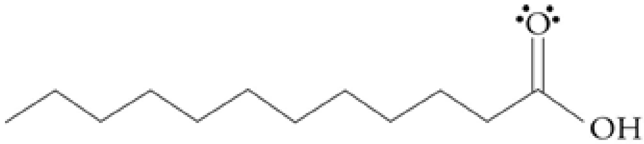
36. Write a condensed formula and line drawing to represent the Lewis structure below. (4 points)

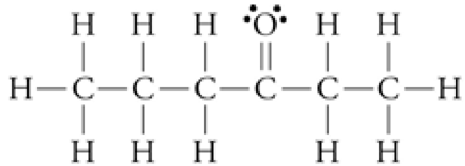


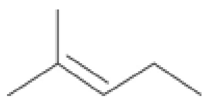


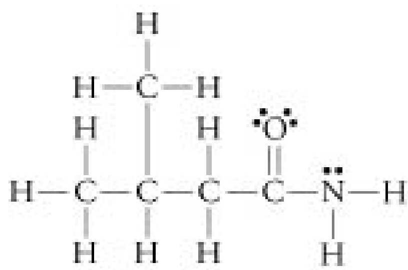
$CH_3CH(CH_3)CH_2COCH_2CH_2CH_3$

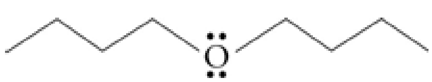
37. Identify each of these as representing an alkane, alkene, alkyne, arene (aromatic), alcohol, carboxylic acid, aldehyde, ketone, ether, ester, amine, or amide. (1 point each)

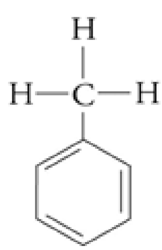
a.  **carboxylic acid**

b.  **ketone**

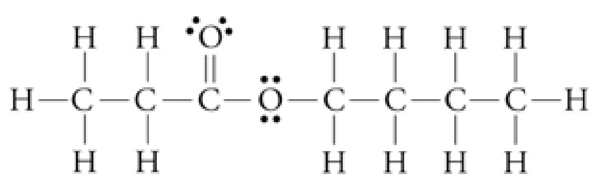
c.  **alkene**

d.  **amide**

e.  **ether**

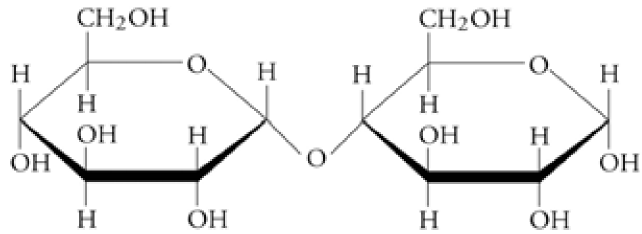
f.  **arene**

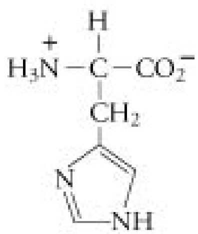
g. CH_3CHO **aldehyde**

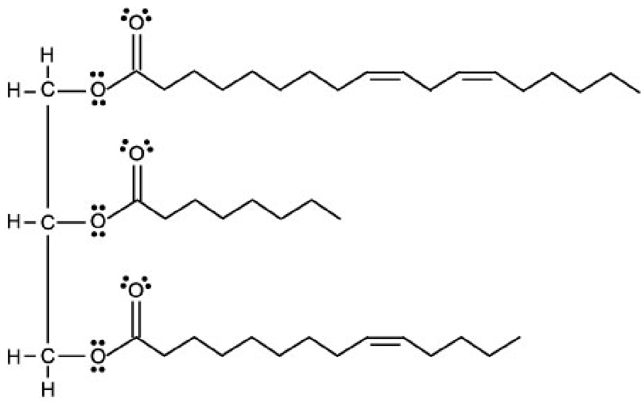
h.  **ester**

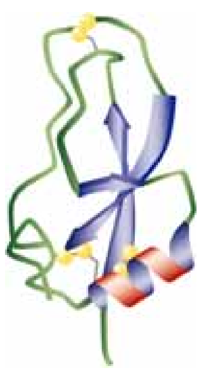
i. $CH_3CH_2CH(CH_3)CH_2OH$ **alcohol**

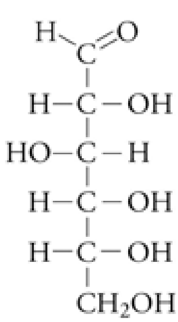
38. Identify each of the following structures as representing a carbohydrate, amino acid, peptide (or protein), triglyceride, or steroid. (1 point each)

a.  **carbohydrate**

b.  **amino acid**

c.  **triglyceride**

d.  **peptide/protein**

e.  **carbohydrate**

For the following calculations, be sure to show your work and report your answer with the correct significant figures, units, and scientific notation. (6 points each)

