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.

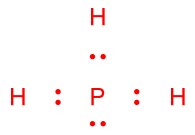
1. For each of the following elements, indicate their number of valence electrons and the number of covent bonds they would normally form as part of molecules.

5/5

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

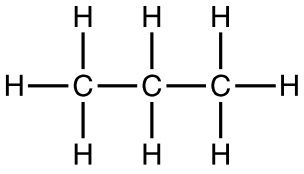
2. Draw the Lewis dot structures for the following molecules

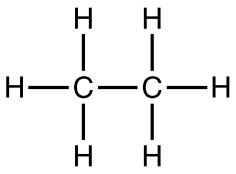
6/6

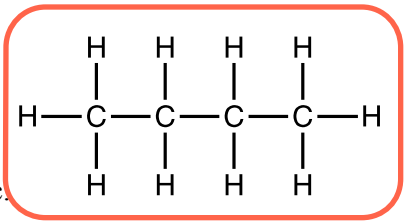
	Lewis dot structure
PH_3	
CH_2O	
HCN	

3. Which of the following compounds has the *strongest 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 valence electrons?

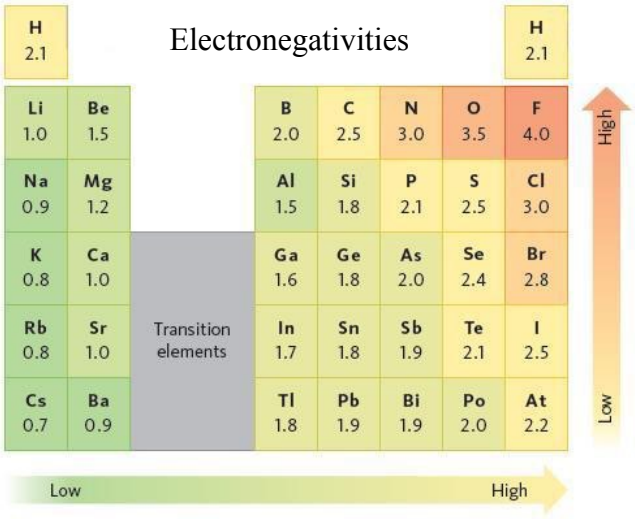
4/4

a. Si

b. P

c. S

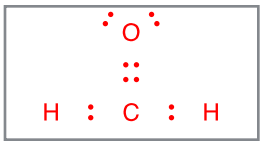
d. Cl



5. Formaldehyde is toxic because it is highly reactive with biological molecules. The molecular formula for formaldehyde is CH_2O

6/6

a. Draw the Lewis dot structure for hydrogen formaldehyde:



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

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

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

5/5

a. PF_3 ionic / molecular

b. $(NH_4)_2C_2O_4$ ionic / molecular

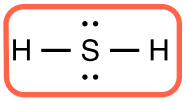
c. BaO ionic / molecular

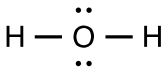
d. NaF ionic / molecular

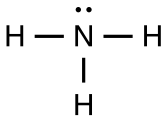
e. CH_2O ionic / molecular

7. The following molecules all have approximately the same molar mass, which is expected to have the *lowest* 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 as it just leaves your hand 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 when it reaches its highest point before returning back to earth. kinetic / potential

9. As you cool 252 mL of water from 80°C to 24°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 cool the 252 mL of water from 80°C to 24°C?

$$252\ \text{mL}\left(\frac{1.0\ \text{g}}{1\ \text{mL}}\right)\left(\frac{1.0\ \text{cal}}{1\ ^\circ\text{C}\cdot\text{g}}\right)(24^\circ\text{C} - 80^\circ\text{C}) = -14{,}112\ \text{cal} = -1.4 \times 10^4\ \text{cal (2 sig.figs.)}$$

-1.4 x 10^4 cal

   c. Describe what will happen to the water if you continue to remove heat (thermal energy) from the water after it reaches 24°C

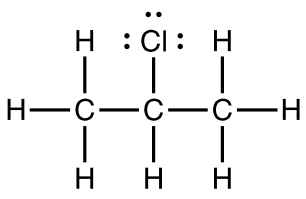
It will continue to cool down until reaching 0°C, at which point, the temperature will stop changing and the liquid water will change to ice. When all of the liquid water has converted to ice, the temperature will once again start cooling.

