The CHEM124 Workbook

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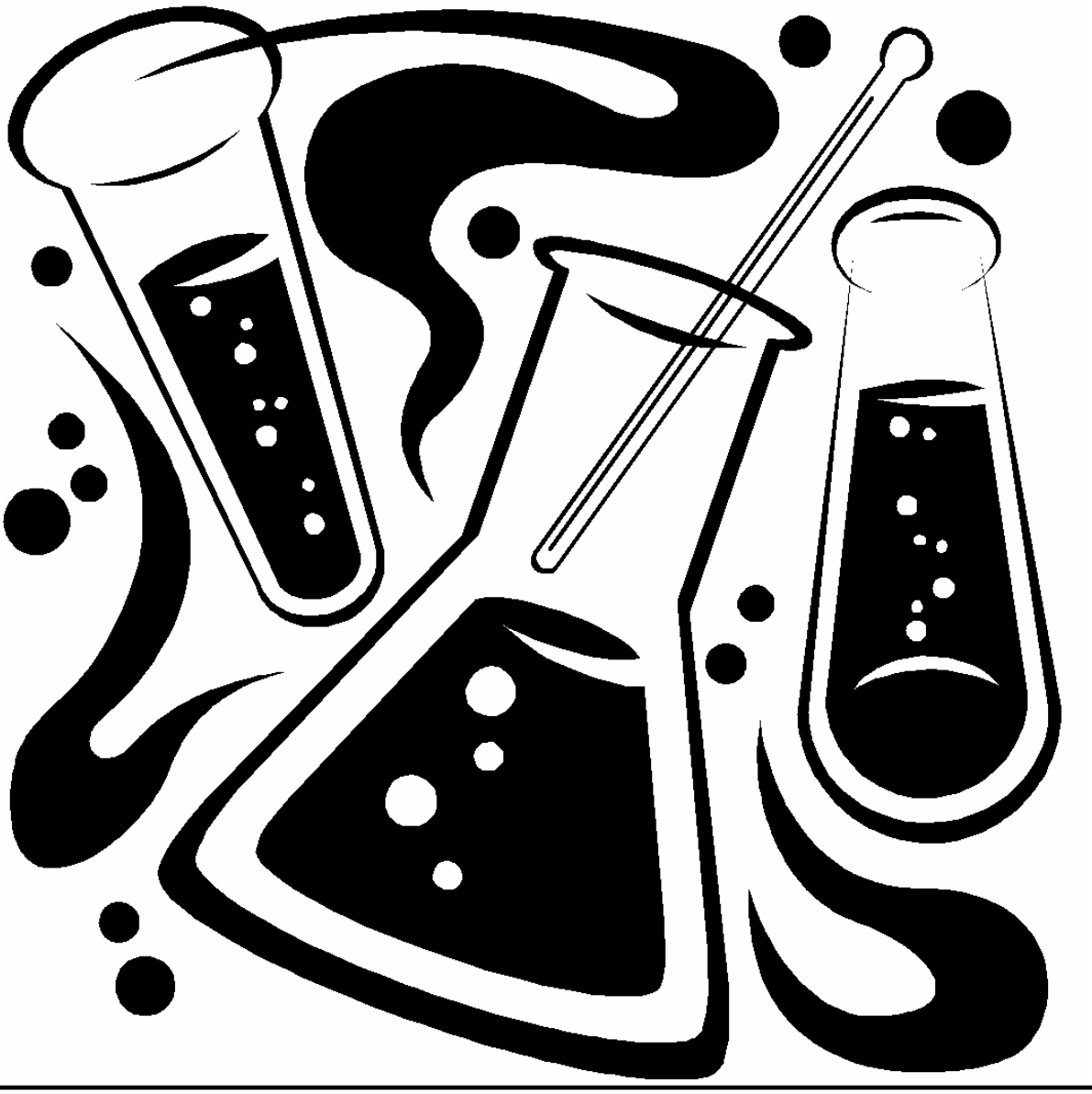

By Brent Huigens and Cal Poly Chemistry Faculty

PERIODIC CHART OF THE ELEMENTS

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H 1.0																1 H 1.0	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (99)	44 Ru 101.0	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3 ●	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.0	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226) ✚	103 Lr (257)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh	108 Hs	109 Mt	110	111							

● Lanthanides

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0

✚ Actinides

89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (253)

104-109 named by IUPAC

Spring, 1997 Atwood

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Special Thanks

CHEM124 workbook was created in cooperation with the Department of Chemistry and Bio Chemistry at California Polytechnic State University - San Luis Obispo, California.

******PLEASE TAKE 5 MINUTES TO READ THE FOLLOWING*****

As an author of this workbook and accompanying website solutions, and because I'm also a student at Cal Poly who's "been there", I feel compelled to share the following:

This workbook will not help you if watching the online video is all that's done in preparation for quizzes and tests. It is very important that each problem be attempted at length, prior to viewing the video solution online.

As a student, I understand completely that when it comes to studying, shorter is better; it feels very tedious to work on a single problem for 20 minutes and not reach a solution. However, the time you spend struggling is as important as getting the right answer. After struggling with a problem, when you finally reach the solution, you're less likely to forget the process that led you to the solution…good grades become easier.

Struggling with a problem is the MOST important and valuable part of studying…and yes it's the worst part about school. But, come test time, you won't regret it, I promise.

Always work hard and be efficient. Good luck.

