

CHEMISTRY 1A

Spring 2011 Final Exam Key

YOU MIGHT FIND THE FOLLOWING USEFUL;

$$\Delta H^\circ = \Delta E^\circ + (\Delta n)RT \quad R = \frac{0.008314 \text{ kJ}}{\text{K} \cdot \text{mol}}$$

$$q = - \left[C_{\text{cal}} + \frac{0.00418 \text{ kJ}}{\text{g} \cdot ^\circ\text{C}} m_w \right] \Delta T$$

$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H_f^\circ (\text{products}) - \sum \Delta H_f^\circ (\text{reactants})$$

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

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

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

Electronegativities

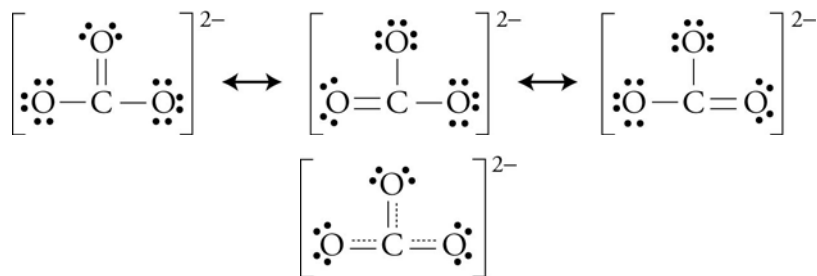
H 2.2							
Li 0.98	Be 1.57	B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	
Na 0.93	Mg 1.31	Al 1.61	Si 1.9	P 2.19	S 2.58	Cl 3.16	
K 0.82	Ca 1.0	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	
Rb 0.82	Sr 0.95	In 1.78	Sn 1.96	Sb 2.05	Te 2.1	I 2.66	Xe 2.6
Cs 0.79	Ba 0.89	Tl 2.33	Pb 2.02	Bi 2.0	Po 2.2		

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

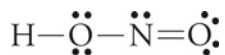
1. The elements in group 2 or 2A on the periodic table are called **alkaline earth metals**.
2. The intermolecular attraction between a nitrogen, oxygen, or fluorine atom of one molecule and a hydrogen atom bonded to a nitrogen, oxygen, or fluorine atom in another molecule is called a(n) **hydrogen bond**.
3. **Isomers** are compounds that have the same molecular formula but different molecular structures.
4. The gas in a solution of a gas in a liquid, the solid in a solution of a solid in a liquid, or the minor component in other solutions is called a(n) **solute**.
5. A(n) **weak electrolyte** is a substance that ionizes or dissociates *incompletely* in an aqueous solution.
6. A(n) **strong acid** is an acid that donates its H^+ ions to water in a reaction that goes completely to products. Such a compound produces close to one H_3O^+ ion in solution for each acid molecule dissolved in water.
7. Any chemical change in which at least one element gains electrons, either completely or partially is called **reduction**.
8. **Potential energy** is a retrievable, stored form of energy an object possesses by virtue of its position or state.
9. A(n) **endothermic** change is a change that leads to *heat* energy being absorbed from the surroundings.
10. A(n) **trans** isomer is a structure that has like groups on different carbons (which are linked by a double bond) and on the different sides of the double bond.
11. **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.
12. A polar molecule or ion (or a portion of a molecule or polyatomic ion) that is attracted to water is called **hydrophilic**.
13. A(n) **catalyst** is a substance that speeds a chemical reaction without being permanently altered itself.
14. 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.
15. A(n) **disulfide bond** is a covalent bond between two sulfur atoms of two different amino acids in a protein molecule.

