Name _____

Chem 150 - Fall 2015
Exam I

- There is periodic table for you to use on the last page of the exam.
- Be certain that what you hand in represents your own work.

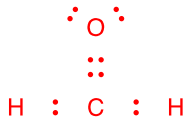
1. For each of the following elements, indicate their number of valence electrons and the number of covent bonds they would normally form as part of molecules.

5/5

	No. valance electrons	No. of bonds
Se	6	2
P	5	3
C	4	4
Br	7	1
H	1	1

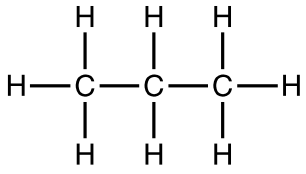
2. Draw the Lewis dot structures for the following molecules

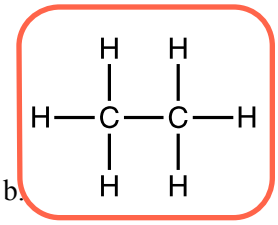
6/6

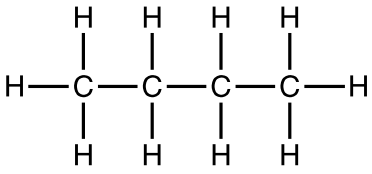
	Lewis dot structure
PH_3	
CH_2O	
HCN	

3. Which of the following compounds has the *weakest dispersion force* between its molecules in its pure form (circle one)?

4/4

a. 

b. 

c. 

4. Which Period 3 element has the lowest affinity for its valence electrons?

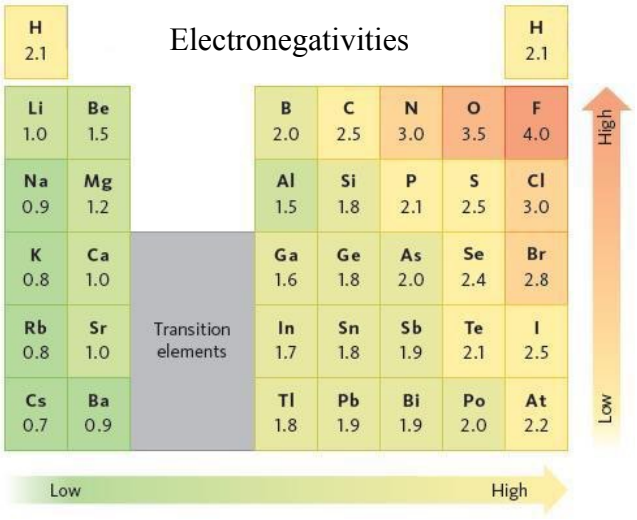
4/4

a. Si

b. P

c. S

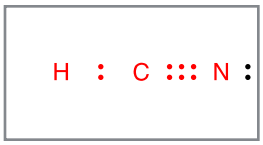
d. Cl



5. Hydrogen cyanide is extremely toxic because it halts cellular respiration. The molecular formula for hydrogen cyanide is HCN

6/6

a. Draw the Lewis dot structure for hydrogen cyanide:



b. Is hydrogen cyanide a polar molecule? (circle one) yes / no

c. If so, which atom is the more negatively charged? N

6. Identify each of the following compounds as either *ionic* or *molecular* (circle one).

5/5

a. BaO ionic / molecular

b. $(NH_4)_2C_2O_4$ ionic / molecular

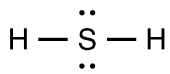
c. NaF ionic / molecular

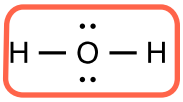
d. CH_2O ionic / molecular

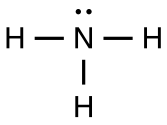
e. PF_3 ionic / molecular

7. The following molecules all have approximately the same molar mass, which is expected to have the *highest* boiling point (circle one)?

4/4

a. 

b. 

c. 