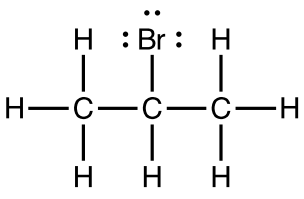
   d. Water (H_2O) has a very high melting point compared to other molecules of similar size and composition, *e.g.*, H_2S, CH_4, NH_3, HF, which unlike water are all gases at room temperature. Explain why water stands out among this group

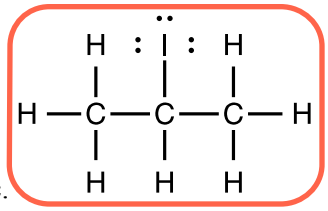
Water molecules have much stronger intermolecular interactions with their neighbors than the other molecules in this list. In addition to dispersion interactions, it is polar and can hydrogen bond to four of its neighbors simultaneously, while each neighbor can do the same.

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

4/4

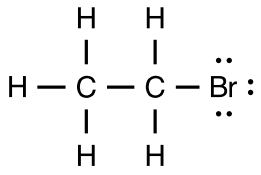
a. 

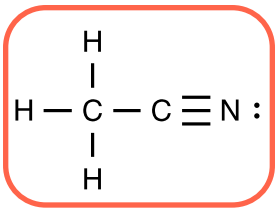
b. 

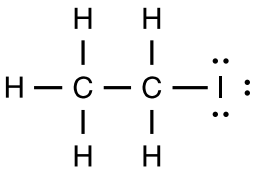
c. 

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

4/4

a. 

b. 

c. 

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

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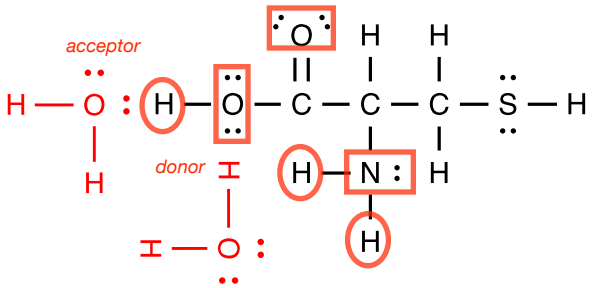

a. *Circle* all of the hydrogen atoms that can participate in hydrogen bonds.

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 *most* 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 absorbed from 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 absorbed in the reaction.

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

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

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

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 2 ½ ounces of ethanol. (molar mass of C_2H_6O = 46.0682 g/mole)

$$2.5\ oz\ C_2H_6O\left(\frac{28.4\ g\ C_2H_6O}{1\ oz\ C_2H_6O}\right)\left(\frac{1\ mol\ C_2H_6O}{46.0682\ g\ C_2H_6O}\right)\left(\frac{331\ kcal}{1\ mol\ C_2H_6O}\right) = 510\ kcal$$

5.1×10^2 kcal (2 sig figs.)

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

$KH_2PO_4 \xrightarrow{H_2O} K^+ + H_2PO_4^-$ $\left(\frac{0.080\ mol\ KH_2PO_4}{L}\right)\left(\frac{1\ mol\ K^+}{1\ mol\ KH_2PO_4}\right) = 0.080\ M\ K^+/L$

a. What is the molar concentration of potassium ions?

0.080 M K^+

8/8

$\left(\frac{0.080\ mol\ KH_2PO_4}{L}\right)\left(\frac{1\ mol\ K^+}{1\ mol\ H_2PO_4^-}\right) = 0.080\ M\ K^+/L$

b. What is the molar concentration of dihydrogen phosphate ions

0.080 M $H_2PO_4^-$

$\left(\frac{0.080\ mol\ K^+}{L}\right)\left(\frac{1\ Eq\ K^+}{1\ mol\ K^+}\right)\left(\frac{1{,}000\ mEq\ K^+}{1\ Eq\ K^+}\right) = 80.\ mEq\ K^+/L$

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

80 mEq K^+/L

$\left(\frac{0.080\ mol\ H_2PO_4^-}{L}\right)\left(\frac{1\ Eq\ H_2PO_4^-}{1\ mol\ H_2PO_4^-}\right)\left(\frac{1{,}000\ mEq\ H_2PO_4^-}{1\ Eq\ H_2PO_4^-}\right) = 80.\ mEq\ H_2PO_4^-/L$

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

80 mEq $H_2PO_4^-$/L

17. A 0.400 M solution of lactic acid ($HC_3H_5O_3$) is determined to have a *pH* of 2.15. What are the concentrations of hydronium ion (H_3O^+) and hydroxide ion (OH^-) in this solution?

a. $[H_3O^+]$ = 7.1x10^{-3} M

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

$= 10^{-2.15}$

$= 7.1\times10^{-3}$ M

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

$= \frac{1.0\times10^{-14}\ M^2}{7.1\times10^{-3}\ M}$

$= 1.4\times10^{-12}$ M

10/10

b. $[OH^-]$ = 1.4x10^{-12} M

(Lactic acid is a weak acid, because if it were a strong acid, the hydronium ion concentration would be 0.400 M not 0.0071 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]