Brent Huigens
5th Year Materials Engineering Student

Comments or questions about anything associated with the workbook or the accompanying website? Please don't hesitate to contact me @

huigensr@yahoo.com

Section 1: Thermochemistry

1) What is the equation for the total internal energy of a system? What is the value of the work and heat if each energy form leaves the system?

2) A cordless fan and its battery do 250kJ of work. The fan also gives off 50kJ of heat due to friction, and the battery gives off 30kJ of heat. What is the change in internal energy of the system? (assume the system is the fan and its battery)

3) Write the balanced chemical equation or balanced thermochemical equation for each situation:

   a. When Iron III metal is mixed with aqueous hydrochloric acid, a gas is given off and the resulting solution is clear and colorless.

   b. Carbon dioxide gas reacts with nitrogen gas to produce carbon monoxide gas and nitrogen monoxide gas. 373kJ of heat is taken in with this process.

4) Describe the difference between $\Delta H°_f$, $\Delta H°_{rxn,}$ ΔH_{rxn}, ΔH_{fusion}, $\Delta H_{vaporization}$, and $\Delta H_{sublimation}$. What is the purpose of each enthalpy form? How/where are they applied?

5) What is the difference between an endothermic and exothermic reaction? How does this relate to sign of enthalpy?

6) a. Would the products or reactants of an exothermic reaction have higher thermal energy on an enthalpy diagram? Draw an enthalpy diagram to represent a generic exothermic reaction.

b. In an exothermic reaction, do the products or the reactants have stronger bonds? Explain the logic of why this is true.

c. In an endothermic reaction, do the products or the reactants have stronger bonds? Explain the logic of why this is true.

d. Would the products or reactants of an endothermic reaction have higher thermal energy on an enthalpy diagram? Draw an enthalpy diagram to represent a generic endothermic reaction.

7) What is entropy? What are the 5 criteria you must consider when trying to determine whether a given reaction corresponds to an entropy increase or decrease?

8) What is ΔS? $S°$? $\Delta S°_{rxn}$? ΔS_{rxn}? How are they calculated/where are they used?

9) What does it mean to describe a reaction as spontaneous? How does ΔG relate to spontaneity? Does ΔG° relate to spontaneity? If not, what does ΔG° relate to? How are ΔG and ΔG° calculated? Are they calculated using the same equation or is it only a similar equation?

10) Are all exothermic reactions spontaneous? If not, what could overpower the enthalpy to make the free energy positive?

11) What does it mean to say that a reaction is enthalpy driven? entropy driven? What is the sign of the variable (ΔH or ΔS) for each case?

12) Which substance has the greater entropy? Assume substances exist in one mole amounts, unless otherwise shown.

a. H_20 (g) or H_20(l)

b. $2H_20$ (g) or H_20 (g)

c. H_20 (g) @ 25°C or H_20 (g) @ 100°C

d. H_20_2 (g) or H_20 (g)

e. F_2 (g) or Br_2 (g)

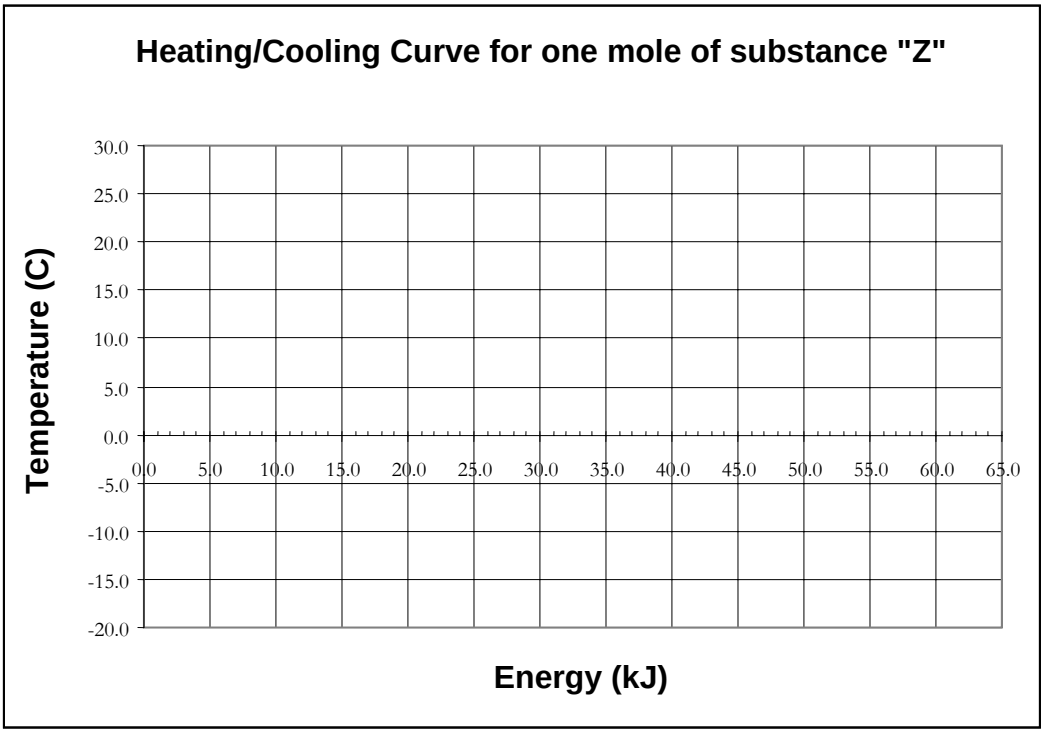
13) Thermite welding involves an exothermic reaction between iron (III) oxide and aluminum according to the following balanced equation:

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s) \qquad \Delta H_{rxn} = -847.5 \text{ kJ}$$

This reaction is used to weld railroad tracks together, as well as for underwater welding of oil rigs, etc.

