Chemistry 2   Exam 3 Key
Chapters 11, 15, and 16

You might find the following useful.

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

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

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. **Partial pressure** is the portion of the total pressure that one gas in a mixture of gases contributes. Assuming ideal gas character, the partial pressure of any gas in a mixture is the pressure that the gas would yield if it were alone in the container.
2. A(n) **functional group** is a small section of an organic molecule that to a large extent determines the chemical and physical characteristics of the molecule.
3. A(n) **polymer** is a large molecule composed of repeating units. A(n) **monomer** is the repeating unit.
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. **Secondary** protein structure is the arrangement of atoms that are close to each other in a polypeptide chain. Examples are α-helix and β-sheet.
6. **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.
7. A(n) **enzyme** is a naturally occurring catalyst.
8. A(n) **substrate** is a molecule that an enzyme causes to react.
9. **Nucleons** are the particles that reside in the nucleus of atoms (protons and neutrons).
10. A(n) **nuclide** is a particular type of nucleus that is characterized by a specific atomic number (Z) and nucleon number (A).

11. **Half-life** is the time it takes for one-half of a sample to disappear.
12. **Free radicals** are particles with unpaired electrons.
13. **Binding energy** is the amount of energy released when a nucleus is formed.
14. **Fusion** is a nuclear reaction that yields energy by combining smaller atoms to make larger, more stable ones.
15. **Fission** is nuclear reaction that yields energy by splitting larger atoms to form more stable, smaller atoms.
16. A(n) **chain reaction** is a process in which one of the products of a reaction initiates another identical reaction.

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

alpha	glucose units	protein
amylopectin	glycerol	pull
amylose	glycogen	pushed
close to each other	Kelvin temperature	rapidly reproducing
electrostatic	larger than	ratio
energy	molar mass	releases
excite	molarity	smaller than
fatty acids	monosaccharides	strong
fructose	photons	too high
galactose	point-masses	too low

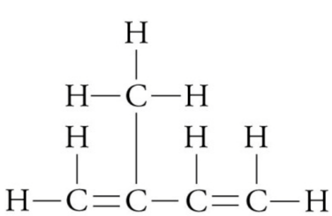
17. The particles of an ideal gas are assumed to be **point-masses**, that is, particles that have a mass but occupy no volume.
18. The pressure of an ideal gas is directly proportional to the **Kelvin temperature** of the gas if the volume and the number of gas particles are constant. This relationship is sometimes called Gay-Lussac's Law.

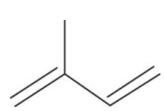
19. There are three different ways to convert between a measurable property and moles in equation stoichiometry problems. For pure liquids and solids, we can convert between mass and moles, using the **molar mass** as a conversion factor. For gases, we can convert between volume of gas and moles using the methods described above. For solutions, **molarity** provides a conversion factor that enables us to convert between moles of solute and volume of solution.
20. Lactose, or milk sugar, is a disaccharide consisting of **galactose** and glucose.
21. Sucrose is a disaccharide that contains glucose and **fructose**.
22. 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.
23. Almost every kind of plant cell has **energy** stored in the form of starch. Starch itself has two general forms, **amylose** and **amylopectin**.
24. The arrangement of atoms that are **close to each other** in the polypeptide chain is called the secondary structure of the protein.
25. 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**.
26. There are two forces among the particles within the nucleus. The first, called the **electrostatic** force, is the force between electrically charged particles. The second force, called the **strong** force, holds nucleons (protons and neutrons) together.
27. Larger atoms with more protons in their nuclei require a greater **ratio** of neutrons to protons to balance the increased repulsion between protons.
28. One of the ways that heavy nuclides change to move back into the band of stability is to release two protons and two neutrons in the form of a helium nucleus, called a(n) **alpha** particle.
29. When a radioactive nuclide has a neutron to proton ratio that is **too high**, it undergoes beta emission ($\beta-$). In this process, a neutron becomes a proton and an electron. The proton

stays in the nucleus, and the electron, which is called a beta particle in this context, is ejected from the atom.