16. A(n) **salt bridge** is an attraction between a negatively charged side chain and a positively charged side chain in a protein molecule.
17. **Hydrolysis** is a chemical reaction in which larger molecules are converted into smaller molecules by adding water to their structure.
18. A(n) **enzyme** is a naturally occurring catalyst.
19. A(n) **substrate** is a molecule that an enzyme causes to react.
20. A specific section of the protein structure of an enzyme in which the substrate fits and reacts is called a(n) **active site**.
21. A(n) **condensation (or step-growth) polymer** is a polymer formed when small molecules, such as water, are released in its formation. This category includes nylon and polyester.
22. A(n) **free radical** is a molecule with an unpaired electron.
23. The abbreviated electron configuration for Cd^{2+} is **[Kr] 4d¹⁰**.
24. The disaccharide sucrose is composed the monosaccharides **glucose** and **fructose**.
25. In digestion, proteins are converted into **amino acids**.
26. Draw a Lewis structure for each of the following. If there is resonance, draw all the resonance structures and the resonance hybrid. Show all formal charges.
(4 points each)

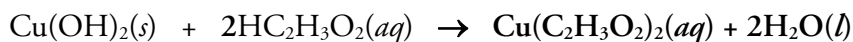
a. CO_3^{2-}



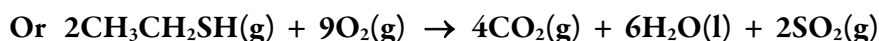
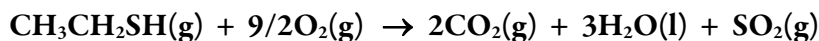
b. Nitrous acid, HNO_2



27. Write the complete equation, the complete ionic equation, **and** the net ionic equation for the neutralization reaction that takes place between the following reactants. (8 points)



28. Write a complete, balanced equation for the combustion of ethanethiol, $\text{CH}_3\text{CH}_2\text{SH}(g)$. (4 points)



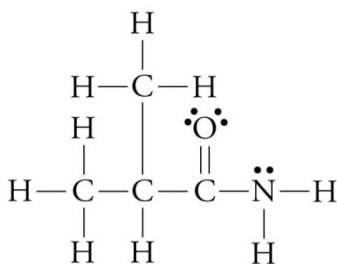
29. Identify each of the following as a binary covalent compound, a binary ionic compound, a binary acid, an ionic compound with a polyatomic ion, an oxyacid, an alcohol, or a sugar. Write the name for each. (7.5 points)

Chemical formula	Type of substance	Name
H ₂ SO ₃	oxyacid	sulfurous acid
Cl ₂ F ₈	binary covalent	dichlorine octafluoride
HF(aq)	binary acid	hydrofluoric acid
Fe(HSO ₄) ₂	ionic with polyatomic ion	Iron(II) hydrogen sulfate
Al ₂ (HPO ₄) ₃	ionic with polyatomic ion	aluminum hydrogen phosphate

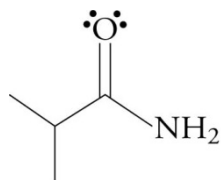
30. Identify each of the following as a binary covalent compound, a binary ionic compound, a binary acid, an ionic compound with a polyatomic ion, an oxyacid, an alcohol, or a sugar. Write the formula for each. (7.5 points)

Chemical name	Type of substance	Formula
2-propanol	alcohol	CH₃CHOHCH₃
potassium hypochlorite	ionic with polyatomic ion	KClO
hydrogen chloride	binary covalent	HCl
hypophosphorous acid	oxyacid	H₃PO₂
potassium dihydrogen phosphate	ionic with a polyatomic ion	KH₂PO₄

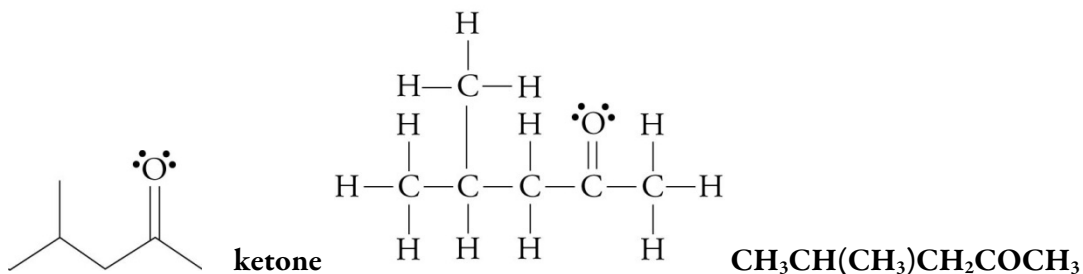
31. Draw the line drawing and condensed formula for the Lewis structure below. Classify it as an alkane, alkene, alkyne, arene (aromatic), alcohol, carboxylic acid, aldehyde, ketone, ether, ester, amine, or amide. (6 points)