Assume you are provided with 100.g of iron oxide powder, and excess amounts of Al powder to ensure that the 100.g of iron oxide fully reacts. How many moles of water (initially at 25°C) could be brought to the normal boiling temperature, using the exothermic heat of the reaction of 100.g of Fe_2O_3?

14) Below is a blank grid for drawing the heating/cooling curve for one mole of a yet to be named substance, "Z". See page 424 in your textbook for a similar curve.



a. Starting at the origin, draw a heating cooling curve (actually straight lines…connect the dots) for substance "Z", which meets the following criteria:

- "Z" melting at 5°C and vaporizing at 25°C
- 20 kJ/mol to change "Z" from a solid to a liquid (ΔH_{fusion})
- 10 kJ for substance "Z" to pass from its melting temperature (after becoming fully liquid) to its boiling temperature (before it becomes steam)
- 25 kJ/mol to change "Z" from a liquid to a gas ($\Delta H_{vaporization}$)

b. Label the solid, liquid, and gas phases on the graph. Label the phase changes with the appropriate ΔH.

c. Assuming the atomic mass of substance "Z" is 125g/mol, and that 500g of "Z" is present, what is the heat (in kJ) associated with fusing and vaporizing this 500 g sample of substance "Z"?

d. What is the specific heat of substance "Z" in its solid state?

15) Ammonium nitrate, when dissolved with water, produces a cooling effect by drawing heat out from the water. This is why NH_4NO_3 is used in cold-packs for athletic injuries. When the pack is squeezed, the ammonium nitrate dissolves, forming an aqueous solution. The thermochemical equation for the dissolving of ammonium nitrate in water is as follows:

$$NH_4NO_3\,(s) \rightarrow NH_4NO_3\,(aq) \qquad \Delta H_{rxn} = +25.7\ kJ$$

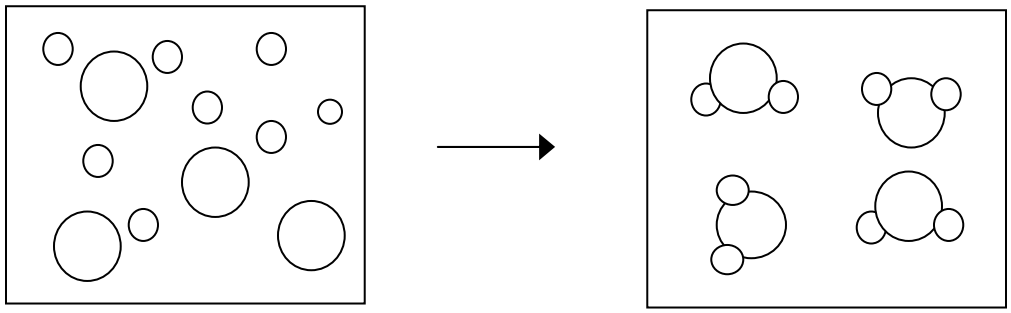
Assuming that 25g of ammonium nitrate is added to 150mL of water (starting at 25°C), what will be the final temperature of the cold pack, after all 25g has dissolved? (density of water, 1.00g/mL)

16) a. The information provided below pertains to the formation of ozone from its reactants. Find the standard free energy (ΔG°) of this process at 25°C, using the information provided:

	O (g)	**+**	**O_2 (g)**	**→**	**O_3 (g)**
$\Delta H°_f$ (kJ/mol	249.2		0		143
S° (J/K•mol	160.9		205.0		238.8

b. Find the temperature (°C) at which the ΔG° for this process changes from positive to negative.

17) The following reaction is spontaneous and involves X atoms (big circles) and Y atoms (small circles):



a. Write a balanced chemical equation for the above reaction. Be sure to include phase labels for the reactants and products.

b. What are the signs (positive or negative) of ΔH, ΔS, and ΔG for the above reaction? Fully explain your answer.

18) How much heat energy is required to heat 96g of water from 20.0°C to 156°C? From 156°C to 20°C? (specific heat of water vapor = 1.839 J/g °C)

19) 67g of solid copper is cooled to -28°C in a freezer. The Cu is then dropped into a Styrofoam cup, containing 156mL of water initially at 46°C. What is the final temperature once thermal equilibrium is reached? (specific heat of Cu = 0.387 J/g °C; ΔH_{vap} (water)= 40.7kJ/mol)

20) How many grams of Al, initially at 267°C would be needed to completely vaporize 25.0g of water, initially at 20.0°C? (specific heat of Al = 0.90 J/g °C; ΔH_{vap} (water)= 40.7kJ/mol)

21) Consider the following reaction:

$$3Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g) \qquad \Delta H_{rxn} = -48.5 \text{ kJ}$$

a. Is this reaction endothermic or exothermic?

b. How much heat is produced when 56g of iron(III) oxide is reacted? Assume there is excess carbon monoxide to ensure the iron oxide reacts fully.

c. If an enthalpy change of 186 kJ is observed, how many grams of Fe_2O_3 are produced? Of CO?

d. How many kilojoules of heat are exchanged when 34g of Fe_3O_4 (with excess carbon dioxide) is decomposed into iron oxide and carbon monoxide? Is this reaction endothermic or exothermic? What would be the sign of the ΔH_{rxn}?