8. Identify whether each of the described energies below are an example of *kinetic* or *potential* energy (circle one)

4/4

a. The dispersion force that exists between molecules kinetic / potential

b. When a ball is thrown straight up into the air, the energy it has when it reaches its highest point before returning back to earth. kinetic / potential

c. The nutritional energy in a slice of pizza kinetic / potential

d. When a ball is thrown straight up into the air, the energy it has as it just leaves your hand kinetic / potential

9. As you heat 352 mL of water from 24°C to 80°C,

   a. Do the average velocities of the water molecules, speed up / slow down / remain the same

10/10

   b. If the density of water is 1.0 g/mL, and the specific heat of water is 1.0 cal/°C-g, how many calories of heat are required to heat the 352 mL of water from 24°C to 80°C?

$$352\ \text{mL}\left(\frac{1.0\ \text{g}}{1\ \text{mL}}\right)\left(\frac{1.0\ \text{cal}}{1\ ^\circ\text{C}\cdot\text{g}}\right)(80^\circ\text{C} - 24^\circ\text{C}) = 19{,}712\ \text{cal} = 2.0 \times 10^4\ \text{cal (2 sig.figs.)}$$

2.0×10^4 cal

   c. Describe what will happen to the water if you continue to add heat (thermal energy) to the water after it reaches 80°C

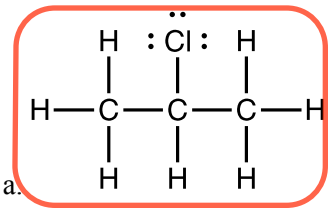
It will continue to warm up until reaching 100°C, at which point, the temperature will stop changing and the liquid water will change to water vapor. When all of the liquid water has converted to water vapor, the temperature will once again to rise.

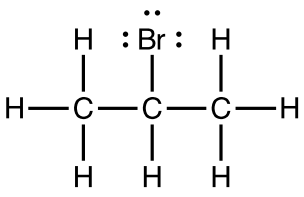
   d. Water (H_2O) has a very high melting point compared to other molecules of similar size and composition, *e.g.*, H_2S, CH_4, NH_3, HF, which unlike water are all gases at room temperature. Explain why water stands out among this group

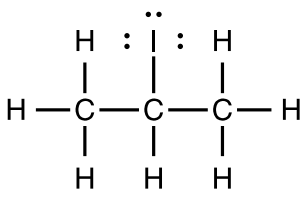
Water molecules have much stronger intermolecular interactions with their neighbors than the other molecules in this list. In addition to dispersion interactions, it is polar and can hydrogen bond to four of its neighbors simultaneously, while each neighbor can do the same.

10. Which of the following compounds has the *weakest dispersion force* between its molecules when in its pure form (circle one)?

4/4

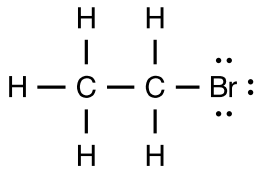
a. 

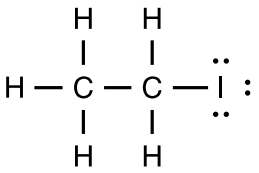
b. 

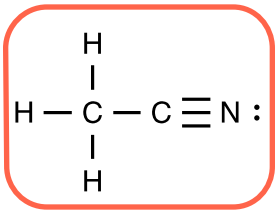
c. 

11. Which of the following compounds contains a covalent bond that is strongly polar (circle one)?

4/4

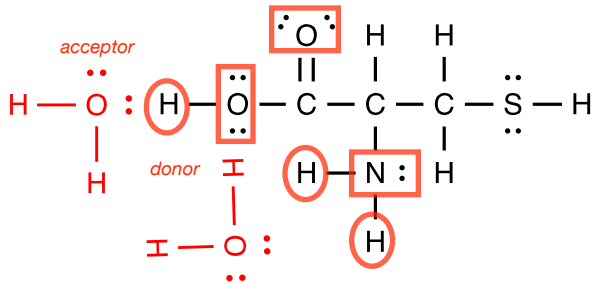
a. 



c. 