39. What is the density of krypton gas at 18.2 °C and 762 mmHg?

$\frac{g}{V} = ?$ P = 762 mmHg T = 18.2 °C + 273.15 = 291.4 K

$$PV = \frac{g}{M}RT \qquad \frac{g}{V} = \frac{PM}{RT} = \frac{762\,\text{mmHg}\left(83.80\,\frac{\text{g}}{\text{mole}}\right)}{0.082058\,\frac{\text{L} \bullet \text{atm}}{\text{K} \bullet \text{mole}}(291.4\,\text{K})}\left(\frac{1\,\text{atm}}{760\,\text{mmHg}}\right) = \mathbf{3.51\ g/L}$$

40. The hydrogen gas used to manufacture ammonia can be made from small hydrocarbons such as methane in the so-called steam-reforming process, which is run at high temperature and pressure. What volume of methane gas at 21 °C and 1.1 atm must be compressed to yield 1.5×10^4 L of methane gas at 12 atm and 815 °C?

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2} \qquad \text{Assuming constant moles of gas, } \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = V_1\left(\frac{T_2}{T_1}\right)\left(\frac{P_1}{P_2}\right) = 1.5 \times 10^4\ \text{L}\left(\frac{294\ \text{K}}{1088\ \text{K}}\right)\left(\frac{12\ \text{atm}}{1.1\ \text{atm}}\right) = \mathbf{4.4 \times 10^4\ L}$$

41. The carbon tetrachloride made in the process described in the previous problem can be used to make CFC-12, CF_2Cl_2, and CFC-11, $CFCl_3$. What is the minimum volume of HF(*g*) in cubic meters at 1.2 atm and 19 °C that would be necessary to react with 235 kg of CCl_4 in this reaction?

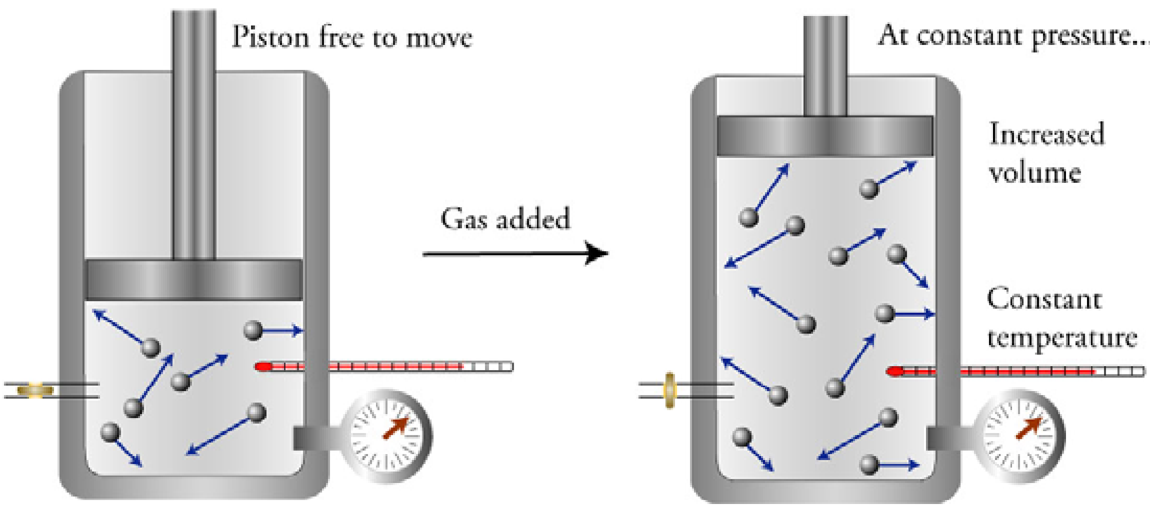
$$3HF(g) + 2CCl_4(g) \rightarrow CF_2Cl_2(g) + CFCl_3(g) + 3HCl(g)$$