22) Suppose you want to make some hot chocolate with 1.00×10^3 g of H_2O. The water from the tap is 15°C, but you need it make it 85°C. Your only heat source is a propane stove, which combusts propane according to the following reaction:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_20(g) \quad \Delta H_{rxn} = -2044 \text{ kJ}$$

How much propane, in grams, must you burn to heat the water fully?

23) a. Use the following thermochemical equations to find the ΔH_{rxn} pertaining to the formation of carbon monoxide from its elements:

$$Pb(s) + CO(g) \rightarrow PbO(s) + C(s) \qquad \Delta H_{rxn} = -106.8 \text{ kJ}$$
$$Pb(s) + 1/2O_2(g) \rightarrow PbO(s) \qquad \Delta H_{rxn} = -217.3 \text{ kJ}$$

b. If 200.g of carbon monoxide was formed from its elements (carbon and oxygen), what would be the enthalpy change associated with the reaction? How much carbon was used to produce all the carbon monoxide? Would you guess this reaction is spontaneous at high temperatures, low temperatures, or both? Explain.

24) Iron (III) oxide can be obtained from a reaction of iron metal and carbon dioxide gas, according to the following equation:

$$2Fe(s) + 3CO_2(g) \rightarrow Fe_2O_3(s) + 3CO(g)$$

Find the ΔH_{rxn} for this process, given the following information. Show all your work explicitly.

$3Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g)$ $\Delta H_{rxn} = -48.5$ kJ
$Fe(s) + CO_2(g) \rightarrow FeO(s) + CO(g)$ $\Delta H_{rxn} = -11.0$ kJ
$Fe_3O_4(s) + CO(g) \rightarrow 3FeO(s) + CO_2(g)$ $\Delta H_{rxn} = +22.0$ kJ

Section 2: Quantum Mechanics and Electron Configurations

Light Energy:

1) What two terms define a light wave's energy, according to the equations we use? Are these both directly proportional to a wave's energy? Are they independent of each other?

2) Does amplitude affect a light-wave's energy? Explain.

3) What is the range of wavelengths for visible light? What colors correspond to these wavelengths? Which color has the highest energy?

4) What is the range of wavelengths for "invisible" light (everything other than the visible range); i.e. microwave to X-ray? From the book, what type of ray pertains to these wavelengths? Which ray has the highest energy? In general, are microwaves considered a high or low source of energy?

5) Light energy is quantized. What does this mean? How does this effect our three (yes there are three) biggest equations concerning light energy?

6) Which electron transition in the hydrogen atom involves more energy: **level 1→4** or **level 4→1**? Do these values differ from one another? What equation solves for the energy exchange of transitioning electrons (between various energy levels)?

7) Which electron transition in the hydrogen atom involves a shorter wavelength: **level 1→4** or **level 4→1**? Do these two wavelengths differ from one another? What equation solves for the wavelengths associated with transitioning electrons (between various energy levels)?

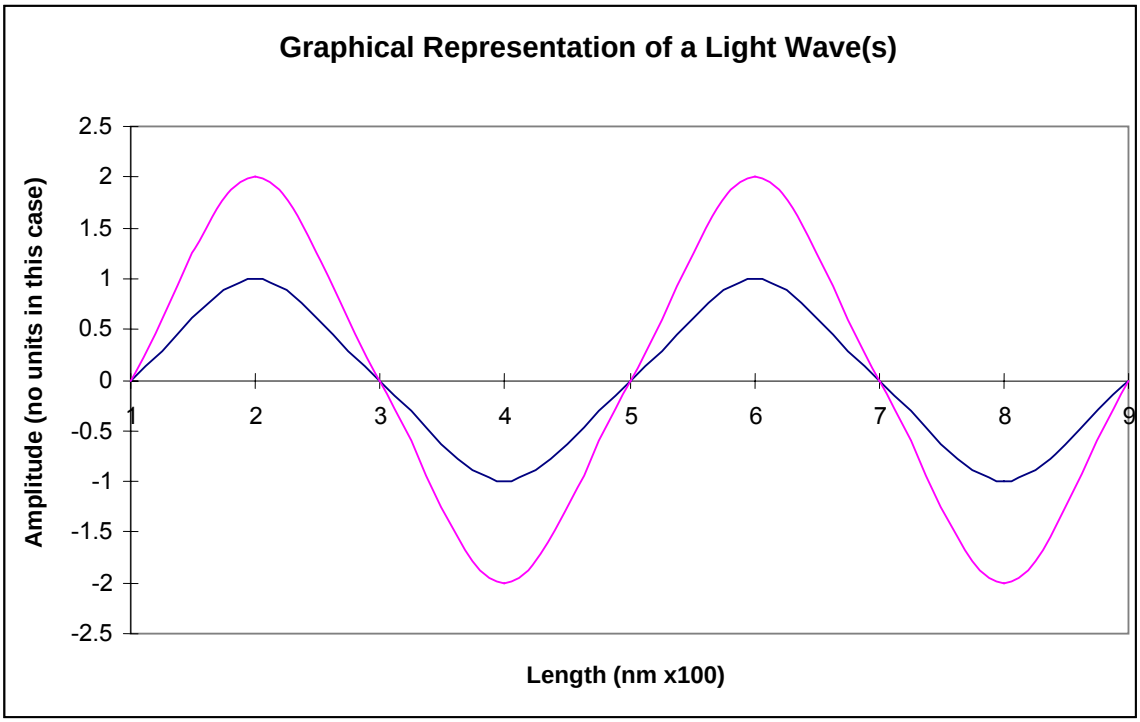
8) How does the distance between energy levels change as we move away from the nucleus? Does it take more energy to travel from energy level **n=1→n=2** or **n=2→n=3**?