12. Shown below is the structural formula for the amino acid cysteine?

8/8



a. *Circle* all of the hydrogen atoms that can participate in hydrogen bonds.

b. Draw a *square* around each of the atoms that can serve as an acceptor in a hydrogen bond.

c. Draw one example of a water molecule hydrogen bonding to cysteine with the water molecule serving as the *acceptor*.

d. Draw one example of a water molecule hydrogen bonding to cysteine with the water molecule serving as the *donor*.

13. Which of the following compounds is expected to be the *least* soluble in water (circle one)?

4/4

a. $CH_3-CH_2-CH_2-CH_3$ b. $HO-CH_2-CH_2-CH_3$ c. $HO-CH_2-CH_2-OH$

14. When hydrochloric acid reacts with potassium monohydrogen phosphate in solution to form potassium dihydrogen phosphate, and potassium chloride, 28.2 kcal of heat are released into the surroundings per mole of potassium monohydrogen phosphate that reacts.

a. If this reaction is carried out in a beaker, how does the beaker feel to the touch (circle one)?
warmer / cooler / unchanged

6/6

b. Using chemical formulas, write the net ionic equation for this reaction, which also includes the heat that is released in the reaction.

molecular: $HCl_{(aq)} + K_2HPO_{4(aq)} \longrightarrow KH_2PO_{4(aq)} + KCl_{(aq)} + 28.2\ kcal$

(acid, base, conjugate acid, conjugate acid)

TIE: $H^+ + Cl^- + 2K^+ + HPO_4^{2-} \longrightarrow K^+ + H_2PO_4^- + K^- + Cl^- + 28.2\ kcal$

NIE: $H^+ + HPO_4^{2-} \longrightarrow H_2PO_4^- + 28.2\ kcal$

c. This is an acid base reaction. For each species in your balance chemical equation, use labels to identify the *acid*, the *base*, the *conjugate acid*, and the *conjugate base.*

15. The gasoline that is sold today can contains up to 85% ethanol (CH_3-CH_2-OH) by weight, which is produced from renewable sources.

a. Write a balanced chemical equation for the complete combustion of ethanol to CO_2 and H_2O

8/8

$$C_2H_6O + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

b. One ounce of ethanol weights 28.4 g. If 331 kcal of heat are released per mole of ethanol that undergoes combustion, how many kcal of heat are released from the burning of 3 ½ ounces of ethanol. (molar mass of C_2H_6O = 46.0682 g/mole)

$$3.5\ oz\ C_2H_6O\left(\frac{28.4\ g\ C_2H_6O}{1\ oz\ C_2H_6O}\right)\left(\frac{1\ mol\ C_2H_6O}{46.0682\ g\ C_2H_6O}\right)\left(\frac{331\ kcal}{1\ mol\ C_2H_6O}\right) = 714\ kcal$$

7.1×10^2 kcal (2 sig figs.)

16. For a 0.080 M solution of potassium monohydrogen phosphate,

$K_2HPO_4 \xrightarrow{H_2O} 2K^+ + HPO_4^{2-}$ $\left(\frac{0.080 \text{ mol } KH_2PO_4}{L}\right)\left(\frac{2 \text{ mol } K^+}{1 \text{ mol } KH_2PO_4}\right) = 0.160 \text{ M } K^+/L$

a. What is the molar concentration of potassium ions?

0.160 M K^+

8/8

$\left(\frac{0.080 \text{ mol } KH_2PO_4}{L}\right)\left(\frac{1 \text{ mol } HPO_4^{2-}}{1 \text{ mol } KH_2PO_4}\right) = 0.080 \text{ M } HPO_4^{2-}/L$

b. What is the molar concentration of monohydrogen phosphate ions

0.080 M HPO_4^{2-}

$\left(\frac{0.160 \text{ mol } K^+}{L}\right)\left(\frac{1 \text{ Eq } K^+}{1 \text{ mol } K^+}\right)\left(\frac{1{,}000 \text{ mEq } K^+}{1 \text{ Eq } K^+}\right) = 160. \text{ mEq } K^+/L$

c. What is the concentration of potassium ions in units of mEq/L?