amide



32. Draw the Lewis structure and condensed formula for the line drawing below. Classify it as an alkane, alkene, alkyne, arene (aromatic), alcohol, carboxylic acid, aldehyde, ketone, ether, ester, amine, or amide. (6 points)



33. For each of the following, write the name of the type of attraction holding these particles in the solid and liquid form. Indicate the formula in each pair that represents the substance that you would expect to have the higher melting point and boiling point. (3 points each)

a. sodium nitrate, NaNO_3

type of attraction **ionic bonds**

or methylamine, CH_3NH_2

type of attraction **hydrogen bonds and London forces**

higher m.p. and b.p. **NaNO_3**

b. Decanoic acid, $\text{CH}_3(\text{CH}_2)_8\text{CO}_2\text{H}$

type of attraction **hydrogen bonds and London forces**

or formic acid, HCO_2H

type of attraction **hydrogen bonds and London forces**

higher m.p. and b.p. **$\text{CH}_3(\text{CH}_2)_8\text{CO}_2\text{H}$**

c. diamond, $\text{C}(\text{dia})$

type of attraction **covalent bonds**

or acetone, CH_3COCH_3

type of attraction **dipole-dipole attractions and London forces**

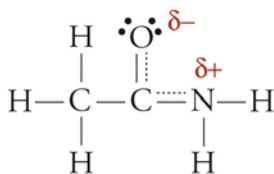
higher m.p. and b.p. **diamond**

34. Look at the front screen in the lecture hall and answer the following questions.

(1 point each)

- a) What type of organic compound does this image represent? (alkane, alkene, alkyne, alcohol, carboxylic acid, ester, ether, ketone, aldehyde, amine, or amide) **Alcohol**
- b) What type of organic compound does this image represent? **Aldehyde**
- c) What type of organic compound does this image represent? **Carboxylic acid**
- d) What type of organic compound does this image represent? **Ether**
- e) What type of organic compound does this image represent? **Ester**
- f) What type of organic compound does this image represent? **Alkyne**
- g) What type of organic compound does this image represent? **Amine**
- h) What type of organic compound does this image represent? **Amide**
- i) Does this image represent a carbohydrate, a triglyceride, an amino acid, a protein, or a steroid? **Peptide**
- j) Does this image represent a carbohydrate, a triglyceride, an amino acid, a peptide (not a protein), a protein, or a steroid? **Amino acid**
- k) Does this image represent a carbohydrate, a triglyceride, an amino acid, a peptide (not a protein), a protein, or a steroid? **Steroid**
- l) Does this image represent a carbohydrate, a triglyceride, an amino acid, a peptide (not a protein), a protein, or a steroid? **Triglyceride**
- m) Does this image represent a carbohydrate, a triglyceride, an amino acid, a peptide (not a protein), a protein, or a steroid? **Protein**
- n) Does this image represent glucose or fructose? **Fructose**
- o) Does this image represent α -glucose or β -glucose? **α -glucose**
- p) Is the linkage shown in this structure an $\alpha(1\rightarrow4)$ linkage or a $\beta(1\rightarrow4)$ linkage?
 $\beta(1\rightarrow4)$

35. Consider the following Lewis structure for ethamide, CH_3CONH_2 . (12 points)



What is the hybridization for left carbon atoms? sp^3

What is the hybridization for middle carbon atoms? sp^2

What is the hybridization for the oxygen atom? sp^2

What is the hybridization for the nitrogen atom? sp^2

Write a description of the bonding, stating whether each bond is sigma, pi, or part of a delocalized pi system and by stating which atomic orbitals overlap to form the bonds.