9) What equation is used to calculate the wavelength of moving matter? (make sure you know what each term in this equation stands for!)

10) What is the Heisenburg uncertainty principal? What equation solves for this uncertainty? (again…know the terms!)

11) What does Schroedinger's wave equation relate to? What does Ψ^2 tell us? How does the Ψ^2 value change as we move away from the nucleus?

12) Answer the following questions using the diagram below:



a. Mark one wavelength for each wave on the graph. Numerically, what is the wavelength for each wave? Do these two waves have different wavelength values? What does this tell you about the two waves?

b. Is this light wave visible? How do you know? Given your knowledge of the ElectoMagnetic Spectrum (IR, Visible, etc), exactly what wave is this graph a representation of?

c. Mark the amplitude on the graph. Given the two waves, which one will be more intense? Explain. Mark the nodes on the graph.

d. What is the frequency (Hz) of these waves?

e. What is the energy per photon of each light wave? Are these values different? How many Joules are associated with one mole of these photons?

f. If the work function of a certain element is 2.67×10^{-19} J, what would be the speed of the ejected electron (m/s) if this element were hit by a photon from one of the above two waves?

13) Assuming that 7.50% of the energy output of a 60.0 W light bulb is visible light (with wavelength of 575nm), how many photons are emitted by the light bulb every second? Every hour? (note: 1W = 1 J/s)

14) X-ray has a wavelength of 5.49×10^{-6} mm. What is the energy per photon of this X-ray? When compared to ultraviolet light (250nm), which one do you suspect will be more damaging to human tissue? Explain.

15) a. The photoelectric work function for calcium is 4.34×10^{-19}J. What is the MINIMUM frequency of light needed to eject an electron? What will be the speed of the ejected electron?

b. What is the speed of an electron ejected from Ca if the Ca was hit with a photon of 345nm light?

16) An electron in a hydrogen atom travels from energy level n=5→n=3. What is the frequency of the emitted light? (hint: this takes two steps)

17) What is the smallest wavelength(nm) of electromagnetic radiation EMITTED by the hydrogen atom undergoing a transition from energy level n=4?

18) What is the de Broglie wavelength(nm) of an electron traveling 3.00×10^6 m/s?

19) a. If an electron's speed is measured to be 3.00×10^6 m/s with an uncertainty of 1%, what is the uncertainty in the position of the electron?

b. Instead of an electron, what if the object was a 12g bullet traveling 200.m/s, again with 1% uncertainty? Explain the difference between parts A and B.

Quantum numbers:
(some of these questions may seem confusing…please ask questions in class and GO ONLINE!)

20) What is the purpose of quantum numbers; what do they tell us? What are the four quantum numbers (more like quantum letters)? What does each quantum number represent in regards to an electron's location? What are the possible values for each quantum number?

21) What is the "realistic range" of the principal quantum number "n"? List the four common types of the "l" quantum number; what letter corresponds to an "l" value of 0,1,2,3,4?. What is the basic shape of each type? How does the "m_l" relate to the "l" quantum number? How does "m_l" relate the boxes in an electron box diagram?

22) How many electrons fit into an electron orbital? How does each electron relate to the "m_s" quantum number? What does it mean for an element to be Paramagnetic? Diamagnetic?

23) What are the three representations for an element's electron configuration? Know how to use each method correctly.

24) Where in the transition metals do the “exceptions” to expected filling order occur? Why do they occur at these two places in the periodic table?

25) What is a cation? What is its sign? Are electrons added or removed to make a cation? What is an anion? What is its sign? Are electrons added or removed to make an anion?

26) When making cations, where are electrons removed from, with regards to the element’s neutral electron configuration? When making anions, where are electrons added, with regards to the element’s neutral electron configuration?

27) What does it mean for an element to be isoelectronic with another element? How are anions and cations involved?

28) When dealing with groups 1a-7a (not 4a) on the periodic table, which group(s) tend to form cations, and which form anions? What are the typical ionic charges associated with each group? Why does each group form the specific ions that they do?

29) How many nodal planes are found in an s-type orbital? p-type? d-type? f-type?

30) For each of the elements listed below, give a valid set of four quantum numbers (n, l, m_l, m_s) for one of the highest energy elections in each: i.e. one of the last electrons to fill in. [ex: $_{46}$Pb (4, 2, -2, +½)]

a. $_{7}$N

b. $_{14}$Si

c. $_{49}$In

d. $_{37}$Rb

e. $_{64}$Gd

31) Write out the complete electron configuration for:

a. $_{18}$Ar

b. $_{24}$Cr

c. $_{65}$Tb

32) Write out the abbreviated electron configuration for:

a. $_{12}Mg^{+2}$

b. $_{16}S^{-2}$

c. $_{26}Fe^{+3}$

33) Draw the orbital box diagram for the following elements. Label whether they are Paramagnetic or Diamagnetic.

a. $_{32}Ge$

b. $_{20}Ca$

Periodic Properties:
(these are VERY important…make sure they make sense because they help to explain a whole lot in regards to an element's quantum behavior!)

34) Define atomic size. How does atomic size vary across a period? Down a group? Be sure you understand this trend.