160 mEq K^+/L

$\left(\frac{0.080 \text{ mol } HPO_4^{2-}}{L}\right)\left(\frac{2 \text{ Eq } HPO_4^{2-}}{1 \text{ mol } HPO_4^{2-}}\right)\left(\frac{1{,}000 \text{ mEq } H_2PO_4^-}{1 \text{ Eq } H_2PO_4^-}\right) = 160. \text{ mEq } H_2PO_4^-/L$

d. What is the concentration of monohydrogen phosphate ions in mEq/L?

160 mEq HPO_4^{2-}/L

17. A 0.200 M solution of lactic acid ($HC_3H_5O_3$) is determined to have a *pH* of 2.30. What are the concentrations of hydronium ion (H_3O^+) and hydroxide ion (OH^-) in this solution?

a. $[H_3O^+]$ = 5.0x10^{-3} M

$[H_3O^+] = 10^{-pH}$

$= 10^{-2.30}$

$= 5.0\text{x}10^{-3}$ M

$[OH^-] = \frac{K_w}{[H_3O^+]}$

$= \frac{1.0\text{x}10^{-14} \text{ M}^2}{5.0\text{x}10^{-3} \text{ M}}$

$= 2.0\text{x}10^{-12}$ M

10/10

b. $[OH^-]$ = 2.0x10^{-12} M

(Lactic acid is a weak acid, because if it were a strong acid, the hydronium ion concentration would be 0.200 M not 0.0050 M.)

c. Is lactic acid a weak or a strong acid (circle one) (weak) / strong

d. The conjugate base for lactic acid is the lactate ion.

Write the chemical formula for the lactate ion $C_3H_5O_3^-$

e. If the pK_a for lactic acid is 3.90, what is the *pH* of a solution made by mixing equal amounts of lactic acid and sodium lactate?

pH = 3.90

f. Explain what this solution could be used for?

It is good for buffering or resisting changes in the *pH* when the *pH* is around 3.90. A buffer is a mixture of a weak acid in the presence of its conjugate base, and it works best as a buffer when there is an equal ratio of the two. It does this by having the conjugate base (lactate ion) react with strong acids to produce a weak acid (lactic acid), or by reacting the weak acid (lactic acid with a strong base to produce a weak base (lactate ion).