30. When a radioactive nuclide has a neutron to proton ratio that is **too low**, it can move toward stability in one of two ways, positron emission or electron capture. In positron emission (β+), a proton becomes a neutron and a positron. The neutron stays in the nucleus, and the positron speeds out of the nucleus at high velocity.
31. Because radioactive decay leads to more stable products, it always **releases** energy, some in the form of kinetic energy of the moving product particles, and some in the form of gamma rays. Gamma rays can be viewed as a stream of high-energy **photons**.
32. As alpha particles, which move at up to 10% the speed of light, move through the tissues of our bodies, they **pull** electrons away from the tissue's atoms.
33. The repulsion between negatively charged beta particles and the electrons on atoms and molecules of our tissues leads to electrons being **pushed** off the uncharged particles.
34. Gamma photons are ionizing radiation, because they can **excite** electrons enough to actually remove them from atoms.
35. Gamma photons that penetrate the body do more damage to **rapidly reproducing** cells than to others.
36. For atoms **smaller than** iron-56, energy is released when smaller atoms combine to form larger ones.
37. For atoms **larger than** iron-56, splitting larger atoms to form more stable, smaller atoms releases energy.

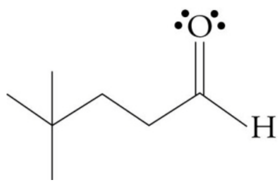
38. Draw the line drawing and condensed formula for the Lewis structure below. (4 points)

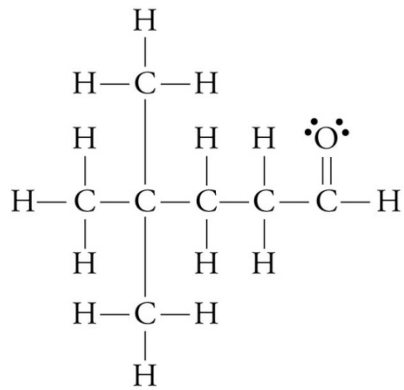




$CH_2C(CH_3)CHCH_2$

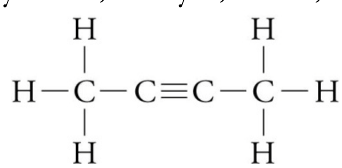
39. Draw the Lewis structure and condensed formula for the line drawing below. (4 points)

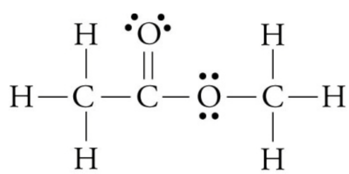




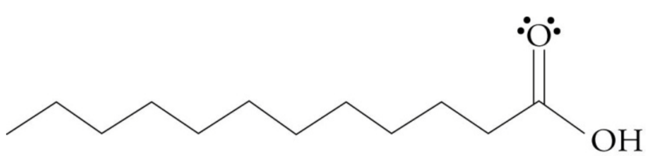
$CH_3C\ (CH_3)_2CH_2CH_2CHO$

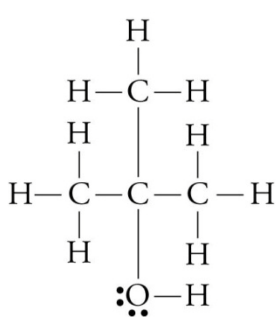
40. Identify each of these as representing an alkane, alkene, alkyne, arene (aromatic), alcohol, carboxylic acid, aldehyde, ketone, ether, ester, amine, or amide. (1 point each)