35) What is "ionization energy"? How does ionization energy vary across a period? Down a group? Be sure you understand this trend.

36) What is "electron affinity"? How does electron affinity vary across a period? Down a group? Be sure you understand this trend.

37) Define $Z_{effective}$. How does it affect atomic size?

38) Consider the following elements: Ag, Al, F, Ga, Cl

Arrange these elements for increasing:

- Atomic Size:
- Ionization Energy:
- Electron Affinity:
- $Z_{effective}$:
- Metallic Character:

39) Are cations bigger or smaller than the base element? Are anions bigger or smaller than the base element? (this is tricky…make sure you understand!)

40) What is "metallic character"? How does it relate to ionization energy and electron affinity? Where is metallic character the strongest? Weakest?

41) On the periodic table, where are the smallest atoms? Where are the biggest atoms? Make sure you see a connection between $Z_{effective}$ and atomic size; then make sure you see the connection between atomic size and ionization energy/electron affinity.

Section 3: Solid State, Bonding, and Lewis Structures

Solid State:

1) Draw the z-diagrams for the three most common cubic unit cells. What is the contribution of each atom relative to its placement in a Z-diagram? How many net atoms are contained within each cubic structure?

2) What is the equation for packing efficiency? (know the terms!) What is the value of packing efficiency for the three common cubic structures?

3) What is the edge length for each cubic structure in terms of atomic radii? How are these calculated? (know the basic geometry used to solve)

4) What does coordination number refer to? What is the coordination number of each cubic structure? Does CN change for different atoms (i.e. corner vs. a face atom)?

5) What cubic structure most closely resembles the NaCl ionic cubic structure? Is this cubic structure identical to the structure of NaCl?

6) What cubic structure most closely resembles the CsCl cubic structure? Is this cubic structure identical to the structure of CsCl?

7) In general, when using z-diagrams to determine ionic charges on elements in an ionic compound, why do we usually ask for the charges on transition metals, and not the elements from the main groups 1a-7a?

8) In terms of band structure, what differentiates a conductor, from a semiconductor, from an insulator? In terms of E_g, what are approximate values for each material type?

9) In terms of areas/regions of the periodic table, where are elements that induce large band gaps in compounds? Is the $Z_{effective}$ of these "large band gap inducing elements" large or small? Explain.

10) How do materials with large band gaps compare to metals in regards to EN (electronegativity)?

11) How does an oxidizing agent affect the band gap of a semi-conductor with an $E_g = 1.1$? A reducing agent? Give a possible value for the new E_g in each case.

12) What are the three forms of energy (that we discuss) used to move electrons across a band gap? What are the equations/conversions associated with each energy form?

13) If the color of gold is a yellow-ish tint, does this mean that yellow light is absorbed or transmitted by gold? Explain your answer with a band structure diagram. (note: Au is a conductor with a partially filled valence band)

14) a. How does heat affect the conductivity of a metal? Explain your answer fully,
referencing how heat effects the material on an atomic level.

b. How does heat affect the conductivity of a semiconductor? Explain your answer fully, referencing how heat affects the material on an atomic level. (make sure you understand the difference between 14 and 15!)

15) What effect does a change in temperature have on the intensity of an LED? Explain why this happens.

16) What is a naturally occurring semiconductor? What group from the periodic table are they most commonly found in? What are the two most common naturally occurring semiconductors used?

17) What is it called when we alter the band gap of a naturally occurring semiconductor by adding in a small amount of another element? What are the two categories of alterations? Regardless of which type we use, how is the band gap affected? For the semi-conductor Si, give an example element corresponding to each type of band gap alteration.

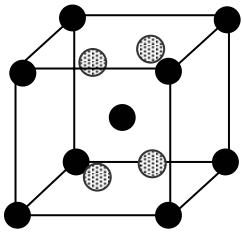
18) What is a compound semiconductor? What groups can theoretically come together to form compound semiconductors? Give a theoretical example for each compound group combination.

19) What is it called when we alter the band gap of a compound semiconductor? How can the band gap be affected by these alterations? Give an example element that will increase the band gap of GaAs. Give an example element that will decrease the band gap of GaAs.

20) What is the Fermi level? How is it affected when we turn an intrinsic semiconductor into an extrinsic semiconductor?

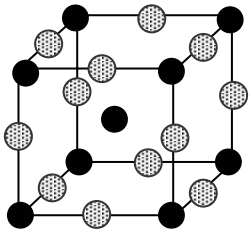
21) What is resistance? How does it change in a metal and semiconductor with increased temperature? What is special about a superconductor with respect to resistance? What is the Meissner effect?

22) Shown below are two derived unit cells representing two different ionic solids. Construct the z-diagrams for each ionic compound. From these, establish how many atoms exist in each unit cell, and determine the correct ionic formula for each compound with each element's charge.

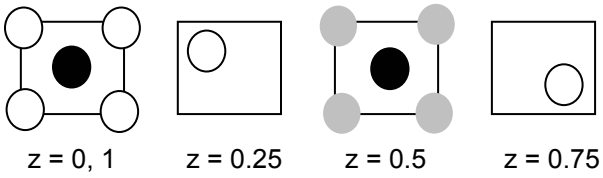


KEY: M (metal)

N (nonmetal)

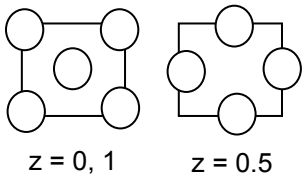


23) Below are the z-diagrams for unit cell containing A, B, and C atoms. Determine the net number of atoms for each element present. From this, determine the simplest formula for the compound, with the included charges. Assume that elements B and C come from group 5a of the periodic table.