3 σ H-C bonds due to $1s\text{-sp}^3$ overlap

1 σ C-C bonds due to $\text{sp}^3\text{-sp}^2$ overlap

1 σ C-O bonds due to $\text{sp}^2\text{-sp}^2$ overlap

1 σ C-N bonds due to $\text{sp}^2\text{-sp}^2$ overlap

1 delocalized pi system due to p orbitals on O, C, and N overlapping in parallel

What is the name of the electron group geometry around the left carbon atom?

tetrahedral

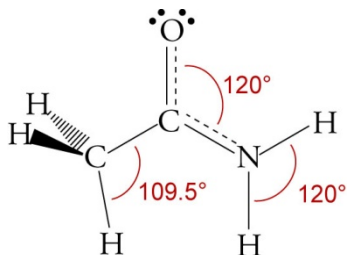
What is the name of the electron group geometry around the middle carbon atom?

trigonal planar

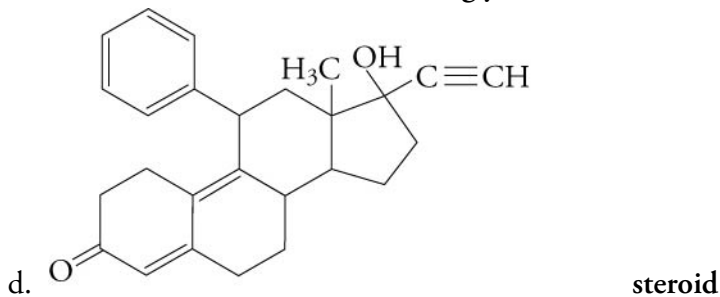
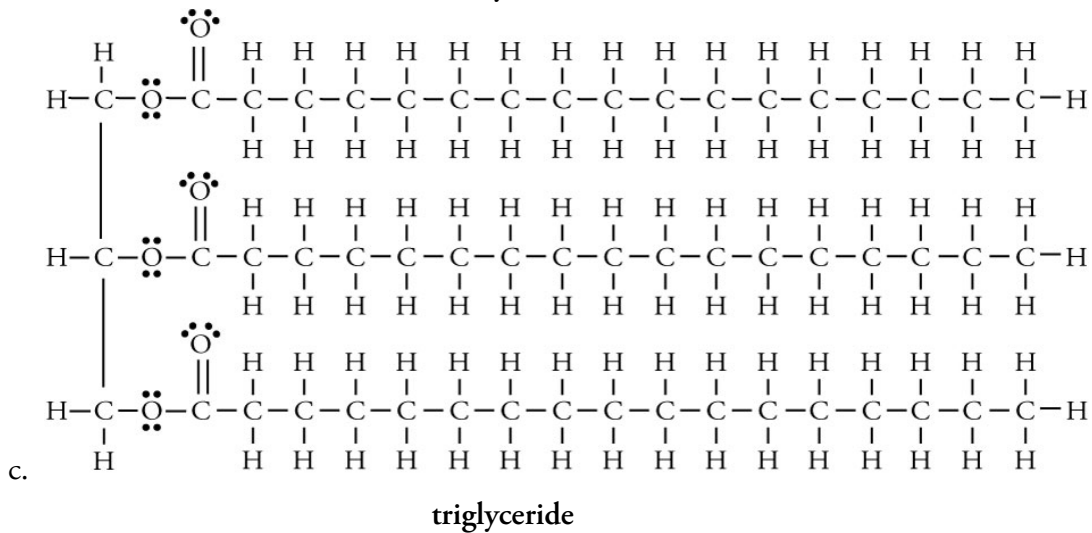
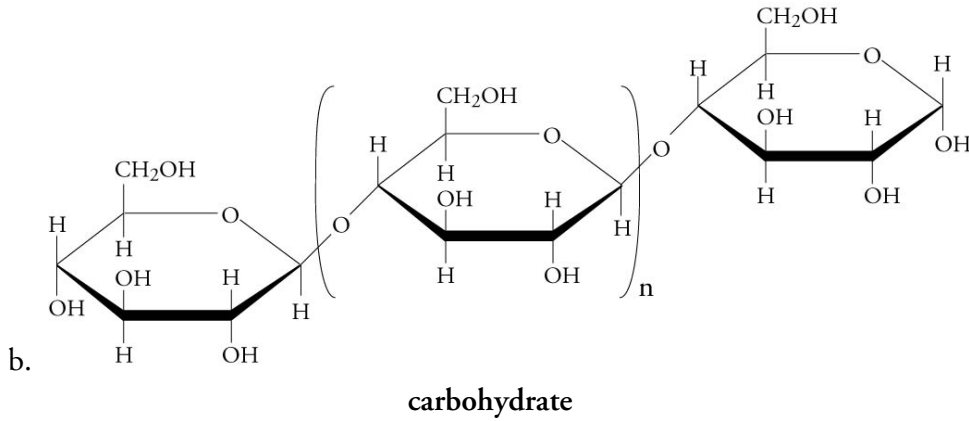
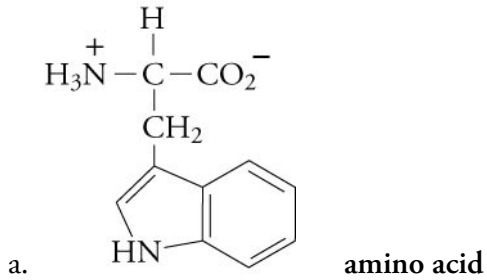
What is the name of the electron group geometry around the nitrogen atom?