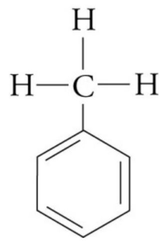
a.  **alkyne**

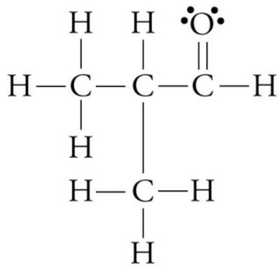
b.  **ester**

c. $CH_3(CH_2)_7NH_2$ **amine**

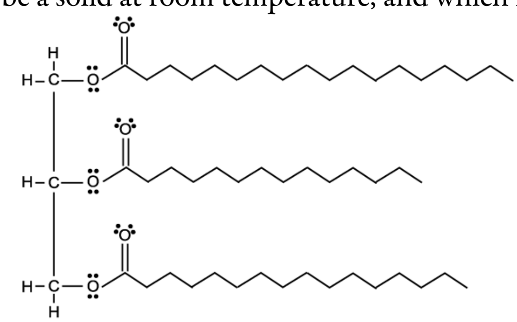
d.  **carboxylic acid**

e.  **alcohol**

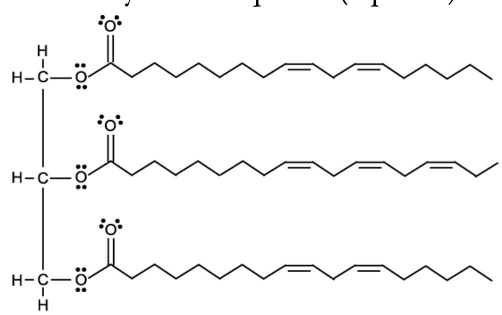
f.  **arene**

g.  **aldehyde**

41. Identify each of the following triglycerides as saturated or unsaturated. Which is more likely to be a solid at room temperature, and which is more likely to be a liquid? (4 points)

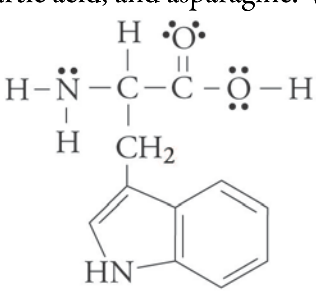


saturated – solid

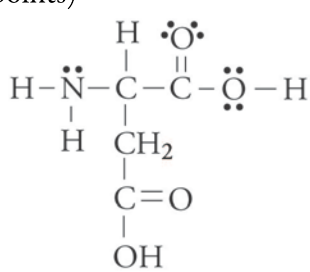


unsaturated – liquid

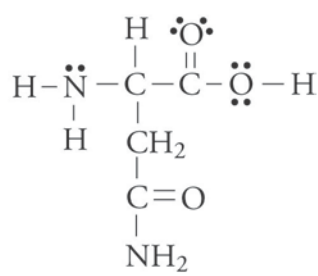
42. Draw the structure of the tripeptide that forms from linking the amino acids tryptophan, aspartic acid, and asparagine. (4 points)