KEY: A B C

24) Aluminum crystallizes in the unit cell structure shown below:



What is this unit cell type? How many net atoms are contained within this cell, and what is the cell's packing efficiency? Using the necessary geometry, solve for the edge length of this unit cell type. If Al has a density of 2.70 g/cm^3, what is the radius of an Al atom in pm?

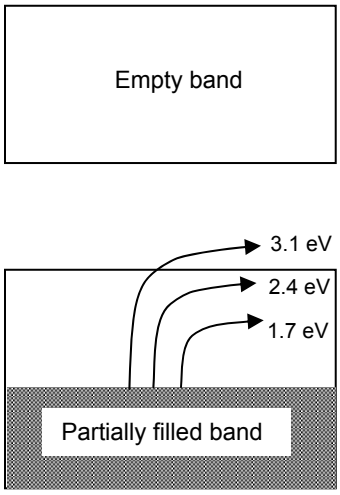
25) If the metallic radius of manganese, $_{25}Mn$, is 127 pm and it forms a BCC unit cell, what is its density in g/cm^3?

26) How much must we heat a semiconductor (E_g = 1.76 eV) in order to move electrons across its gap?

27) How thin (cm) must a semiconductor (E_g = 1.76 eV) be in order for 120 V to supply sufficient energy to move electrons across its gap?

28) Does light with wavelength 600 nm provide enough energy to move electrons in a metal? A semiconductor? An insulator? Determine the maximum band gap that an electron could jump using energy from light of this wavelength.

29) a. Below is the band structure for gold (Au). From the diagram, calculate the wavelengths of light that electrons in the partially filled band are able to absorb.



b. Explain why gold is the color it is, given the information from part "a".

Bonding:

30) What is the goal of bonding, in regards to valence electrons?

31) How do we define an ionic bond in regards to valence electrons; are electrons shared or exchanged? What sort of elements partake in an ionic bond? What is lattice energy? What is the trend in lattice energy with respect to (or as a function of) charge on ions?

32) How do we define a covalent bond in regard to valence electrons; i.e. are electrons shared or exchanged? What sort of elements bond this way?

33) What is metallic bonding? What elements bond in this way? How are valence electrons used in this type of bonding?

34) Construct a Born Haber Cycle for the formation of $BaCl_2$, solving for the lattice energy of the product ($\Delta H_{formation}$ = -848kJ). Be sure to label each step on the energy diagram.

Atomization of Ba	180kJ
Bond Energy of Cl2	236kJ
First ioniztion energy of Ba	502.9kJ
Second ioniztion energy of Ba	965.2kJ
Electron affinity of Cl	342kJ (negative)

Lewis Structures & VSEPR Shapes:

35) What are Lewis Structures; what do they represent? How are VSEPR structures different?

36) What is formal charge? How is it calculated? What are resonance structures?

37) How can ΔH_{rxn} be calculated using Lewis Structures? Calculate the enthalpy of reaction for the following reaction:

$CH_3CH_2Br \rightarrow CH_2CH_2 + HBr \qquad \Delta H_{rxn} = ?$

Bond	Bond Energy (kJ)
C-C	347
C=C	614
C-H	413
H-H	432
H-Br	363
C-Br	276

38) Lewis Structures and VSEPR structures are used to diagram what sort of bonds? How do you know?

39) What is polarity? How do lone pairs of electrons (around the central atom) affect the polarity of a VSEPR structure?

40) What is the general process for drawing Lewis Structures and VSEPR structures?

41) Draw the best Lewis Structure for each covalent species. Be sure to show the calculation for the # of valance electrons, as well as formal charge.

ClO_3^-

C_2F_4

$COCl_2$

NO_2^+

42) For the following covalent compounds, draw the VESPR sketch (showing the 3-D shape), and state:

- Total number of valence electrons
- Total number of electron groups around the central atom
- Electron group geometry
- Total number of bonded groups around the central atom
- Molecular geometry
- Polar or not?

NO_3^-

ClF_2^+

$XeOF_4$

SeF_4

Section 4: Organic Chemistry

1) What is the "base element" of an organic compound? What other elements do we commonly see in organic compounds?

2) Are organic compounds bound by ionic, covalent, or metallic bonds? Explain.

3) How many bonds does carbon like to make? How does this relate to the number of valence electrons carbon has?

4) What is an alkane? How is it different from an alkene and/or an alkyne? How would a 6-carbon-chain be named in each case?

5) What does an alcohol group look like? Where can they reside on the main carbon chain? How does this affect the naming of a compound?

6) What is the difference between an aldehyde and a ketone? How do each of these affect the naming of a compound?

7) When several alkyl, halogen, and/or functional groups are present in the same compound, from which side of the main-carbon-chain should the additions be numbered; what takes precedence?

8) What is a skeletal isomer? Give an example. Do the same for a positional and functional isomer. (note: these last two are a bit more tricky)

9) What is a “mono”-mer? What’s the term for when multiple monomers (same or different) come together to form a “poly”-mer (polymer = plastic)?

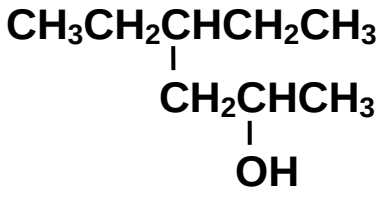
10) What are the two types of polymerization? What’s the main difference between the two?