trigonal planar

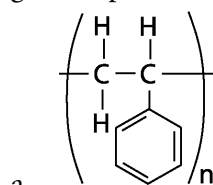
Draw a sketch with bond angles.



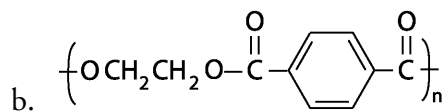
36. Identify each of the following structures as representing a carbohydrate, amino acid, peptide, protein (and peptide), triglyceride, or steroid. (8 points)



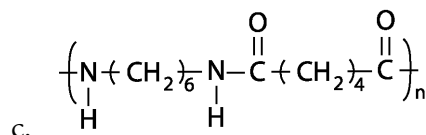
37. Identify each of the following as representing nylon, polyester, polyethylene, poly(vinyl chloride), polypropylene, or polystyrene. (In each case, the n represents some large integer.) (6 points)



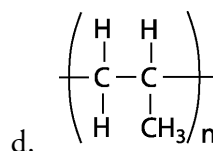
polystyrene



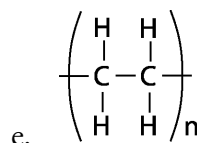
polyester



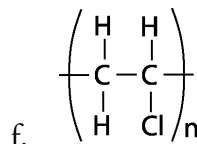
nylon



polypropylene



polyethylene



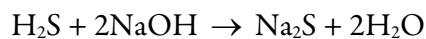
poly(vinyl chloride)

For the following calculations, be sure to show your work and round your final answer off correctly. NOTE: Remember that there is part credit for each problem. Even if you cannot do all of a problem, be sure to set up as much of it as you can.

38. If 21.8 mL of 0.505 M NaOH is required to neutralize 25.00 mL of a phosphoric acid, H_3PO_4 , solution, what is the molarity of the phosphoric acid? (5 points)

$$\begin{aligned} \frac{? \text{ mol H}_3\text{PO}_4}{\text{L H}_3\text{PO}_4 \text{ soln}} &= \frac{21.8 \text{ mL NaOH soln}}{25.00 \text{ mL H}_3\text{PO}_4 \text{ soln}} \left(\frac{0.505 \text{ mol NaOH}}{10^3 \text{ mL NaOH soln}} \right) \left(\frac{1 \text{ mol H}_3\text{PO}_4}{3 \text{ mol NaOH}} \right) \left(\frac{10^3 \text{ mL}}{1 \text{ L}} \right) \\ &= 0.147 \text{ M H}_3\text{PO}_4 \end{aligned}$$