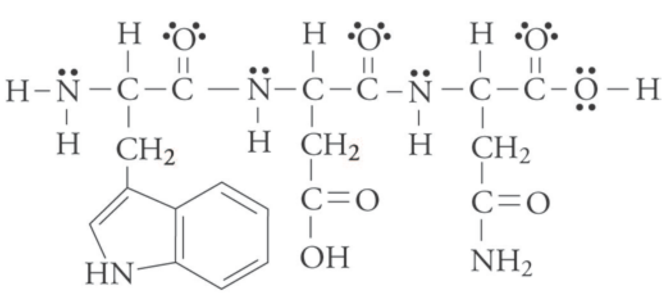
tryptophan



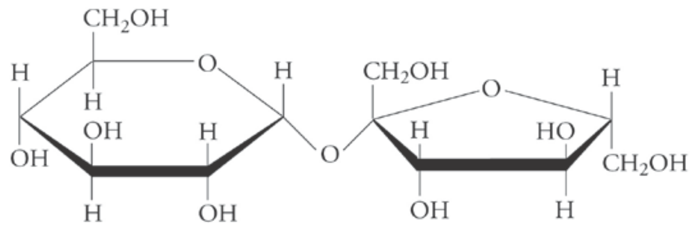
aspartic acid



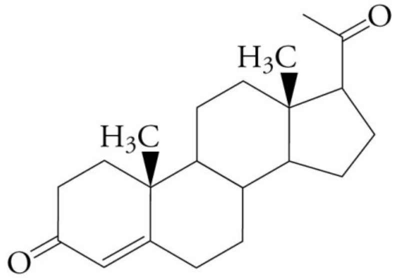
asparagine



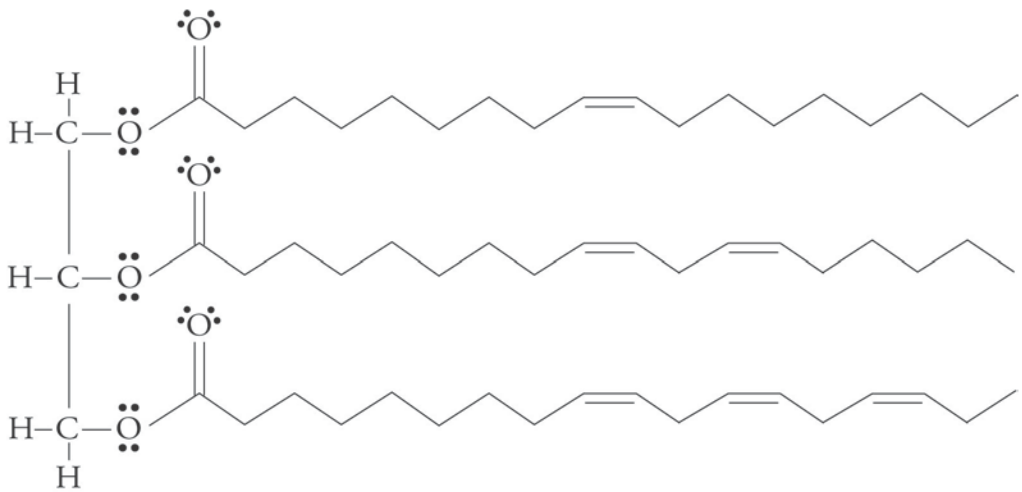
43. Identify each of the following structures as representing a carbohydrate, amino acid, peptide (or protein), triglyceride, or steroid. (2 points each)

a. 

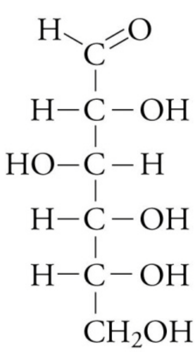
carbohydrate

b. 

steroid

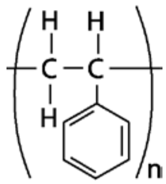
c. 

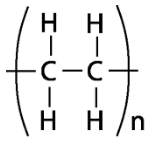
triglyceride

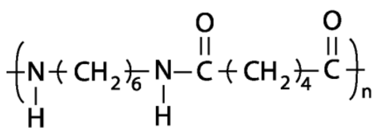
d. 

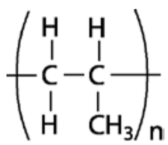
carbohydrate

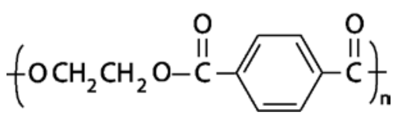
44. Identify each of the following as representing nylon, polyester, polyethylene, poly(vinyl chloride), polypropylene, or polystyrene. (In each case, the n represents some large integer.) (5 points)

a.  **polystyrene**

b.  **polyethylene**

c.  **nylon**

d.  **polypropylene**

e.  **polyester**

45. Radioactive xenon-133 is used to measure lung capacity. It shifts toward stability by emitting beta particles. Write the nuclear equation for this reaction. (3 points)

$$^{133}_{54}Xe \rightarrow {}^{133}_{55}Cs + {}^{0}_{-1}e$$

46. In September 1982, the element meitnerium-266, $^{266}_{109}Mt$, was made from the bombardment of bismuth-209 atoms with iron-58 atoms. Write a nuclear equation for this reaction. (One or more neutrons may be released in this type of nuclear reaction.) (3 points)

$$^{209}_{83}Bi + {}^{58}_{26}Fe \rightarrow {}^{266}_{109}Mt + {}^{1}_{0}n$$

47. Astatine-216 atoms undergo an alpha emission, a beta emission, and another alpha emission before they reach a stable nuclide. What is the final product? (3 points)

$$^{216}_{85}At \rightarrow {}^{212}_{83}Bi \rightarrow {}^{212}_{84}Po \rightarrow \mathbf{{}^{208}_{82}Pb}$$

For the following calculations, be sure to show your work and report your answer with the correct significant figures, units, and scientific notation. (4 points each)

48. The bulbs used for fluorescent lights have a mercury gas pressure of 1.07 Pa at 40 °C. How many milligrams of liquid mercury must evaporate at 40 °C to yield this pressure in a 1.39-L fluorescent bulb?

$$PV = \frac{g}{M}RT \qquad g = \frac{PVM}{RT} = \frac{1.07\text{ Pa}\,(1.39\text{ L})\,\frac{200.59\text{ g}}{1\text{ mol}}}{\left(\frac{8.3145\text{ L}\bullet\text{kPa}}{\text{K}\bullet\text{mol}}\right)313\text{ K}}\left(\frac{1\text{ kPa}}{10^3\text{ Pa}}\right)\left(\frac{10^3\text{ mg}}{1\text{ g}}\right)$$

$$= \mathbf{0.115\ mg}$$

49. Consider a weather balloon with a volume on the ground of 113 m^3 at 101 kPa and 14 °C. If the balloon rises to a height where the temperature is −50 °C and the pressure is 2.35 kPa, what will its volume be? (In 1958, a balloon reached 101,500 ft, or 30.85 km, the height at which the temperature is about −50 °C.)