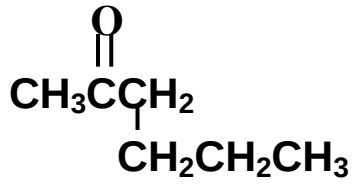
11) In condensation polymerization, what is a common byproduct? (note: knowing this byproduct will help you to notice how/where the condensation reaction occurs!)

12) In a qualitative gas chromatograph, will the peak corresponding to hexane or butane appear further to the right (with a longer elution time)? Understanding the basics of how a gas chromatograph works.

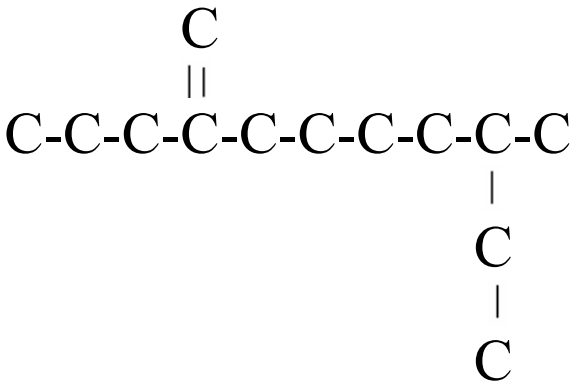
13) Name the following compounds:

a. 

b. 

c. 

d. (assume hydrogen bonds exist where needed)



14) Draw the following compounds:

a. 5-fluoro-decane

b. 5-bromo-3-decyne

c. 3-ethyl-4,4,6-trimethyl-2-nonene

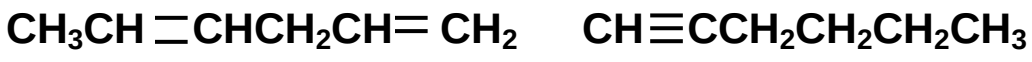
15) What is wrong with the naming of each compound?

a. 2-bromo-4-pentene

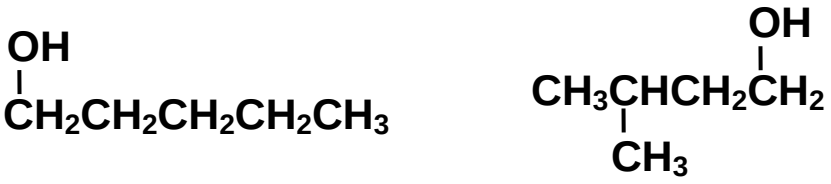
b. 2,2,4-triethyl-7-hexanol

c. 2-methyl-6-heptanal

16) Determine the type of isomer displayed by each pairing:

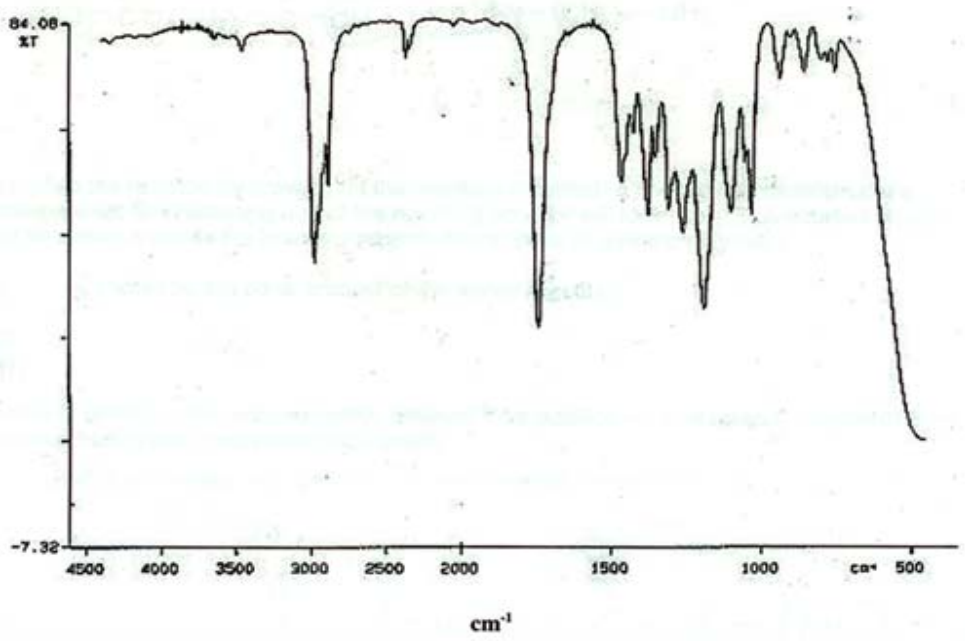
a. 

b. 

c. 

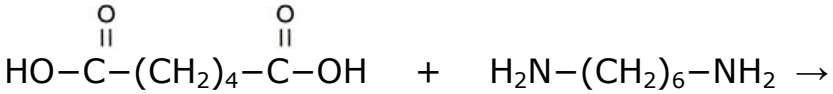
17) Draw <u>all</u> the possible skeletal isomers of hexane.

18) Circle the molecule whose structure is best indicated by the provided IR spectrum:



hexane or hexanal or hexanol

19) Nylon-66 is a common polymer. It is formed via a condensation polymerization as shown below. Fill in the resulting monomer unit in the blank line provided.



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20) Draw an 8 carbon-long "polymer" chain that would result when the following monomer unit undergoes an addition polymerization reaction.