39. When natural gas is heated to 370 °C, the sulfur it contains is converted to hydrogen sulfide. The H₂S gas can be removed by a reaction with sodium hydroxide that forms solid sodium sulfide and water. What is the percent yield of sodium sulfide when 2.1 Mg of Na₂S are recovered from the reaction of 2.7 Mg NaOH and 1.8 × 10³ m³ H₂S at 370 °C and 1.1 atm? (8 points)



$$? \text{ Mg Na}_2\text{S} = 2.7 \text{ Mg NaOH} \left(\frac{1 \times 78.046 \text{ Mg Na}_2\text{S}}{2 \times 39.9971 \text{ Mg NaOH}} \right) = 2.6 \text{ Mg Na}_2\text{S}$$

$$? \text{ Mg Na}_2\text{S} = 1.8 \times 10^3 \text{ m}^3 \text{ H}_2\text{S} \left(\frac{10^3 \text{ L}}{1 \text{ m}^3} \right) \left(\frac{\text{K} \cdot \text{mol}}{0.082058 \text{ L} \cdot \text{atm}} \right) \left(\frac{1.1 \text{ atm}}{643 \text{ K}} \right) \left(\frac{1 \text{ mol Na}_2\text{S}}{1 \text{ mol H}_2\text{S}} \right) \left(\frac{78.046 \text{ g Na}_2\text{S}}{1 \text{ mol Na}_2\text{S}} \right) \left(\frac{1 \text{ Mg}}{10^6 \text{ g}} \right) = 2.9 \text{ Mg Na}_2\text{S}$$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{2.1 \text{ Mg Na}_2\text{S}}{2.6 \text{ Mg Na}_2\text{S}} \times 100 = \mathbf{81\% \text{ yield}}$$

40. Hydrochloric acid, HCl(aq) is used for a variety of purposes, including the removal or metal oxides from metals to prepare them for painting or for the addition of a chrome covering.

- a. What is the density of hydrogen chloride gas at 22 °C and 1.00 bar of pressure? (There are 100 kPa per bar.) (4 points)

$$PV = \frac{g}{M} RT \quad \frac{g}{V} = \frac{PM}{RT} = \frac{1.00 \text{ bar} \left(36.4606 \frac{\text{g}}{\text{mole}} \right) \left(\frac{100 \text{ kPa}}{1 \text{ bar}} \right)}{8.3145 \frac{\text{L} \cdot \text{kPa}}{\text{K} \cdot \text{mole}} (295 \text{ K})} = \mathbf{1.49 \text{ g/L}}$$

- b. Using your density for part (a), calculate the number of tons of 29% by mass hydrochloric acid, HCl(aq), that could be made from 1.1 × 10¹¹ liters of hydrogen chloride gas at 22 °C and 1.00 bar? (There are 2000 lb/ton.) (4 points)

$$? \text{ kg soln} = 1.1 \times 10^{11} \text{ L HCl} \left(\frac{1.49 \text{ g HCl}}{1 \text{ L HCl}} \right) \left(\frac{100 \text{ g soln}}{29 \text{ g HCl}} \right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}} \right) \left(\frac{1 \text{ ton}}{2000 \text{ lb}} \right) = \mathbf{6.2 \times 10^5 \text{ kg hydrochloric acid solution}}$$

Answer the following in short answer form.

41. Explain why each enzyme only acts on a specific molecule or a specific type of reaction.
(6 points)

- **The active site of each enzyme has a physical shape that only allows certain substrates to fit into it.**
- **Binding groups attract specific substrates to the active site, which is the portion of the enzyme where the reaction occurs. The orientation of these groups fit certain groups on certain substrates so that the substrates are placed in the correct orientation to react.**
- **Catalytic groups stabilize the intermediates and therefore speed reactions. The orientation of these groups also fit certain groups on certain substrates.**