$$?\ \text{m}^3\ \text{HF} = 235\ \text{kg CCl}_4\left(\frac{10^3\ \text{g}}{1\ \text{kg}}\right)\left(\frac{1\ \text{mol CCl}_4}{153.822\ \text{g CCl}_4}\right)\left(\frac{3\ \text{mol HF}}{2\ \text{mol CCl}_4}\right)\left(\frac{0.082058\ \text{L} \bullet \text{atm}}{\text{K} \bullet \text{mol}}\right)\left(\frac{292\ \text{K}}{1.2\ \text{atm}}\right)\left(\frac{1\ \text{m}^3}{10^3\ \text{L}}\right) = \mathbf{46\ m^3\ HF}$$

Answer the following in short answer form. (6 points each)

42. For the relationship between volume and number of gas particles when pressure and temperature are constant, (1) describe the relationship between these properties, (2) describe a simple system that could be used to demonstrate the relationship, and (3) explain the reason for the relationship.

V ∝ n when P and T are constant



Increased number of gas particles

↓

Increased number of collisions with the walls

↓

Increased total force of collisions

↓

Initial increased in force per area - that is, in pressure

↓

Inside pressure is greater than external pressure

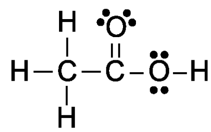
↓

Container expands → **Increased volume**

↓

Decreased pressure until the inside pressure equals the external pressure

43. The primary components of vinegar are acetic acid and water, both of which are composed of polar molecules with hydrogen bonds that link them. These two liquids will mix in any proportion. With reference to the ideas mentioned in Section 13.1 of the text, explain why acetic acid and water are miscible.



Acetic acid

Picture a layer of acetic acid that is carefully added to water (See Figure 13.3 in the text. Picture acetic acid molecules in the place of the ethanol molecules.). Because the particles of a liquid are moving constantly, some of the acetic acid particles at the boundary between the two liquids will immediately move into the water, and some of the water molecules will move into the acetic acid. In this process, water-water and acetic acid-acetic acid attractions are broken and acetic acid-water attractions are formed. Both acetic acid and water are molecular substances with O–H bonds, so the attractions broken between water molecules and the attractions broken between acetic acid molecules are hydrogen bonds. The attractions that form between the acetic acid and water molecules are also hydrogen bonds. We expect the hydrogen bonds that form between water molecules and acetic acid molecules to be similar in strength to the hydrogen bonds that are broken. Because the attractions between the particles are so similar, the freedom of movement of the acetic acid molecules in the water solution is about the same as their freedom of movement in the pure acetic acid. The same can be said for the water. Because of this freedom of movement, both liquids will spread out to fill the total volume of the combined liquids. In this way, they will shift to the most probable, most dispersed state available, the state of being completely mixed. There are many more possible arrangements for this system when the acetic acid and water molecules are dispersed throughout a solution than when they are restricted to separate layers.

44. You throw a backyard party that resembles your idea of a big Texas barbecue. The guests get more food than they can possibly eat, including a big juicy steak in the center of each plate. Referring to the interactions between particles and the corresponding changes that take place on the submicroscopic level, describe how soap or detergent can help you clean the greasy plates that you're left with when your guests go home.

To clean a greasy dish, we first scrub its surface and agitate the water. Although fat and oil molecules (triglycerides) have some polar bonds, they are primarily nonpolar, so they do not dissolve in water and are not easily removed from an object by scrubbing it with water alone. Without soap (or detergent) in the water, the oil droplets quickly regroup and return to the surface you are trying to clean. If soap or detergent anions are in the solution, however, their nonpolar hydrocarbon ends enter the nonpolar triglyceride droplets, while their anionic ends stick out into the water. Soon every drop of fat or oil is surrounded by an outer coating of soap or detergent. (See Figure 13.12 in the textbook.) When two droplets approach each other, the negative ends of the soap or detergent anions cause the droplets to repel each other, preventing the triglyceride droplets from recombining and redepositing on the object being cleaned. The droplets stay suspended in the solution and are washed down the drain with the dishwater. (See Figure 13.13 in the textbook.)