100/100

Periodic Table of the Elements

1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8.A
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 2.1 **H** 1.00794(7)																	helium 2 **He** 4.002602(2)
lithium 3 1.0 **Li** 6.941(2)	beryllium 4 1.5 **Be** 9.012182(3)											boron 5 2.0 **B** 10.811(7)	carbon 6 2.5 **C** 12.0107(8)	nitrogen 7 3.0 **N** 14.0067(7)	oxygen 8 3.5 **O** 15.9994(3)	fluorine 9 4.0 **F** 18.9984032(5)	neon 10 **Ne** 20.1797(6)
sodium 11 0.9 **Na** 22.989770(2)	magnesium 12 1.2 **Mg** 24.3050(6)											aluminium 13 1.5 **Al** 26.981538(2)	silicon 14 1.8 **Si** 28.0855(3)	phosphorus 15 2.1 **P** 30.973761(2)	sulfur 16 2.5 **S** 32.065(5)	chlorine 17 3.0 **Cl** 35.453(2)	argon 18 **Ar** 39.948(1)
potassium 19 0.8 **K** 39.0983(1)	calcium 20 1.0 **Ca** 40.078(4)	scandium 21 **Sc** 44.955910(8)	titanium 22 **Ti** 47.867(1)	vanadium 23 **V** 50.9415(1)	chromium 24 **Cr** 51.9961(6)	manganese 25 **Mn** 54.938049(9)	iron 26 **Fe** 55.845(2)	cobalt 27 **Co** 58.933200(9)	nickel 28 **Ni** 58.6934(4)	copper 29 **Cu** 63.546(3)	zinc 30 **Zn** 65.38(2)	gallium 31 1.6 **Ga** 69.723(1)	germanium 32 1.8 **Ge** 72.64(1)	arsenic 33 2.0 **As** 74.92160(2)	selenium 34 2.4 **Se** 78.96(3)	bromine 35 2.8 **Br** 79.904(1)	krypton 36 **Kr** 83.798(2)
rubidium 37 0.8 **Rb** 85.4678(3)	strontium 38 1.0 **Sr** 87.62(1)	yttrium 39 **Y** 88.90585(2)	zirconium 40 **Zr** 91.224(2)	niobium 41 **Nb** 92.90638(2)	molybdenum 42 **Mo** 95.96(2)	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07(2)	rhodium 45 **Rh** 102.90550(2)	palladium 46 **Pd** 106.42(1)	silver 47 **Ag** 107.8682(2)	cadmium 48 **Cd** 112.411(8)	indium 49 1.7 **In** 114.818(3)	tin 50 1.8 **Sn** 118.710(7)	antimony 51 1.9 **Sb** 121.760(1)	tellurium 52 2.1 **Te** 127.60(3)	iodine 53 2.5 **I** 126.90447(3)	xenon 54 **Xe** 131.293(6)
caesium 55 0.7 **Cs** 132.90545(2)	barium 56 0.9 **Ba** 137.327(7)	lutetium 71 **Lu** 174.9668(1)	hafnium 72 **Hf** 178.49(2)	tantalum 73 **Ta** 180.9479(1)	tungsten 74 **W** 183.84(1)	rhenium 75 **Re** 186.207(1)	osmium 76 **Os** 190.23(3)	iridium 77 **Ir** 192.217(3)	platinum 78 **Pt** 195.078(2)	gold 79 **Au** 196.96655(2)	mercury 80 **Hg** 200.59(2)	thallium 81 1.8 **Tl** 204.3833(2)	lead 82 1.9 **Pb** 207.2(1)	bismuth 83 1.9 **Bi** 208.98038(2)	polonium 84 2.0 **Po** [209]	astatine 85 2.2 **At** [210]	radon 86 **Rn** [222]
francium 87 0.7 **Fr** [223]	radium 88 0.9 **Ra** [226]	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [267]	dubnium 105 **Db** [268]	seaborgium 106 **Sg** [271]	bohrium 107 **Bh** [272]	hassium 108 **Hs** [270]	meitnerium 109 **Mt** [276]	darmstadtium 110 **Ds** [281]	roentgenium 111 **Rg** [280]	ununbium 112 **Uub** [285]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	ununhexium 116 **Uuh** [293]	ununseptium 117 **Uus** —	ununoctium 118 **Uuo** [294]

Key:

element name
atomic number EN
symbol
2003 atomic weight (mean relative mass)

Lanthanoids	lanthanum 57 **La** 138.9055(2)	cerium 58 **Ce** 140.116(1)	praseodymium 59 **Pr** 140.90765(2)	neodymium 60 **Nd** 144.24(3)	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36(3)	europium 63 **Eu** 151.964(1)	gadolinium 64 **Gd** 157.25(3)	terbium 65 **Tb** 158.92534(2)	dysprosium 66 **Dy** 162.500(1)	holmium 67 **Ho** 164.93032(2)	erbium 68 **Er** 167.259(3)	thulium 69 **Tm** 168.93421(2)	ytterbium 70 **Yb** 173.054(5)
Actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.0381(1)	protactinium 91 **Pa** 231.03588(2)	uranium 92 **U** 238.02891(3)	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]