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

$$V_2 = V_1\left(\frac{T_2}{T_1}\right)\left(\frac{P_1}{P_2}\right) = 113\text{ m}^3\left(\frac{223\text{ K}}{287\text{ K}}\right)\left(\frac{101\text{ kPa}}{2.35\text{ kPa}}\right) = \mathbf{3.77\times10^3\ m^3}$$

50. When natural gas is heated to 370 °C, the sulfur it contains is converted to hydrogen sulfide. The H_2S gas can be removed by a reaction with sodium hydroxide that forms solid sodium sulfide and water.

$$H_2S + 2NaOH \rightarrow Na_2S + 2H_2O$$

What volume of $H_2S(g)$ at 370 °C and 1.1 atm can be removed by 2.7 Mg of NaOH?

$$?\text{ m}^3\ H_2S = 2.7\text{ Mg NaOH}\left(\frac{10^6\text{ g}}{1\text{ Mg}}\right)\left(\frac{1\text{ mol NaOH}}{39.9971\text{ g NaOH}}\right)\left(\frac{1\text{ mol }H_2S}{2\text{ mol NaOH}}\right)$$

$$\left(\frac{0.082058\text{ L}\bullet\text{atm}}{\text{K}\bullet\text{mol}}\right)\left(\frac{643\text{ K}}{1.1\text{ atm}}\right)\left(\frac{1\text{ m}^3}{10^3\text{ L}}\right) = \mathbf{1.6\times10^3\ m^3\ H_2S}$$

Answer the following in short answer form. (4 points each)

51. Explain why decreased volume for the gasoline-air mixture in the cylinders of a gasoline engine, increased number of gas particles, and increased temperature lead to an increase in pressure in the cylinders.

    Decreased volume leads to increased concentration of gas. This leads to more particles near the walls and therefore more collisions per second with the walls. This creates a greater force per unit area (pressure) against the walls.

    A spark ignites the mixture of compressed gases in a cylinder, and the hydrocarbon compounds in the gasoline react with the oxygen in the air to form carbon dioxide gas and gaseous water. (See Figure 11.8 in the textbook.) A typical reaction is

    $$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g) + \text{energy}$$

    In the representative reaction shown above, a total of 27 moles of gas are converted into 34 moles of gas. This increase in moles of gas leads to an increase in number of collisions per second with the walls of the cylinder, which creates greater force acting against the walls and a greater gas pressure in the cylinder. The pressure is increased even more by the increase in the temperature of the gas due to the energy released in the reaction. The increased temperature increases the average velocity of the gas particles, which leads to more frequent collisions with the walls and a greater average force per collision. (See Figure 11.8 in the textbook.)

52. Explain why short-lived radioactive nuclides are found in nature.

    Although short-lived radioactive nuclides disappear relatively quickly once they form, they are constantly being replenished because they are products of other radioactive decays. There are three long-lived radioactive nuclides (uranium-235, uranium-238, and thorium-232) that are responsible for many of the natural radioactive isotopes.

53. Describe the fission reaction of uranium-235, and explain how it can lead to a chain reaction.

    When uranium-235 atoms are bombarded with neutrons, they form uranium-236 atoms, which decompose to form atoms such as krypton-95 and barium-138 as well as neutrons.

    $${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{95}_{36}Kr + {}^{138}_{56}Ba + 3\,{}^{1}_{0}n$$

    The nuclides formed in the reaction above are only two of many possible fission products of uranium-235. More than 200 different nuclides form of 35 different elements. Another possible reaction is

    $${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{144}_{54}Xe + {}^{90}_{38}Sr + 2\,{}^{1}_{0}n$$

    The reason why the fission of uranium-235 can generate a lot of energy in a short period of time is that under the right circumstances, it can undergo a chain reaction, which is a process in which one of the products of the reaction initiates another identical reaction. In the case of the fission of uranium-235, one or more of the neutrons formed in the reaction can collide with another uranium-235 atom to cause it to fission also (Figure 16.5 in the textbook).